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UNITED STATES ARMY AEROMEDICAL RESEARCH LABORATORY

# U.S. Army Aeromedical Research Laboratory Fiscal Year 2024 Annotated Bibliography

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## Foreword

Open literature publications, technical reports, and technical memorandums by the United States Army Aeromedical Research Laboratory (USAARL) in Fiscal Year (FY) 2024 are included in this annotated bibliography, this edition dated October 2024.

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## Summary of Technical Products

In FY24, USAARL published 22 open literature manuscripts, 42 technical reports, and 13 technical memorandums, totaling 77 publications. USAARL delivered 54 oral presentations and 21 poster presentations.

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## Open Literature Publications

Bartsch, A., & Rooks, T. (2023). Head impacts in the top 1% by peak linear acceleration and/or work cause immediate concussion signs and 'check engine' responses in military Service Members and civilian athletes. *Annals of Biomedical Engineering.* https://doi.org/10.1007/s10439-023-03393-w

Historically, head impact monitoring sensors have suffered from single impact measurement errors, leading to their data described by clinical experts as 'clinically irrelevant.' The purpose of this study was to use an accurate impact monitoring mouthguard system and (1) define head impact distributions for military Service Members and civilians and (2) determine if there was a dose-response relationship between accurately measured head impact magnitudes versus observations of concussion signs. A laboratory-calibrated commercial impact monitoring mouthguard system, along with video and hardware to confirm the sensor was on the teeth during impacts, was used to acquire 54,602 head acceleration events (HAE) in 973 military and civilian subjects over 3449 subject days.

There were 17,551 head impacts (32% of HAE) measured with peak linear acceleration (PLA) > 10 g and 37,051 low-g events (68% of HAE) in the range of activities of daily living < 10 g PLA. The median of all HAE and of all head impacts was 8 g/15 g PLA and 1 J/4 Joules (J) Work, respectively. The top 1% of head impacts were above 47 g and 32 J, respectively. There were fifty-six (56) head impacts where at least one clinical indicator of a concussion sign was observed. All the clinical indicator impacts were in the top 1% by magnitude of PLA, Work, or both. The median magnitude of these 'check engine' impacts was 58 g and 48 J. This median magnitude was substantially larger than the median of all HAE as well as the median of all head impacts.

This study shows a correlation between single head impacts in the top 1% by peak linear acceleration and/or Work and clinical indicators of concussion signs in civilians and military Service Members.

Brozoski, F., Conti, M., Dudek, J., Chancey, V. C., & Crowley, J. (2024). Direct combat-related U.S. Army aviation injuries 2003-2014. *Military Medicine, usae301*. https://doi.org/10.1093/milmed/usae301

Introduction: The USAARL, a partner in the Joint Trauma Analysis for the Prevention of Injury in Combat (JTAPIC) partnership, conducted a series of retrospective reviews to investigate injuries sustained by occupants of U.S. Army rotary-wing aircraft involved in combat damage incidents. The reviews were conducted to provide occupant survivability information to the Aviation Survivability Development and Tactics team, an agency within the U.S. Army Aviation Center of Excellence. For these reviews, combat damage incidents that produced

casualties were separated into direct events (i.e., events in which an enemy weapon system directly injured occupants) and indirect events (i.e., incidents in which occupants were injured as a result of a crash caused by an enemy weapon system). The previous USAARL reviews provided an overview of injuries sustained during direct and indirect events. The objective of this review was to conduct a detailed analysis of injuries occurring during direct events.

Materials and Methods: A descriptive retrospective review was conducted on injuries sustained by occupants of U.S. Army rotary-wing aircraft involved in combat damage incidents between 2003 and 2014. All Black Hawk, Apache, and Chinook combat aviation damage incidents for the study period were reviewed. Personnel casualty information from the Defense Casualty Information Processing System (DCIPS) was linked to combat damage incident information by matching the aircraft platform, incident date, and circumstantial information found in incident narratives. Injury information for personnel identified in DCIPS as being wounded in action was obtained from the JTAPIC partnership; injury data for personnel killed in action were retrieved from the Armed Forces Medical Examiner System. All injuries were coded using the Abbreviated Injury Scale (AIS). Descriptive statistics were used to describe the frequency and distribution of injuries to personnel involved in direct events.

Results: Overall, the extremities were the most commonly injured body regions, with lower extremities suffering more injuries than upper extremities. Penetrating injuries were identified as the primary injury mechanism for all body regions. Injuries to each AIS body region were predominantly of minor (AIS 1) and moderate (AIS 2) severity.

Conclusions: Although injury severities were generally low (AIS 1 or AIS 2), the results of this effort indicate which body regions may benefit from additional protection during rotary-wing operations in hostile environments. The influence of occupant position within the aircraft and the use and effectiveness of personal protective equipment could not be effectively analyzed due to a lack of information.

D'Alessandro, M., Mackie, R., Wolf, S., McGhee, J., & Curry, I. (2024). Physiological fitness of U.S. Army aviators compared to the U.S. general population. *Aerospace Medicine and Human Performance, 95*(4), 175–186. https://doi.org/10.3357/AMHP.6371.2024

Introduction: U.S. Army aviators are required to maintain a level of physiological fitness as part of their qualifying process, which suggests that they are generally physically healthy. However, it has not been statistically proven that they are more "physiologically fit" than the general population.

Methods: This retrospective study compares physiological measurements of U.S. Army aviators from the Aeromedical Electronic Resource Office database to the U.S. general population using the Center for Disease Control's National Health and

Nutrition Examination Survey data. To enable an accurate comparison of physiological metrics between U.S. Army aviators and the U.S. general population, aviators were categorized into the same age groups and biological genders used for segmentation of the national population data.

Results: On average, pulse rate was 4.85 beats per minute (bpm) lower in male aviators and 6.84 bpm lower in female aviators. Fasting glucose levels were, on average, 10.6 milligrams per deciliter (mg $dL)^{-1}$ lower in aviators compared to the general population. Key metrics like pulse rate and fasting glucose were lower in aviators, indicating cardiovascular and metabolic advantages. However, parameters like cholesterol showed less consistent differences.

Discussion: While aviation physical demands and administrative policies selecting for elite physiological metrics produce improvements on some dimensions, a nuanced view accounting for the multitude of factors influencing an aviator's physiological fitness is still warranted. Implementing targeted health monitoring and maintenance programs based on assessments conducted more frequently than the current annual flight physical may optimize aviator safety and performance over the course of a career.

Duffy, M. J., Feltman, K. A., Kelley, A. M., & Mackie, R. (2024). Limitations associated with transcranial direct current stimulation for enhancement: Considerations for performance tradeoffs in active-duty Soldiers. *Frontiers in Human Neuroscience, 18*. https://doi.org/10.3389/fnhum.2024.1444450

Introduction: Transcranial direct current stimulation (tDCS) is a non-invasive brain stimulation method, popular due to its low cost, ease-of-application, and portability. As such, it has gained traction in examining its potential for cognitive enhancement in a diverse range of populations, including active-duty military. However, current literature presents mixed results regarding its efficacy and limited evaluations of possible undesirable side effects (such as degradation to cognitive processes).

Methods: To further examine its potential for enhancing cognition, a double-blind, randomized, sham-controlled, within-subjects design study, was used to evaluate both online active-anodal and -cathodal stimulation on several cognitive tasks administered. Potential undesirable side effects related to mood, sleepiness, and cognitive performance, were also assessed. Active tDCS was applied for 30 minutes, using 2 milliampere (mA), to the left dorsolateral prefrontal cortex with an extracephalic reference placed on the contralateral arm of 27 (14 males) active-duty Soldiers.

Results: We report mixed results. Specifically, we found improvements in sustained attention (active-anodal) for males in reaction time ($p$ = 0.024, $\eta p^2$ = 0.16) and for sensitivity index in females ($p$ = 0.013, $\eta p^2$ = 0.18). In addition, we found faster reaction time ($p$ = 0.034, $\eta p^2$ = 0.15) and increased accuracy ($p$ = 0.029, $\eta p^2$ = 0.16) associated with executive function (active-anodal and -

cathodal), and worsened working memory performance (active-cathodal; $p$ = 0.008, $\eta p^2$ = 0.18). Additionally, we found increased risk-taking with active-anodal ($p$ = 0.001, $\eta p^2$ = 0.33).

Discussion: tDCS may hold promise as a method for cognitive enhancement, as evidenced by our findings related to sustained attention and executive function. However, we caution that further study is required to better understand additional parameters and limitations that may explain results, as our study only focused on anodal vs. cathodal stimulation. Risk-taking was examined secondary to our main interests which warrants further experimental investigation isolating potential tradeoffs that may be associated with tDCS simulation.

Ernst, K., Roth, E., Militello, L., Sushereba, & Wilson, M. (2023). Synthesized framework of decision making for the Army aviation context. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting.* https://doi.org/10.1177/21695067231192586

This paper presents the results of a project to articulate a theory-based framework for characterizing the decision making and situation awareness of Army aviators. This was the first step toward developing strategies for evaluating the impact of emerging technologies on cognitive performance. The team conducted a literature review of decision making and situation awareness models along with a review of Army aviation cognitive requirements, and identified key decision making concepts. The team synthesized a framework of decision making based on key concepts from the literature tailored to Army aviation. The framework guided a literature review of evaluation methods and measures. Evaluation literature review findings included the use of scenario-based evaluation with a range of complexities, and multiple complementary measures. The synthesized framework served as a useful tool to describe aviator decision making and how technology can influence decision making and situation awareness, and may be useful beyond the Army aviation context.

Feltman, K., & Kelley, A. (2024). Transcranial direct current stimulation and aviator performance during simulated flight. *Aerospace Medicine and Human Performance, 95*(1), 5–15. https://doi.org/10.3357/AMHP.6243.2024

Introduction: tDCS is a promising method for maintaining cognitive performance. Anticipated changes in rotary-wing aircraft are expected to alter aviator performance.

Methods: A single-blind, randomized, sham-controlled study evaluated the effects of 2 mA anodal tDCS to the right posterior parietal cortex on aviator performance in a Black Hawk simulator. A mixed design with one between-subjects factor was assessed: stimulation prior to flight (20 constant minutes) and during flight (two timepoints for 10 minutes each). The within-subjects factor included active vs. sham stimulation. Randomly assigned to each stimulation group were 22 aviators.

Aircraft state metrics derived from the simulator were used to evaluate performance. Subjects completed two flights (active stimulation and sham stimulation) with an in-flight emergency introduced at the end to assess whether the timing of tDCS application (prior or during flight) affected the ability to maintain attention and respond to an unexpected event.

Results: Results found active stimulation during flight produced statistically significant improvements in performance during the approach following the in-flight emergency. Subjects maintained a more precise approach path with glideslope values closer to zero ($M$ = 0.05) compared to the prior-to-flight group ($M$ = 0.15). The same was found for localizer values (during flight, $M$ = 0.07; prior to flight, $M$ = 0.17). There were no statistically significant differences between groups on secondary outcome measures.

Discussion: These findings suggest stimulation during flight may assist in maintaining cognitive resources necessary to respond to an unexpected in-flight emergency. Moreover, blinding efficacy was supported with 32% of subjects correctly guessing when active stimulation was being delivered (52% correctly guessed the sham condition).

Feltman, K., Vogl, J., McAtee, A., & Kelley, A. (2024). Measuring aviator workload using electroencephalography: An individualized approach to workload manipulation. *Frontiers in Neuroergonomics, 5.* https://doi.org/10.3389/fnrgo.2024.1397586

Introduction: Measuring an operator's physiological state and using that data to predict future performance decrements has been an ongoing goal in many areas of transportation. Regarding Army aviation, the realization of such an endeavor could lead to the development of an adaptive automation system which adapts to the needs of the operator. However, reaching this end state requires the use of experimental scenarios similar to real-life settings in order to induce the states of interest that are able to account for individual differences in experience, exposure, and perception to workload manipulations. In the present study, we used an individualized approach to manipulating workload in order to account for individual differences in response to workload manipulations, while still providing an operationally relevant flight experience.

Methods: Eight Army aviators participated in the study, where they completed two visits to the laboratory. The first visit served the purpose of identifying individual workload thresholds, with the second visit resulting in flights with individualized workload manipulations. Electroencephalography (EEG) data was collected throughout both flights, along with subjective ratings of workload and flight performance.

Results: Both EEG data and workload ratings suggested a high workload. Subjective ratings were higher during the high workload flight compared to the low workload flight ($p$ < 0.001). Regarding EEG, frontal alpha ($p$ = 0.04) and theta ($p$ =

0.01) values were lower and a ratio of beta/(alpha+theta) ($p$ = 0.02) was higher in the baseline flight scenario compared to the high workload scenario. Furthermore, the data were compared to that collected in previous studies which used a group-based approach to manipulating workload.

Discussion: The individualized method demonstrated higher effect sizes in both EEG and subjective ratings, suggesting that the use of this method may provide a more reliable way of producing high workload in aviators.

Fetchko, T. J., Hart, G. J., Aderman, M. J., Ross, J. D., Malvasi, S. R., Roach, M. H., Cameron, K. L., & Rooks, T. F. (2023). Measurement of head kinematics using instrumented mouthguards during introductory boxing courses in U.S. Military Academy cadets. *Military Medicine, 188*(6), 584–589. https://doi.org/10.1093/milmed/usad249

Use of wearable impact sensor devices to quantitatively measure head impact exposure remains largely unstudied in military-style martial arts training and combat sports, particularly at the beginner levels. The baseline frequency and severity of head impact exposure during introductory military-style martial arts trainings, such as combatives training, is valuable information for developing future programs of instruction and exposure monitoring programs. The purpose of this study was to describe head impact exposures experienced during introductory combatives training (a boxing course) at the U.S. Military Academy. This study used instrumented mouthguards to measure head impact exposure in U.S. Military Academy cadets during a compulsory boxing course. Summary exposures from a preliminary dataset are presented. Twenty-two male subjects (19.9 ± 1.1 years, 86.6 ± 11.7 kilograms [kg]) participated in 205 analyzed player-bouts (full contact sparring sessions) with 809 video verified impacts (average 3.9 impacts per player-bout). The mean peak linear acceleration was 16.5 ± 7.1 G, with a maximum of 70.8 G. There was a right-skewed distribution, with 640/809 (79.1%) events falling between 10 and 20 G. The mean peak angular acceleration was 1.52 ± 0.96 kiloradians per second squared (krad/$s^2$), with a maximum of 8.85 krad/$s^2$. Compared to other high-risk sports at Service Academies, head impacts from beginner boxing were of similar magnitude to those reported for Service Academy football and slightly lower than those reported for Service Academy rugby. Based on these preliminary data, the risk profile for introductory military-style martial arts training, such as boxing or combatives, may be similar to other contact sports like football and rugby, but further research is required to confirm these findings and understand the effects of the exposures in a shorter duration.

Flanigen, P., Wilson, M., Sarter, N., & Atkins, E. (2024). The effectiveness of sensor visualizations and graphic augmentations for detecting vertical obstacles. *Journal of the American Helicopter Society, 69*(3). https://doi.org/10.4050/JAHS.69.032011

Slow or failed detection of low-salience vertical obstacles and associated wires is one of today's leading causes of fatal helicopter accidents. The risk of collisions with such obstacles is likely to increase as advanced aerial mobility and broadening drone activity promises to increase the density of air traffic at low altitudes, while growing demand for electricity and communication will expand the number of vertical structures. The current see-and-avoid detection paradigm relies on pilots to spend much of their visual attention looking outside for obstacles. This method is inadequate in low-visibility conditions, cluttered environments, and given the need for pilots to engage in multiple competing visual tasks. With the expected growing number of hazards and an increased traffic volume, the current approach to collision avoidance will become even less tenable. A human-in-the-loop helicopter simulator study was conducted to assess the effectiveness of sensor visualizations (image intensification or thermal imaging) and graphic augmentations (a bounding box around a tower and a circle surrounding the base of the tower) for supporting fast and reliable detection of vertical structures. Graphic augmentations resulted in faster tower detection time when ambient visibility and illumination were reduced close to the limit for visual flight. Bounding boxes around towers were detected first in all conditions but tended to mask the obstacle they were meant to highlight. Sensor visualization affected tower detection time only at night, where night vision goggles were more effective than the infrared thermal sensor.

Kroening, L., Kinsler, R., Molles, J., & Lloyd, A. (2023). Efficacy of medical device alarm integration into a simulated H-60 integrated communication system. *Military Medicine, 188*(6), 225–231. https://doi.org/10.1093/milmed/usad096

This study sought to examine the efficacy of integrating medical device alarms into the intercommunication set of a simulated HH-60, allowing medics to hear the alarms over the ambient noise of the aeromedical environment. U.S. Army critical care flight paramedics were recruited as subjects for this study. Subjects participated in two testing scenarios, one with patient monitor alarms integrated into their communication lines and one without integrated alarms (the control condition). Testing took place in a simulated HH-60 interior with two priority-level patients per testing scenario, one on either side of the interior. Subjects provided care to these two patients for 30 minutes per scenario. After both scenarios were complete, the subjects were given a questionnaire to obtain their feedback on alarm integration. Six subjects took part in this study, so the results do not have sufficient power to represent the population. No statistically significant results were found. Looking at the trends in the data, implementing alarm integration showed the indications of reducing reaction time to alarms, decreasing or matching the

amount of time spent with the patient monitor, and equivalent amounts of time dedicated to patient treatment when compared to the nonintegrated scenario. The feedback obtained from the subjects provided a list of perceived benefits, drawbacks, and improvements related to the integration of medical device alarms into the intercommunication set. Although the study was underpowered, the trends in the data indicate a benefit to the medics when integrating medical device alarms. When coupled with strongly favorable end-user feedback, the results provide justification for pursuing the effort of integrating alarms and performing future studies with improved integration systems to optimize the potential of the system.

Madison, A. M., Holderfield, R. M., Olszko, A. V., Novotny, B., McGovern, S. M., Brozoski, F. T., Shivers, B. L., & Chancey, V. C. (2023). Preliminary head-supported mass performance guidance for dismounted Soldier environments. *Military Medicine, 188*(6), 520–528. https://doi.org/10.1093/milmed/usad223

The helmet is an ideal platform to mount technology that gives U.S. Soldiers an advantage over the enemy; the total system is recognized quantitatively as head-supported mass (HSM). The stress placed on the head and neck is magnified by adding mass and increasing the center of mass offset away from the atlanto-occipital complex, the head's pivot point on the spine. Previous research has focused on HSM-related spinal degeneration and performance decrement in mounted environments. The increased capabilities and protection provided by helmet systems for dismounted Soldiers have made it necessary to determine the boundaries of HSM and center of mass offset unique to dismounted operations. A human subject volunteer study was conducted to characterize the head and neck exposures and assess the impact of HSM on performance in a simulated field-dismounted operating environment. Data were analyzed from 21 subjects who completed the Load Effects Assessment Program-Army obstacle course at Fort Moore, GA, while wearing three different experimental HSM configurations. Four variable groups (physiologic/biomechanical, performance, kinematic, and subjective) were evaluated as performance assessments. Weight moments corresponding to specific performance decrement levels were calculated using the quantitative relationships developed between each metric and the study HSM configurations. Data collected were used to develop the performance decrement HSM threshold criteria based on an average of 10% total performance decrement of dismounted Soldier performance responses. A weight moment of 134 Newton-centimeters (N-cm) about the atlanto-occipital complex was determined as the preliminary threshold criteria for an average of 10% total performance decrement. A weight moment of 164 N-cm was calculated for a corresponding 25% average total performance decrement. The presented work is the first of its kind specifically for dismounted Soldiers. Research is underway to validate these limits and develop dismounted injury risk guidance.

Olszko, A., Abraczinskas, A., McGovern, S., Robinette, A., Vasquez, K., Chancey, V. C., & Brozoski, F. (2023). Head flail corridors from sled impact acceleration tests for use in occupant-centric vehicle design. *Military Medicine, 188*(6), 157–165. https://doi.org/10.1093/milmed/usad071

In aircraft crashes, injuries to the head and upper torso are frequently reported, with head injury reported most frequently of all body regions. Because preventing flail of the head and body is of utmost importance for occupant survival, the Aircraft Crash Survival Design Guide (ACSDG), the guide to crashworthy aircraft design, published flail envelopes. However, the ACSDG flail envelopes are based on a single test with an anthropomorphic test device subjected to a frontal acceleration. In this article, human research volunteer response data are used to calculate head flail corridors and evaluate the ACSDG flail envelopes. Data from human research volunteer sled tests were obtained from the historical Naval Biodynamics Laboratory collection of the Biodynamics Data Resource. Digitized high-speed film for each test was tracked and processed to represent the head flail response in a format amenable to corridor development. Time-based and position-based head flail corridors were developed for groups of exposure-matched tests and then compared to the ACSDG flail envelopes. A collection of 714 human research volunteer sled tests conducted in six different impact directions ranging from 3 to 15 g was used to develop time-based and position-based head flail corridors for 39 match groups. The ACSDG vertical limit and anteroposterior limit and curve were not exceeded by the flail corridors, but the lateral limit and curve were exceeded by 4.6 to 15.8 centimeters (cm). The flail corridors provide a useful baseline for representing the well-restrained occupant response at lower, non-injurious exposure levels and across multiple impact directions. Under these conditions, the ACSDG lateral limit and curve are not adequate. At higher exposure levels or with modified restraints, seating, or equipment, the ACSDG vertical limit and anteroposterior limit and curves may also be inadequate.

Rooks, T. F., Chancey, V. C., Baisden, J. L., & Yoganandan, N. (2023). Regional strain response of an anatomically accurate human finite element head model under frontal versus lateral loading. *Military Medicine, 188*(6), 420–427. https://doi.org/10.1093/milmed/usad178

Because brain regions are responsible for specific functions, regional damage may cause specific, predictable symptoms. However, the existing brain injury criteria focus on whole brain response. This study developed and validated a detailed human brain computational model with sufficient fidelity to include regional components and demonstrate its feasibility to obtain region-specific brain strains under selected loading. Model development used the Simulated Injury Monitor (SIMon) model as a baseline. Each SIMon solid element was split into eight, with each shell element split into four. Anatomical regions were identified from the FreeSurfer fsaverage neuroimaging template. Material properties were obtained from literature. The model was validated against experimental intracranial pressure, brain-skull displacement, and brain strain data. Model simulations used

data from laboratory experiments with a rigid arm pendulum striking a helmeted head-neck system. Data from impact tests (6 meters per second [m/s]) at two helmet sites (front and left) were used. Model validation showed good agreement with intracranial pressure response, fair to good agreement with brain-skull displacement, and good agreement for brain strain. Correlation analysis scores were between 0.72 and 0.93 for both maximum principal strain (MPS) and shear strain. For frontal impacts, regional MPS was between 0.14 and 0.36 (average of left and right hemispheres). For lateral impacts, MPS was between 0.20 and 0.48 (left hemisphere) and between 0.22 and 0.51 (right hemisphere). For frontal impacts, regional cumulative strain damage measure (CSDM20) was between 0.01 and 0.87. For lateral impacts, CSDM20 was between 0.36 and 0.99 (left hemisphere) and between 0.09 and 0.93 (right hemisphere). Recognizing that neural functions are related to anatomical structures and most model-based injury metrics focus on whole brain response, this study developed an anatomically accurate human brain model to capture regional responses. Model validation was comparable with current models. The model provided sufficient anatomical detail to describe brain regional responses under different impact conditions.

Rooks, T. F., Chancey, V. C., Baisden, J. L., & Yoganandan, N. (2023). Strain response of an anatomically accurate nonhuman primate finite element brain model under sagittal loading. *Military Medicine, 188*(6), 634–641. https://doi.org/10.1093/milmed/usad288

Prevention and treatment of traumatic brain injuries is critical to preserving Soldier brain health. Laboratory studies are commonly used to reproduce injuries, understand injury mechanisms, and develop tolerance limits; however, this approach has limitations for studying brain injury, which requires a physiological response. The nonhuman primate (NHP) has been used as an effective model for investigating brain injury for many years. Prior research using the NHP provides a valuable resource to leverage using modern analysis and modeling techniques to improve our understanding of brain injury. The objectives of the present study are to develop an anatomically accurate finite element model of the NHP and determine regional brain responses using previously collected NHP data. The finite element model was developed using a neuroimaging-based anatomical atlas of the rhesus macaque that includes both cortical and subcortical structures. Head kinematic data from 10 sagittal NHP experiments, four +Gx (rearward) and six −Gx (frontal), were used to test model stability and obtain brain strain responses from multiple severities and vectors. For +Gx tests, the whole-brain cumulative strain damage measure exceeding a strain threshold of 0.15 (CSDM15) ranged from 0.28 to 0.89, and 95$^{th}$ percentile of the whole-brain maximum principal strain (MPS95) ranged from 0.21 to 0.59. For −Gx tests, whole-brain CSDM15 ranged from 0.02 to 0.66, and whole-brain MPS95 ranged from 0.08 to 0.39. Recognizing that NHPs are the closest surrogate to humans combined with the limitations of conducting brain injury research in the laboratory, a detailed anatomically accurate finite element model of an NHP was developed and exercised using previously collected data from the Naval Biodynamics Laboratory. The presently developed

model can be used to conduct additional analyses to act as pilot data for the design of newer experiments with statistical power because of the sensitivity and resources needed to conduct experiments with NHPs.

Temme, L., Wittels, H. L., Wishon, M. J., St. Onge, P., McDonald, S. M., Hecocks, D., & Wittels, S. H. (2023). Continuous physiological monitoring of the combined exposure to hypoxia and high cognitive load in military personnel. *Biology, 12*(11), 1398. https://doi.org/10.3390/biology12111398

Military aviators endure high cognitive loads and hypoxic environments during flight operations, impacting the autonomic nervous system (ANS). The synergistic effects of these exposures on the ANS, however, are less clear. This study investigated the simultaneous effects of mild hypoxia and high cognitive load on the ANS in military personnel. This study employed a two-factor experimental design. Twenty-four healthy participants aged between 19 and 45 years were exposed to mild hypoxia (14.0% oxygen [$O_2$]), normoxia (21.0% $O_2$), and hyperoxia (33.0% $O_2$). During each epoch ($n$ = 5), participants continuously performed one 15 minute and one 10 minute series of simulated, in-flight tasks separated by 1 minute of rest. Exposure sequences (hypoxia–normoxia and normoxia–hyperoxia) were separated by a 60 minute break. Heart rate (HR), heart rate variability (HRV), and $O_2$ saturation ($SpO_2$) were continuously measured via an armband monitor (Warfighter Monitor, Tiger Tech Solutions, Inc., Miami, FL, USA). Paired and independent $t$-tests were used to evaluate differences in HR, HRV, and $SpO_2$ within and between exposure sequences. Survival analyses were performed to assess the timing and magnitude of the ANS responses. Sympathetic nervous system (SNS) activity during hypoxia was highest in epoch 1 (HR: +6.9 bpm, $p$ = 0.002; root mean square of successive difference between normal heartbeats [rMSSD]: −9.7 milliseconds [ms], $p$ = 0.003; standard deviation of normal-to-normal interbeat intervals measured in milliseconds [SDNN]: −11.3 ms, $p$ = 0.003; $SpO_2$: −8.4%, $p < 0.0000$) and appeared to slightly decline with non-significant increases in HRV. During normoxia, SNS activity was heightened, albeit non-significantly, in epoch 1, with higher HR (68.5 bpm vs. 73.0 bpm, $p$ = 0.06), lower HRV (rMSSD: 45.1 ms vs. 38.7 ms, $p$ = 0.09 and SDNN: 52.5 ms vs. 45.1 ms, $p$ = 0.08), and lower $SpO_2$ (−0.7%, $p$ = 0.05). In epochs 2–4, HR, HRV, and $SpO_2$ trended toward baseline values. Significant between-group differences in HR, HRV, and $O_2$ saturation were observed. Hypoxia elicited significantly greater HRs (+5.0, $p$ = 0.03), lower rMSSD (−7.1, $p$ = 0.03), lower SDNN (−8.2, $p$ = 0.03), and lower $SpO_2$ (−1.4%, $p$ = 0.002) compared to normoxia. Hyperoxia appeared to augment the parasympathetic reactivation reflected by significantly lower HR, in addition to higher HRV and $O_2$ relative to normoxia. Hypoxia induced a greater ANS response in military personnel during the simultaneous exposure to high cognitive load. The significant and differential ANS responses to varying $O_2$ levels and high cognitive load observed highlight the importance of continuously monitoring multiple physiological parameters during flight operations.

Thomas, V., Kelley, A., Lee, A., Fotopoulos, T., Boggs, J., & Campbell, J. (2023). Preliminary evaluation of an osteopathic manipulative treatment to prevent motion sickness. *Aerospace Medicine and Human Performance, 94*(5), 934–938. https://doi.org/10.3357/AMHP.6248.2023

Introduction: Motion sickness affecting military pilots and aircrew can impact flight safety and, if severe, can lead to disqualification from flight status. However, due to the common adverse effects of motion sickness pharmaceuticals (e.g., drowsiness), medication options are severely limited. The purpose of this study was to explore the potential utility of a nonpharmaceutical method for motion sickness prevention, specifically an osteopathic manipulative technique (OMT).

Methods: A novel OMT protocol for the reduction of motion sickness symptoms and severity was evaluated using a sham-controlled, counterbalanced, between-subjects study design. The independent variable was OMT treatment administered prior to the motion sickness-inducing procedure (rotating chair). The primary dependent measures were total and subscale scores from the Motion Sickness Assessment Questionnaire.

Results: The OMT treatment group experienced significantly fewer gastrointestinal (mean scores postprocedure, treatment $M$ = 20.42, sham $M$ = 41.67) and sopite-related (mean scores postprocedure, treatment $M$ = 12.81, sham $M$ = 20.68) symptoms than the sham group while controlling for motion sickness susceptibility. There were no differences between groups with respect to peripheral and central symptoms.

Discussion: The results suggest that the treatment may prevent gastrointestinal (nausea) and sopite-related symptoms (sleepiness). These preliminary findings support further exploration of OMT for the prevention of motion sickness. A more precise evaluation of the mechanism of action is needed. Additionally, the duration of the effects needs to be investigated to determine the usefulness of this technique in training and operational settings.

Williams, S. T., Madison, A. M., & Chancey, V. C. (2023). A biomechanical investigation of cervical spine range of motion for UH-60 aviators in real and simulated flight environments. *Military Medicine, 188*(6), 240–245. https://doi.org/10.1093/milmed/usad101

Military flight surgeons evaluating aviators for flight fitness based on the cervical spine range of motion (CROM) have no operationally relevant reference with which to make a reliable determination. The published physiological limits for the general population do not necessarily apply to military aviators. CROM requirements for rotary-wing aviators would ideally be defined by measurements taken directly within their operational environment. Nine subjects performed the same predetermined one-hour flight mission in a UH-60 aircraft and then, at least two

days later, in the USAARL NUH-60 flight simulator. Head position was recorded using an optical-based inertial tracker attached to the night vision goggle mount of the subjects' flight helmets. Matched-pair t-tests were implemented to compare the maximum CROM between aircraft and simulated flights and the published general population. The percent of flight time in severe flexion and lateral bending was not statistically different ($P > 0.05$) between real and simulated flights but was statistically lower in the simulator for severe twist rotation ($P < 0.05$). The maximum CROM for the advanced maneuvers was significantly lower than the norms for the general population ($P < 0.05$). The flight simulator could be a useful platform for flight surgeons determining CROM-related flight fitness if methods to increase the frequency of neck twist rotation movements during flight were implemented. The published maximum CROM values for the general population are not an appropriate reference for flight surgeons making flight fitness determinations related to CROM.

Wittels, H., Wittels, H., Wishon, M. J., Vogl, J., St. Onge, P., McDonald, S., & Temme, L. (2024). Examining the influence of cognitive load and environmental conditions on autonomic nervous system response in military aircrew: A hypoxia-normoxia study. *Biology, 13*(5), 43. https://doi.org/10.3390/biology13050343

Executing flight operations demand that military personnel continuously perform tasks that utilize low- and high-order cognitive functions. The ANS is crucial for regulating the supply of $O_2$ to the brain, but it is unclear how sustained cognitive loads of different complexities may affect this regulation. Therefore, in the current study, ANS responses to low and high cognitive loads in hypoxic and normoxic conditions were evaluated. The present analysis used data from a previously conducted, two-factor experimental design. Healthy subjects ($n = 24$) aged 19 to 45 years and located near Fort Novosel, AL, participated in the parent study. Over two 2-hour trials, subjects were exposed to hypoxic (14.0% $O_2$) and normoxic (21.0% $O_2$) air while simultaneously performing one 15-minute and one 10-minute simulation incorporating low- and high-cognitive load aviation-related tasks. The tests were alternated across five 27-minute epochs; however, only epochs two through four were used in the analyses. HR, HRV, and arterial $O_2$ saturation were continuously measured using the Warfighter Monitor (Tiger Tech Solutions, Inc., Miami, FL, USA), a previously validated armband device equipped with electrocardiographic and pulse oximetry capabilities. Analysis of variance (ANOVA) regression models were performed to compare ANS responses between the low and high cognitive load assessments under hypoxic and normoxic conditions. Pairwise comparisons corrected for familywise error were performed using Tukey's test within and between high and low cognitive loads under each environmental condition. Across epochs two through four, in both the hypoxic condition and the normoxic condition, the high cognitive load assessment (Multi-Attribute Task Battery [MATB]-II) elicited heightened ANS activity, reflected by increased HR (+2.4 ± 6.9 bpm) and decreased HRV (-rMSSD: -0.4 ± 2.7 ms and SDNN: -13.6 ± 14.6 ms). Conversely, low cognitive load (Automated Desktop Vision Test [ADVT]) induced an improvement in ANS activity, with reduced HR (-

2.6 ± 6.3 bpm) and increased HRV (rMSSD: +1.8 ± 6.0 ms and SDNN: vs. +0.7 ± 6.3 ms). Similar observations were found for the normoxic condition, albeit to a lower degree. These within-group ANS responses were significantly different between high and low cognitive loads (HR: +5.0 bpm, 95% CI: 2.1, 7.9, $p < 0.0001$; rMSSD: -2.2 ms, 95% CI: -4.2, -0.2, $p = 0.03$; SDNN: -14.3 ms, 95% CI: -18.4, -10.1, $p < 0.0001$) under the hypoxic condition. For normoxia, significant differences in ANS response were only observed for HR (+4.3 bpm, 95% CI: 1.2, 7.4, $p = 0.002$). Lastly, only high cognitive loads elicited significant differences between hypoxic and normoxic conditions but just for SDNN (-13.3 ms, 95% CI, -17.5, -8.9, $p < 0.0001$). Our study observations suggest that compared to low cognitive loads, performing high-cognitive-load tasks significantly alters ANS activity, especially under hypoxic conditions. Accounting for this response is critical, as military personnel during flight operations sustain exposure to high cognitive loads of unpredictable duration and frequency. Additionally, this is likely compounded by the increased ANS activity consequent to pre-flight activities and anticipation of combat-related outcomes.

Yoganandan, N., Shah, A., Baisden, J., Stemper, B., Otterson, M., Somberg, L., Bass, C., Salzar, R., McMahon, J., Chancey, C., & McEntire, B. J. (2024). Matched-pair hybrid test paradigm for behind armor blunt trauma using an experimental animal model. *Trauma Surgery & Acute Care Open, e001194*. https:// doi.org/ 10. 1136/ tsaco- 2023-001194

Background: The current behind armor blunt trauma (BABT) injury criterion uses a single penetration limit of 44 millimeters (mm) in Roma Plastilina clay and is not specific to thoracoabdominal regions. However, different regions in the human body have different injury tolerances. This manuscript presents a matched-pair hybrid test paradigm with different experimental models and candidate metrics to develop regional human injury criteria.

Methods: Live and cadaver swine were used as matched pair experimental models. An impactor simulating backface deformation profiles produced by body armor from military-relevant ballistics was used to deliver BABT loading to liver and lung regions in cadaver and live swine. Impact loading was characterized using peak accelerations and energy. For live swine, physiological parameters were monitored for 6 hours, animals were euthanized, and a detailed necropsy was done to identify injuries to skeletal structures, organs, and soft tissues. A similar process was used to identify injuries to the cadaver swine for targeted thoracoabdominal regions.

Results: Two cadavers and one live swine were subjected to BABT impacts to the liver. One cadaver and one live swine were subjected to BABT impacts to the left lung. Injuries to both regions were similar at similar energies between the cadaver and live models.

Conclusions: Swine is an established animal for thoracoabdominal impact studies in automotive standards, although at lower insult levels. Similarities in BABT responses between cadaver and live swine allow for extending testing protocols to human cadavers and for the development of scaling relationships between animal and human cadavers, acting as a hybrid protocol between species and live and cadaver models. Injury tolerances and injury risk curves from live animals can be converted to human tolerances via structural scaling using these outcomes. The present experimental paradigm can be used to develop region-based BABT injury criteria, which are not currently available.

Yoganandan, N., Shah, A., Koser, J., Somberg, L., Stemper, B., Chancey, V., & McEntire, B. J. (2024). Analysis of injury metrics from experimental cardiac injuries from behind armor blunt trauma using live swine tests: A pilot study. *Military Medicine, usae297*. https://doi.org/10.1093/milmed/usae297

Introduction: Warfighters are issued hard body armor designed to defeat ballistic projectiles. The resulting backface deformation can injure different thoracoabdominal organs. Developed over decades ago, the behind armor blunt impact criterion of maximum 44 mm depth in clay continues to be used independent of armor type or impact location on the thoracoabdominal region covered by the armor. Because thoracoabdominal components have different energy absorption capabilities, their mode of failures and mechanical properties are different. These considerations underscore the lack of effectiveness of using the single standard to cover all thoracoabdominal components to represent the same level of injury risk. The objective of this pilot study is to conduct cardiac impact tests with a live animal model and analyze biomechanical injury candidate metrics for behind armor blunt trauma applications.

Materials and Methods: Live swine tests were conducted after obtaining approvals from the U.S. Department of Defense. An intravenous line was introduced into the swine before administering anesthesia. Pressure transducers were inserted into lungs and aorta. An indenter simulating backface deformation profiles produced by body armor from military-relevant ballistics to human cadavers delivered impacts to the heart region. The approved test protocol included 6-hour monitoring and necropsies. Indenter accelerometer signals were processed to compute the velocity and deflection, and their peak magnitudes were obtained. The deflection time signal was normalized with respect to chest depth along the impact axis. The peak magnitude of the viscous criterion, kinetic energy, force, momentum, and stiffness were obtained.

Results: Out of the eight specimens, two were sham controls. The mean total body mass and soft tissue thickness at the impact site were 81.1 ± 4.1 kg and 3.8 ± 1.1 cm. The peak velocities ranged from 30 to 59 m/s, normalized deflections ranged from 15 to 21%, and energies ranged from 105 to 407 J. The range in momentum and stiffness were 7.0 to 13.9 kilogram-meters per second (kg-m/s) and 22.3 to 79.9 newton-meters (N/m). The maximum forces and impulse data

ranged from 2.9 to 11.7 kilonewtons (kN) and 1.9 to 5.8 newton-seconds (N-s). The peak viscous criterion ranged from 2.0 to 5.3 m/s. One animal did not sustain any injuries, two had cardiac injuries, and others had lung and skeletal injuries.

Conclusions: The present study applied blunt impact loads to the live swine cardiac region and determined potential candidate injury metrics for characterization. The sample size of six swine produced injuries ranging from none, to pure skeletal, to pure organ trauma. The viscous criterion metric associated with the response of the animal demonstrated a differing pattern than other variables with increasing velocity. These findings demonstrate that our live animal experimental design can be effectively used with testing additional samples to develop behind armor blunt injury criteria for cardiac trauma in the form of risk curves. Injury criteria obtained for cardiac trauma can be used to enhance the effectiveness of the body armor, reduce morbidity and mortality, and improve Warfighter readiness in combat operations.

Yoganandan, N., Shah, A., Somberg, L., Baisden, J., Stemper, B. D., Bass, C., Salzar, R. S., Chancey, V. C., & McEntire, J. (2024). A novel paradigm to develop regional thoracoabdominal criteria for behind armor blunt trauma based on original data. *Military Medicine, 188*(6), 598–605. https://doi.org/10.1093/milmed/usad272

For BABT, recent prominent BABT standards for chest plates define a maximum deformation distance of 44 mm in clay. It was developed for soft body armor applications with limited animal, gelatin, and clay tests. The legacy criterion does not account for differing regional thoracoabdominal tolerances to behind armor-induced injury. This study examines the rationale and approaches used in the legacy BABT clay criterion and presents a novel paradigm to develop thoracoabdominal regional injury risk curves. A review of the original military and law enforcement studies using animals, surrogates, and body armor materials was conducted, and a reanalysis of data was performed. A multiparameter model analysis describes survival–lethality responses using impactor/projectile (mass, diameter, and impact velocity) and specimen (weight and tissue thickness) variables. Binary regression risk curves with ± 95% confidence intervals (CIs) and peak deformations from simulant tests are presented. Injury risk curves from 74 goat thorax tests showed that peak deflections of 44.7 mm (± 95% CI: 17.6 to 55.4 mm) and 49.9 mm (± 95% CI: 24.7 to 60.4 mm) were associated with the 10% and 15% probability of lethal outcomes. 20% gelatin and Roma Plastilina #1 clay were stiffer than goat. The clay was stiffer than 20% gelatin. Penetration diameters showed greater variations (on a test-by-test basis, difference 36-53%) than penetration depths (0-12%) across a range of projectiles and velocities. While the original authors stressed limitations and the importance of additional tests for refining the 44 mm recommendation, they were not pursued. As live swine tests are effective in developing injury criteria, the responses of different areas of the

thoracoabdominal regions are different because of anatomy, structure, and function, a new set of swine and human cadaver tests are necessary to develop scaling relationships. Live swine tests are needed to develop incapacitation/lethal injury risk functions. Using scaling relationships, human injury criteria can be developed.

## Technical Reports

USAARL-TECH-SR--2024-01. **Preliminary human factors evaluation of prototype exoskeleton design for use in military litter carry scenarios**. October 2023. AD1214364

By Robinette, A., Barazanji, K., Hall, J., Madison, A., & Chancey, V. C.

> DISTRIBUTION STATEMENT D. Distribution authorized to Department of Defense and U.S. DoD contractors only; Controlled Technical Information (CTI); 30 SEPT 2023. Other requests for this document must be referred to U.S. Army Aeromedical Research Laboratory (FCMR-UAC/Commander), Bldg 6901 Farrel Road, Fort Novosel, AL 36362.

USAARL-TECH-BB--2024-02. **USAARL FY23 annotated bibliography**. October 2023. AD1214365

By SIC

> Open literature publications, technical reports, and technical memorandums by the USAARL in FY 2023 are included in this annotated bibliography, this edition dated October 2023.

USAARL-TECH-FR--2024-03. **Efficacy of donepezil to enhance cognitive and functional performance in healthy, rested Soldiers.** October 2023. AD1214367

By Kelley, A., Persson, I., Mackie, R., & Wolf, S.

> We evaluated the cognitive enhancement effects of a single dose (5 milligrams [mg]) of donepezil in healthy, rested Soldiers using a randomized, placebo-controlled, within-subjects, double-blind experimental design. The independent variable was drug (donepezil 5 mg, placebo) and abstract reasoning ability was included as a moderator variable. The primary outcomes were cognitive ability (attention, visual information processing, memory), marksmanship performance, and flight performance on a subset of aviators. Participants were 23 male, U.S. Army active-duty Soldiers. Eight participants were rated aviators and completed three simulated flights. Out of nine tasks (including three simulated flights), only one significant difference between drug conditions was found. The effect was seen on one of the simulated flights, which were only completed by rated aviators, approximately 36 percent of participants who completed the study ($n$ = 8). Further research, particularly that focuses on the role cognitive workload and intrinsic motivation may play, is required prior to recommendations regarding donepezil and its enhancement properties.

USAARL-TECH-SR--2024-04. **Preliminary steps towards comprehensive guidance for the development of dismounted head-supported mass injury curves for operationally-relevant exposures.** October 2023.
AD1217043

By Rhodes, D., Duemmler, M., Brozoski, F. T., Madison, A. M., & Chancey, V. C.

> DISTRIBUTION STATEMENT D. Distribution authorized to Department of Defense and U.S. DoD contractors only; CTI; 30 SEPT 23. Other requests for this document must be referred to U.S. Army Aeromedical Research Laboratory (FCMR-UAC/Commander), Bldg 6901 Farrel Road, Fort Novosel, AL 36362.

USAARL-TECH-FR--2024-05. **Environmental sensors in training: Lessons learned.** October 2023.
AD1217052

By Rooks, T., Novotny, B., Winegar, A., & Chancey, V. C.

> Between 2000 and the first quarter of 2019, the number of reported mild traumatic brain injury (mTBI) diagnoses totaled 342,747 for all military branches. Recent estimates indicate that as many as 80% of these mTBIs were diagnosed in garrison (potentially during training), as opposed to during combat operations (Helmick et al., 2015). In response, the Environmental Sensors in Training (ESiT) research program was initiated to evaluate wearable sensors designed to detect and quantify head acceleration exposures. The present report summarizes lessons learned through multiple studies conducted between 2015 and 2018 under the ESiT research program informing future device development and continued research involving wearable devices. Care should be taken in use and interpretation of reported data and study results potentially confounded by poor human factors designs (e.g., devices out of position or uncomfortable), poor device performance (e.g., false-positives and large device-to-device variability), and time-consuming device administration. At this time, the available devices may be useful for identifying the level of exposure to the head or helmet; however, they are not capable of determining whether an injury occurred and cannot be used blindly.

USAARL-TECH-FR--2024-06. **Evaluation of litter carriage performance and post-carry fatigue effects in prolonged combat field care environments (Part 2): Effects of assistive device use during simulated litter transport.** November 2023.
AD1217055

By Ballard, M. T., Madison, A. M., Novotny, B. McGovern, S., Robinette, A., Stewart, A., Hasapes, S., Williams, S. T., Brozoski, F. T., & Chancey, V. C.

> Litter carriage transport is a standard procedure for initial casualty evacuation from the point of injury to the medical aid or evacuation zone, and is generally done on foot. Using an assistive device during litter transport could decrease fatigue and increase the litter bearer's ability to carry the litter, provide critical

care, and sustain Warfighter tasks. Improvements in these capabilities are critical with upcoming large scale combat operations (LSCO) and multi-domain operations (MDO), which could extend distance and duration away from medical evacuation zones or definitive medical treatment. We examined the effects of commercial-off-the-shelf (COTS) assistive device use (i.e., shoulder harness and wrist hooks) on litter bearer performance and post-carry fatigue during simulated prolonged care and transport scenarios. Assistive device usage resulted in positive benefits to litter carry distance, grip strength, and spinal posture during the litter carriage task. The use of an assistive device also demonstrated limited benefit to muscular fatigue. Overall, the study outcomes demonstrated that an assistive device 2-person litter carry technique could replace the traditional unassisted 4-person litter carry technique in remote and mass casualty scenarios.

USAARL-TECH-TR--2024-07. **Assessment of suitability of Army ambulance medical equipment set and consumable supplies for Arctic environments.** November 2023.
AD1217059

By Snyder, S. B., & Kroening, L.

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USAARL-CNPA-BC--2024-08. **Effects of hypoxia, hyperoxia, and ocular fatigue on dynamic stereoscopic vision.** December 2023.
AD1309161

By Temme, L.

A summary and update presented to the 2024 Shoresh meeting, describing an experiment assessing the impact of hypoxia, hyperoxia, and prolonged aviation task performance on measures of binocularity and acuity. The presentation describes the context for the study, including its operational importance and scientific background, as well as the experimental design, instrumentation, and procedures. The hypotheses the study addresses are listed. Preliminary results are described and discussed. Important observations include a decrease in dynamic stereoacuity with normobaric hypoxia, an effect which was not found with typical measures of static stereopsis. Thus, one class of measures was sensitive to the effects of hypoxia and the other was not. This is an important factor to consider when extrapolating observations from the laboratory to the real world.

USAARL-TECH-TR--2024-09. **Comparison of eye tracking system performance within a six-axis motion-based UH-60 Black Hawk simulator.** December 2023. AD1217065

By Aura, C., Yue, X., & Feltman, K.

> DISTRIBUTION STATEMENT D. Distribution authorized to Department of Defense and U.S. DoD contractors only; CTI, SEPT 23. Other requests for this document must be referred to U.S. Army Aeromedical Research Laboratory (FCMR-UAC/Commander), Bldg 6901 Farrel Road, Fort Novosel, AL 36362.

USAARL-TECH-TR--2024-10. **Measuring trust in automation in operational aeromedical settings: A systematic review of the literature.** December 2023. AD1217068

By Ranes, B., Wilkins, J., Kenser, E., & Caid-Loos, M.

> As military environments integrate more complex technological systems, operators increasingly require more assistance in the form of automation. When used properly, automation has the potential to significantly enhance performance; however, proper use is predicated on the operator's trust in the automation (TIA). TIA, like trust among people, is a complex construct that is influenced by biological, psychosocial, and behavioral aspects that affect (and are affected by) how a user feels about a system. While options for measuring TIA have rapidly expanded in the past decade, there has been little consideration for how well these measures can perform in operational environments. The purpose of this review was to explore the literature produced over the previous ten years to identify all means of measuring TIA, evaluating the quality of the studies that used each measure, and rating how well each measure would perform in an operational aeromedical environment. A recommendation of 28 behavioral, physiological, and user-reported TIA measures is provided, as well as a list of 23 measures with a cautious recommendation (including caveats for use) and 6 TIA measures that are not recommended. While these recommendations offer a starting point for testing TIA in aeromedical settings, further research is required to test how well these recommended measures actually perform in an operational aeromedical environment.

USAARL-TECH-FR--2024-11. **Environmental sensors in training: Head acceleration dose response.** December 2023.
AD1219887

By Rooks, T. F., Kelley, A. M., Duffy, M., & Chancey, V. C.

> Within the military, it has been estimated that nearly 20 percent of Service Members deployed to Iraq or Afghanistan have sustained at least one mTBI. While concussion management and education have significantly improved in recent years, there is still a concern over the possibility of Soldiers with mTBI being missed for evaluation, diagnosis, and treatment. Over the past two

decades, civilian and military researchers and clinicians have attempted to leverage environmental sensors, providing the capability to monitor head impact exposures in vivo, to develop a dose-response model for mTBI and concussion. The ESiT research program evaluated the ability of available devices to identify potentially concussive events resulting from HAE in the military. The present report summarizes the results of the USAARL-led accelerative exposure arm of the ESiT research program aimed at developing a dose-response relationship for identifying potentially concussive events with wearable device data.

USAARL-TECH-SR--2024-12. **Instrumented mouthguard laboratory evaluation using two anthropometric test device headforms.** December 2023.
AD1219889

By Brown, B. A., Daniel, R., & Rooks, T.

This study is in support of the Human Head Impact Dose Concussion Risk Functions and Sensor-Based Military-Specific Environmental Monitoring System project (BA150149, W81XWH-17-1-0019). Test methods and results comparing the measured kinematics using a boil-and-bite instrumented mouthguard with reference kinematics from two anthropomorphic test device headforms under multiple exposure types and severities are provided. Mouthguard performance was comparable to prior literature; however, there was an increase in variability due to fitting. The Mandible Load Sensing Headform resulted in poor comparisons between the mouthguard and reference due to several issues with jaw movement and interactions with the mouthguard. A modified National Operating Committee on Standards for Athletic Equipment headform resulted in good comparisons between the mouthguard and reference data. Increased variability in mouthguard response compared to the reference was primarily attributed to the use of boil-and-bite versus fully custom-molded mouthguards commonly used in the literature. While increased, when compared to custom-molded mouthguards, the variability was still minimal.

USAARL-TECH-TR--2024-13. **Evaluation of a multisensory cueing on aviators' performance: Impact of tactile and auditory cueing sensitivity levels.** December 2023.
AD1218341

By Feltman, K. A., Mackie, R., McAtee, A., Aura, C., Noetzel, J., Wilkins, J., Yue, X., McCormick, R., Alcock, S., & Gerstner, J. A.

The present study sought to evaluate the utility of a multisensory cueing system on aviators’ ability to maintain performance, their experience of workload, and its impact on their situation awareness. Four combinations of cueing sensitivities were evaluated: high auditory/low tactile, high auditory/high tactile, low auditory/low tactile, and low auditory/high tactile. From this study it was concluded that cueing configurations featuring low auditory sensitivity were preferred in terms of performance. Additionally, the majority of participants

indicated preference of the configuration featuring low auditory/high tactile cueing, which was also reflected in their workload ratings and performance data.

USAARL-TECH-FR--2024-14. **Methodology and considerations for combining historic accelerative loading research to update the U.S. Army Aeromedical Research Laboratory head-supported mass curve using survival analysis.** January 2024.
AD1219895

By Brozoski, F. T., Duemmler, M., McGovern, S., Rhodes, D., Vasquez, K., Johnson, B., Beltran, C., Madison, A., & Chancey, V. C.

Military helmets are multi-functional tools that provide blunt and ballistic impact protection and are frequently used as a mounting platform for life support and operational enhancement technologies. The frequent use of these helmet-mounted technologies can increase the risk of cervical spine injury, both acute and chronic, to Warfighters due to the increase in HSM and changes in the location of the combined center of mass (CM) of the helmet and helmet-mounted technologies. Evidence of an increased neck injury risk was provided through epidemiological research. This evidence led the USAARL to investigate and develop HSM requirements for Army rotary-wing helmets in 1997 (McEntire & Shannahan, 1997). Over the 25 years since the introduction of the USAARL HSM Curves, additional research has been conducted into the effects of HSM and HSM CM location. The body of knowledge on the effects of HSM and CM location on performance and cervical spine injury generated over the previous 25 years was mined to identify data for refining the USAARL HSM Injury Curve. Survival analysis offers a means to re-analyze historical HSM research and update the USAARL HSM Injury guidance. Since the development of the USAARL HSM Injury Curve, survival analysis has become a commonplace statistical technique to generate probabilistic injury risk models (Petitjean & Trosseille, 2011; Yoganandan et al., 2016). Updated guidance on HSM and HSM CM location is needed to inform the design of head-supported devices optimized for use in the future Army aviation environment. This manuscript reviews the available HSM-related research and discusses the application of survival analysis to the historical data to develop an updated USAARL HSM Injury Curve.

USAARL-JAOA-PV--2024-15. **Efficacy of medical device alarm integration into a simulated H-60 integrated communication system.** January 2024.
AD1219898

By Kroening, L., Kinsler, R., Molles, J., & Lloyd, A.

Introduction: This study sought to examine the efficacy of integrating medical device alarms into the intercommunication set of a simulated HH-60, allowing medics to hear the alarms over the ambient noise of the aeromedical environment.

Materials and Methods: U.S. Army critical care flight paramedics were recruited as subjects for this study. Subjects participated in two testing scenarios, one with patient monitor alarms integrated into their communication lines and one without integrated alarms (the control condition). Testing took place in a simulated HH-60 interior with two priority-level patients per testing scenario, one on either side of the interior. Subjects provided care to these two patients for 30 minutes per scenario. After both scenarios were complete, the subjects were given a questionnaire to obtain their feedback on alarm integration.

Results: Six subjects took part in this study, so the results do not have sufficient power to represent the population. No statistically significant results were found. Looking at the trends in the data, implementing alarm integration showed the indications of reducing reaction time to alarms, decreasing or matching the amount of time spent with the patient monitor, and equivalent amounts of time dedicated to patient treatment when compared to the non-integrated scenario.

The feedback obtained from the subjects provided a list of perceived benefits, drawbacks, and improvements related to the integration of medical device alarms into the intercommunication set.

Conclusions: Although the study was underpowered, the trends in the data indicate a benefit to the medics when integrating medical device alarms. When coupled with strongly favorable end-user feedback, the results provide justification for pursuing the effort of integrating alarms and performing future studies with improved integration systems to optimize the potential of the system.

USAARL-TECH-SR--2024-16. **Evaluation of a transparent seat back for motion capture of the thoracolumbar spine on the multi-axis ride simulator.** January 2024. AD1219902

By Ballard, M., Hasapes, S., Robinette, A., Stewart, A., Perkins, S. M., Prusia, M., Shumate, S., Madison, A., & Chancey, V. C.

Low back pain is a pervasive health problem in a range of military occupations. A knowledge gap exists regarding spinal movement in operational ride environments due to limitations in data collection caused by equipment impeding motion capture data collection. This involves the development and validation of a novel transparent seat back (TSB) for the USAARL multi-axis ride simulator to develop a standard methodology to quantify seated spinal motion response to whole-body vibration and jolt during simulated operational transport environments. The TSB was fabricated and affixed to the standard multi-axis ride simulator chair instead of the aluminum seat back. Volunteers were instrumented and asked to perform torso movements within all three planes. Vicon motion capture was used to observe visual distortions through the transparent seat back. Data were collected for a 35$^{th}$ percentile female and 95$^{th}$ percentile male, and x-, y-, and z-positional data were analyzed. Results indicate that the retroreflective

markers can be tracked regardless of TSB configuration with minimal error or distortion. The TSB will add to vibration research capabilities.

USAARL-TECH-TR--2024-17. **Medical standard considerations for the implementation of spatial audio in aviation.** January 2024.
AD1220918

By Noetzel, J., Henry, P., Stefanson, JR, & Jones, H. G.

As the Army advances its force modernization priorities, the development of Future Vertical Lift (FVL) aircraft has become an area of concentrated effort. Tremendous focus placed on extending the reach of current rotary-wing aircraft and operating over new terrains will allow completion of novel mission sets. Given the ambitions of FVL aircraft operations (i.e., high-altitude desert plateau and the urban canyons of megacities), it is imperative the aviator is provided with state-of-the-art technologies and capabilities aimed at increasing their situational awareness, enabling safe operations, optimizing crew performance, and reducing pilot fatigue. One potential solution is the implementation of spatial auditory display technologies (i.e., three-dimensional [3D] audio displays). Spatial auditory displays support a natural, ecologically valid, egocentric representation of space where auditory objects behave realistically in terms of direction, distance, and motion. The present report details the state of the science for spatial audio displays in aviation, considerations for medical standards and biomedical design criteria, an overview of current Department of Defense hearing standards, and highlights the various applications for which spatial audio could benefit the aviator.

USAARL-JAOA-PV--2024-18. **Continuous physiological monitoring of the combined exposure to hypoxia and high cognitive load in military personnel.** January 2024.
AD1226664

By Temme, L., Wittels, H., Wishon, M., St. Onge, P., McDonald, S., Hecocks, D., & Wittels, H.

The health and safety of military aviators is paramount during flight operations. In flight, aviators experience extreme environmental conditions such as high altitude, which reduces oxygen availability to the brain and compromises the function of all bodily systems. The ANS regulates many of the bodily systems, and therefore its function is a strong indicator of the physiological consequences to prolonged exposure to less oxygen. Importantly, aviators spend most of their flight time at less severe altitudes. However, even mild decrements in oxygen may elicit suboptimal function of the ANS, compromising aviator safety. What remains less clear is how the exposure to mild reductions in oxygen while simultaneously performing simulated flight tasks affects the ANS. The current study investigated this question by exposing aviators to varying levels of oxygen while carrying out simulated flight tasks. The aviators' ANS responses were measured throughout the nearly two hours of trials. Our study observed

heightened sympathetic nervous system activity (e.g., “fight or flight”) and found suggestions of increased anxiety. Lastly, we found that the timing and extent of the ANS responses differed between conditions. These observations highlight the importance of monitoring several markers of ANS function to avoid deteriorating aviator function when flying at mild altitudes.

USAARL-TECH-TR--2024-19. **Acoustic measurement of the Spike non-line of sight missile on an AH-64E aircraft.** February 2024.
AD1223601

Stefanson, JR, & Reeves, E.

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USAARL-TECH-TR--2024-20. **Evaluation of a novel wearable EEG/EOG sensor for real-time operator state monitoring.** March 2024.
AD1224548

By D'Alessandro, M., Yue, X., Mackie, R., Barnett, J., Baugher, K., Duffy, M., & Feltman, K.

Real-time monitoring of pilots' cognitive state using psychophysiological measurements is critical for aviation safety. However, current laboratory-grade EEG devices require extensive wired electrodes and setup, limiting feasibility for in-flight use. This study evaluated wireless prototypes consisting of a four channel EEG and two channel electrooculography (EOG) forehead sensor to assess their potential to monitor cognitive state during flight. The sensor utilizes flexible dry electrodes and minimal setup. Comparisons to laboratory EEG were done across varying workload tasks. However, signal contamination at 30 Hertz, potentially from hardware issues, prevented EEG data analysis. Enhanced durability is critical for unreliable environmental settings along with pre-deployment functionality checks. Despite current issues, the compact sensor shows promise if functioning reliably. Considerable further development and rigorous in-flight testing is required before adoption. With refinements ensuring robust data quality, the sensor concept holds promise for objectively monitoring hazardous states like excessive workload and fatigue in-flight. Once thoroughly validated for flight conditions, similar forehead prototypes may someday fill the pressing need for real-time mental state monitoring to enhance aviation safety.

USAARL-TECH-TR--2024-21. **The effects of simulated hearing loss on aviator performance and cognitive workload during simulated flight.** April 2024. AD1226623

By Jones, H., Noetzel, J., Henry, P., Hale, K., Andres, K., Mackie, R., Yue, X., McCormick, R., Lee, K., & Stefanson, JR

Hearing loss can render an aviator more susceptible to the adverse effects of degraded communication signals and consequently lead to an increased allocation of mental resources to the task of processing radio communications (referred to as listening effort). The current study investigated the impact of simulated hearing loss on functional hearing assessments, flight performance, and cognitive workload of military-trained rotary-wing pilots. Subjects underwent current standard clinical audiometric testing and performed simulated rotary-wing flights. Two listening conditions, normal hearing and one of two simulated hearing loss conditions, were tested. Clinical testing was conducted in a sound-treated audiometric booth using a tablet-based system and aviation communication earplugs. Simulated flight performance data were collected from pilots operating a full-motion UH-60 Black Hawk flight simulator at the U.S. Army Aeromedical Research Laboratory. Aviator performance was compared in high and low workloads across the different hearing conditions. Simulated hearing loss decreased all audiometric testing speech scores and decreased speech intelligibility in the flight simulator as well, indicating that the larger the hearing deficit, the more missed or incorrect calls subjects had on average. Findings from this study will be leveraged for developing future protocols for aeromedical standards and provide data for the development of operator state monitoring capabilities.

USAARL-TECH-TR--2024-22. **Army aviator hearing trends: 2016-2023.** April 2024. AD1226624

By Noetzel, J., Henry, P., Stefanson, JR, & Jones, H.

Two Army databases were used to determine the current prevalence and severity of hearing loss among Army aviators and to determine the degree to which waivers are issued for hearing function. Data pulled from the Defense Occupational Environmental Health Readiness System (DOEHRS) database across years 2016 and 2020 along with data pulled from the Aeromedical Electronic Resource Office (AERO) across 1 January 2020 to 11 December 2022 were compared to give an overall picture of the rates of hearing loss. The results of the DOEHRS analysis demonstrated a prevalence of hearing loss in the range of 790 aviators (6% of the aviator population). The results of the AERO analysis demonstrated that approximately 100 waivers are submitted each year, indicating that 1% of Army aviators have hearing loss outside of the standard identified in the Aeromedical Policy Letter. Aviators who fall outside of the standard were nearly always provided a waiver if they were already trained (upon entry) or, if the waiver was needed for continued service. Further research is needed to

determine the degree to which aviator performance is impacted by hearing loss that exists beyond the standard.

USAARL-TECH-TR--2024-23. **Rotary-wing airworthiness certification and evaluation of the Delta Development Team, Autonomous Portable Refrigeration Unit, Model 6L-2.** May 2024.
AD1227739

By Eshelman, R., Cupples, M. W., & Black, R.

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USAARL-TECH-TR--2024-24. **The United States Army Aeromedical Research Laboratory Virtual Reality Vection System.** May 2024.
AD1228334

By Nagy, R., & Temme, L.

The present report describes and documents the USAARL Virtual Reality Vection System (VRVS), a versatile, inexpensive tool to investigate, demonstrate, and characterize vection as a representative example of or type of spatial disorientation (SD). In aviation, SD refers to a pilot's failure to correctly sense the position, motion, and/or attitude of the aircraft with respect to the fixed coordinate system the Earth's surface and its gravitational vertical provide. That is, SD refers to the potentially catastrophic situation in which a pilot does not know where the aircraft is heading relative to the surface of the Earth. One example of SD is vection, which is the illusion of self-motion in an individual who is not moving. Since vection is a form of SD that can be reliably generated under controlled laboratory conditions, it is a convenient SD example for demonstrations as well as a powerful tool to study and characterize SD and its effects in general. The VRVS as described includes its components, software, hardware, and user interfaces. Tests and evaluations, conducted while creating the VRVS and reported here, demonstrate that the system does reliably provoke vection and thus SD. The VRVS includes two complementary methods for quantifying the presence and magnitude of vection. Moreover, the VRVS enables the simultaneous measurement of vection and symptoms of cybersickness, such as nausea.

USAARL-TECH-TR--2024-25. **Human Factors Analysis and Classification System as a potential confounder in Army aviation mishap analysis.** May 2024. AD1228336

By Curry, I., & Lee, A.

Introduction: The U.S. Department of Defense has utilized the Human Factors Analysis Classification System (HFACS) in its various iterations since 2004 to classify and codify the causation of military mishaps. The purpose of this study is to examine the likely accuracy of the HFACS coding of U.S. Army Aviation mishaps.

Methods: The U.S. Army Combat Readiness Center (CRC) database was queried for the years FY 2012-2022. The class A and B aviation mishaps were collated with their associated HFACS codes, and the mishap narratives were examined by an expert panel of senior mishap investigators, aviators, and aeromedical practitioners. The resultant disparities between the CRC coding and the assessed causative factors with special reference to SD were then examined.

Results: In the period under examination (FY 2012-2022) there were 184 class A and B helicopter mishaps recorded in the CRC database. Of those, 106 had HFACS version 7.0 codes assigned to them with 52 unique codes used. With specific reference to SD causation, only 3 of the 7 SD-related codes in HFACS version 7.0 were found to have been used; misinterpretation of instruments, misperception of changing environment, and SD. Combined, these amounted to 36 of the 537 codes used (6.7%). The expert analysis of the 106 mishaps coded showed 58 with no SD component (54.7%), 29 with SD as a contributory factor (27.4%), and 25 where SD was assessed as being causal (23.6%). By contrast, the HFACS coded SD causation in 4 of 106 (3.8%).

Discussion: The review of CRC codes versus expert opinion suggests that the coding does include elements that are very common in SD mishaps but without the final step to assign an SD code to a specific mishap. Thus, the information being presented to Army aviation senior leadership is providing at best an incomplete picture and at worst a significant distortion of mishap causation. This erroneous information may have significant implications for policy making and is particularly dangerous in view of the Future Vertical Lift program currently underway in the U.S. Department of Defense.

USAARL-JAOA-PV--2024-26. **Physiological fitness of U.S. general population (Reprint).** May 2024.
AD1228338

By D'Alessandro, M., Mackie, R., Wolf, S., McGhee, J. S., & Curry, I.


Introduction: U.S. Army aviators are required to maintain a level of physiological fitness as part of their qualifying process, which suggests that they are generally physically healthy. However, it has not been statistically proven that they are more “physiologically fit” than the general population.

Methods: This retrospective study compares physiological measurements of U.S. Army aviators from the Aeromedical Electronic Resource Office database to the U.S. general population using the Center for Disease Control’s National Health and Nutrition Examination Survey data. To enable an accurate comparison of physiological metrics between U.S. Army aviators and the U.S. general population, aviators were categorized into the same age groups and biological genders used for segmentation of the national population data.

Results: On average, pulse rate was 4.85 bpm lower in male aviators and 6.84 bpm lower in female aviators. Fasting glucose levels were, on average, 10.6 mg $dL^{-1}$ lower in aviators compared to the general population. Key metrics like pulse rate and fasting glucose were lower in aviators, indicating cardiovascular and metabolic advantages. However, parameters like cholesterol showed less consistent differences.

Discussion: While aviation physical demands and administrative policies selecting for elite physiological metrics produce improvements on some dimensions, a nuanced view accounting for the multitude of factors influencing an aviator’s physiological fitness is still warranted. Implementing targeted health monitoring and maintenance programs based on assessments conducted more frequently than the current annual flight physical may optimize aviator safety and performance over the course of a career.


USAARL-TECH-HB--2024-27. **A handbook for choosing the right gear for physiological monitoring.** May 2024.
AD1230695

By Warfighter Performance Group


This document is an abbreviated handbook to be used as a reference for individuals who do not have experience in physiological measurement. This handbook provides basic overviews of different types of physiological measurement available and some of the limitations of various products. The purpose is to help individuals be able to make informed decisions regarding some of the products available on the market.

USAARL-JAET-PV--2024-28. **Transcranial direct current stimulation and aviator performance during simulated flight (Reprint).** May 2024.
AD1230696

By Feltman, K., & Kelley, A.

Introduction: tDCS is a promising method for maintaining cognitive performance. Anticipated changes in rotary-wing aircraft are expected to alter aviator performance.

Methods: A single-blind, randomized, sham-controlled study evaluated effects of 2 mA anodal tDCS to the right posterior parietal cortex on aviator performance within a Black Hawk simulator. A mixed design with one between-subjects factor was assessed: stimulation prior to flight (20 constant minutes) and during flight (two timepoints for 10 minutes each). The within-subjects factor included active vs. sham stimulation. Randomly assigned to each stimulation group were 22 aviators. Aircraft state metrics derived from the simulator were used to evaluate performance. Subjects completed two flights (active stimulation and sham stimulation) with an in-flight emergency introduced at the end to assess whether the timing of tDCS application (prior or during flight) affected the ability to maintain attention and respond to an unexpected event.

Results: Results found active stimulation during flight produced statistically significant improvements in performance during the approach following the in-flight emergency. Subjects maintained a more precise approach path with glideslope values closer to zero ($M$ = 0.05) compared to the prior-to-flight group ($M$ = 0.15). The same was found for localizer values (during flight, $M$ = 0.07; prior to flight, $M$ = 0.17). There were no statistically significant differences between groups on secondary outcome measures.

Discussion: These findings suggest stimulation during flight may assist in maintaining cognitive resources necessary to respond to an unexpected in-flight emergency. Moreover, blinding efficacy was supported with 32% of subjects correctly guessing when active stimulation was being delivered (52% correctly guessed the sham condition).

USAARL-TECH-SR--2024-29. **Considerations and approaches for the development of a post-mortem human subject model for human response to whole-body vibration during supine dynamic casualty transport.** May 2024.
AD1230697

By Barazanji, K., Madison, A., Kinsler, R., Rahmatalla, S., Hasapes, S., Rhodes, D., Johnson, B., Conti, M., & Chancey, V. C.

USAARL-JAOA-PV--2024-30. **Examining the influence of cognitive load and environmental conditions on autonomic nervous system response in military aircrew: A hypoxia-normoxia study (Reprint).** May 2024.
AD1230698

By Wittels, H., Wittels, H., Wishon, M., Vogl, J., St. Onge, P., McDonald, S., & Temme, L.

> The health and safety of military aviators is paramount during flight operations. In flight, aviators experience extreme environmental conditions such as high altitude, which reduces oxygen availability to the brain and compromises the function of all bodily systems. The ANS regulates many of the bodily systems, and therefore its function is a strong indicator of the physiological consequences to prolonged exposure to less oxygen. Importantly, aviators spend most of their flight time at less severe altitudes. However, even mild decrements in oxygen may elicit suboptimal function of the ANS, compromising aviator safety. What remains less clear is how the exposure to mild reductions in oxygen while simultaneously performing simulated flight tasks affects the ANS. The current study investigated this question by exposing aviators to varying levels of oxygen while carrying out simulated flight tasks. The aviators' ANS responses were measured throughout the nearly two hours of trials. Our study observed heightened sympathetic nervous system activity (e.g., "fight or flight") and found suggestions of increased anxiety. Lastly, we found that the timing and extent of the ANS responses differed between conditions. These observations highlight the importance of monitoring several markers of ANS function to avoid deteriorating aviator function when flying at mild altitudes.

USAARL-TECH-FR--2023-31. **Recommendations for the development of a spine conditioning and resiliency program for the prevention, management, and mitigation of spinal disorders in U.S. Army rotary-wing aviators.** June 2024.
AD1302386

By Madison, A., Novotny, B., Pederson, T., Pascoe, N., Stewart, A., Barazanji, K., & Chancey, V. C.

> Spinal pain and injury are well documented in domestic and international military aviators, resulting in thousands of lost flight hours and aviator retention concerns. Spine-directed exercise training regimens have been identified and recommended for development by the North American Treaty Organization Human Factors and Medicine Research Task Group-252 (NATO HFM RTG-252) panel as effective prevention and treatment countermeasures for degenerative cervical and lumbar spine anomalies experienced by military aviators. Several fellow NATO HFM RTG-252 panel member nations have developed comprehensive aircrew conditioning programs (ACPs) with general physical fitness and neck-specific training components. However, these have been primarily developed for aviators in jet and high-performance aircraft operational

environments, with rotary-wing environment considerations and applications being secondary.

Aircraft vibration, helmet systems, and seat ergonomics differ between rotary-wing and fixed-wing environments, suggesting the need for a formalized and inclusive exercise regimen for U.S. Army rotary-wing aviators, which needs improvement.

USAARL reviewed published literature and data outcomes over the last 30 years from previous and ongoing neck and back exercise regimen studies, including fellow NATO panel members and U.S. Army approaches. The review also updated the knowledge regarding degenerative spinal mechanisms in military rotary-wing aviation operational environments. Additionally, updated epidemiological data were obtained regarding the incidence and prevalence of cervical and lumbar spinal disorders in the aviation population.

Based on literature review findings and NATO HFM RTG-252 panel recommendations, USAARL, in collaboration with clinicians at Carl R. Darnall Army Medical Center (CRDAMC) and Lyster Army Health Clinic (LAHC), has developed the framework for a detailed, multifaceted aircrew spine conditioning and resiliency program (ASCRP) intended for the prevention, management, and mitigation of both cervical and lumbar spinal disorders in U.S. Army rotary-wing aviators. The proposed ASCRP will include the following exercise strategies: strength and flexibility/mobility, activation, stabilization, and control, as well as strength and endurance components. The ASCRP is also designed to consist of home-based exercises, including a directed cervical spine resistance band intervention and operationally based exercises to be conducted pre-, during, and post-flight. Additionally, the regimen is unique in focusing on both cervical and lumbar spine disorders in rotary-wing aviators. Furthermore, the regimen can be executed as a standalone, standardized initiative or integrated into a multi-disciplinary holistic program that optimizes aviator health and performance.

Recommendations regarding the necessary steps and actions to transition the ASCRP into operational use in U.S. Army rotary-wing aviation units are provided. These interventions and exercises are initially recommended as best practices and will be downselected and finalized after validating the efficacy of the regimen.

USAARL-TECH-TR--2024-32. **Visual and optical survey of presbyopic Apache pilots.** June 2024.
AD1302387

By Trinh, T., Turovets, S., Wilkins, J., & Mackie, R.

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Research Laboratory (FCMR-UAC/Commander), Bldg 6901 Farrel Road, Fort Novosel, AL 36362

USAARL-TECH-FR--2024-33. **Effects of hypoxia and prolonged visually guided performance on dynamic stereoscopic depth tracking and related tasks.** July 2024.
AD1302464

By Temme, L., St. Onge, P., Bowers, B., Andres, K., McAtee, A., & Mackie, R.

Background: To maintain proper visual references, aviators depend on precise binocular depth perception technically called stereopsis. Defective stereopsis may degrade such aviation tasks as hover, taxiing, landing, formation flying, aerial refueling, and hoist and rescue operations. The increased prevalence of stereo displays in the cockpit creates the need for a better understanding of stereo vision in operational contexts.

Hypothesis: Conventional static stereo acuity tests that rely on static stimuli are poor predictors of the dynamic stereo acuity needed for the sustained performance of demanding, real-world visual tasks. Specific Aims: Track dynamic stereo acuity over 2-minute epochs sampled periodically during volunteers' sustained performance of surrogate operational tasks to compare dynamic stereo acuity with conventional static stereo acuity under normoxic and a sustained normobaric hypoxic (14% oxygen) emulation of 10,000 feet above mean sea level.

Study Design: A multivariate, balanced, 2-factor, within-subject randomized experiment with 24 subject volunteers.

Vision performance metrics include in addition to stereoscopic tracking, static stereo acuity, two-dimensional target tracking, and vertical and horizontal fusional ranges. Results showed normobaric hypoxia degraded dynamic stereoscopic but not static stereoscopic vision.

USAARL-TECH-HB--2024-34. **Choosing the right gear: A guide to physiological devices for monitoring operator states of aviators.** July 2024.
AD1302389

By Warfighter Performance Group

The abundance of physiological monitoring devices available and in development can be overwhelming. Thus, this guide was developed to provide decision makers and non-experts with a resource to assist them in understanding what these various devices are measuring, how those measurements tie into cognitive state, and what needs to be considered for using the devices in an operational setting. The focus here is on providing a basic understanding of what exactly each wearable measures. Some of the current states of individual technologies are discussed, but given the rapid pace of development in this area, less focus is

given to this. This guide focuses on measures that are being explored within the aviation domain. Please be aware that new measures are being sought by researchers, so the measures presented here are not exhaustive.

USAARL-TECH-TR--2024-35. **User evaluation of remote control monitoring in a simulated casualty evacuation transport environment.** July 2024.
AD1303904

By Lloyd, A., Kinsler, R., Kroening, L., Snyder, S., Buono, Z., & Sieling-Mondora, N.

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USAARL-CNPA-BC--2024-36. **Assessment of remote patient management system clinical monitoring in a ground simulation of an airborne casualty evacuation transport environment.** July 2024.
AD1306501

By Lloyd, A., Kinsler, R., Kroening, L., Snyder, S., Buono, Z., & Sieling-Mondora, N.

The Unmanned Aircraft Systems Medical Research Platform effort has the goal of developing a testbed system to support the study of remote control and monitoring of medical devices in flight environments. For this effort, the Telemedicine and Advanced Technology Research Center (TATRC) and USAARL have partnered to test medical devices in ground and flight environments. The Remote Patient Management System (RPMS), which includes the Thornhill Medical MOVES SLC patient monitor and ventilator, the NeuroWave AccuPump infusion pump, and the DocBox integration software, was tested. The RPMS underwent airworthiness release (AWR), ground, and flight testing. A limited end-user evaluation was also completed, where two flight surgeons were asked about the utility of the RPMS. Laboratory testing was completed on the RPMS, and a test AWR was granted. The RPMS was able to relay oxygen saturation data within an average 0.44% of the patient vital sign simulator and for non-invasive blood pressure it was accurate within 7.5%. However, the DocBox did not refresh the heart rate information, and showed a constant value for the testing. The participants found implementing treatments easy but found it difficult to know whether the patient received the intervention. The data will be used to identify key impacts to sensor, therapy, and communications functions that may impact the ability for the RPMS to perform adequately.

USAARL-CNPA-BC--2024-37**. Methodology for developing realistic patient scenarios for research applications.** August 2024.
AD1306503

By Kroening, L., Snyder, S., Molles, J., Toelle, R., Kinsler, R., & Lloyd, A.

Introduction: The U.S. Army Aeromedical Research Laboratory's Enroute Care Group (ECG) Research Team has performed several research studies that require participants to provide care to simulated patients during data collection. These simulated patients must mimic human anthropometry, display injuries realistically, provide dynamic vital signs, respond to treatment, etc. ECG has developed a methodology for creating these patient scenarios to meet these requirements. Materials and Methods: Patient requirements are determined during early development of the research protocol, such as casualty evacuation category (urgent surgical, urgent, priority, or routine) and number of patients needed in each category. This decision is made with the input of a subject matter expert (SME), such as a critical care flight paramedic or flight surgeon, to determine realistic patient configurations in the medical evacuation platform being used. A data request form with detailed patient parameters is submitted to the Joint Trauma System (JTS) Department of Defense Trauma Registry. After receiving de-identified patient records from the JTS registry, the SME downselects the records, extracts the essential clinical information, then uses it as the basic structure for the simulated patients. The team then designs the scenarios (e.g., decompensation events, alarms, responses to interventions) using available technology that meets the study objectives and programs them into the patient simulator software. The treatment responses of the simulated patients are customized within the software for added realism. The simulated patients are moulaged with the injury patterns from the JTS record summary, and tactical combat casualty care (TCCC) cards are created for each patient. Participants review the TCCC cards just prior to the start of data collection and begin treatment based on the TCCC information, injuries presented, and the live vital signs displayed on patient monitors. Treatments given during data collection are input into the simulator program by research team members remotely monitoring the scene so that patients respond to the treatments in real-time. Results: The results are realistic, customizable patient scenarios grounded in real-world events suitable for enroute care research and provider training. Conclusion: Over several studies, ECG has iteratively developed a method for customizing patient scenarios, allowing for realistic training during data collection.

USAARL-JAOA-PV--2024-38. **Limitations associated with transcranial direct current stimulation for enhancement: Considerations of performance tradeoffs in active-duty Soldiers (Reprint).** August 2024.
AD1308106

By Duffy, M. J., Feltman, K. A., Kelley, A. M., & Mackie, R.

tDCS is a non-invasive brain stimulation method, popular due to its low cost, ease-of-application, and portability. As such, it has gained traction in examining its potential for cognitive enhancement in a diverse range of populations, including active-duty military. However, current literature presents mixed results regarding its efficacy and limited evaluations of possible undesirable side effects (such as degradation of cognitive processes). To further examine its potential for enhancing cognition, a double-blind, randomized, sham-controlled, within-subjects design, was used to evaluate both online active-anodal and -cathodal stimulation on several cognitive tasks administered. Potential undesirable side effects related to mood, sleepiness, and cognitive performance, were also assessed. Active tDCS was applied for 30 minutes, using 2 mA, to the left dorsolateral prefrontal cortex with an extracephalic reference placed on the contralateral arm of 27 (14 males) active-duty Soldiers. We report mixed results. Specifically, we found improvements in sustained attention (active-anodal) for males in reaction time ($p$ = 0.024, $\eta p^2$ = 0.16) and for sensitivity index in females ($p$ = 0.013, $\eta p^2$ = 0.18).

USAARL-CNPA-BC--2024-39. **Preliminary field evaluation of assistive devices on carry distance and time during two-person litter transport scenarios.** August 2024.
AD1306504

By Stewart, A., Ballard, M., Robinette, A., Perkins, S. M., Prusia, M., Fjerstad, M., Watts, L., Oldham, R., Wagner, C., Arntzen, S., Brozoski, F., Barazanji, K., Madison, A. M., & Chancey, V. C.

Background: Evacuating casualties often relies on dismounted litter transport, a physically demanding task that can quickly drain a Soldier's grip strength. Assistive devices could shift the load to larger muscle groups, reducing muscle strain by distributing weight more evenly along the body. Previous USAARL laboratory-based research demonstrated assistive device use can allow simulated dismounted litter transport over farther distances in two-person assisted litter carries than four-person unassisted litter carries. As a follow-on effort to the laboratory-based simulated litter transport study, USAARL conducted a preliminary field-based study to evaluate assistive device use on litter bearer performance during two-person litter carries.

Methods: U.S. and Dutch Service Members (SMs) participating in the Army Expeditionary Warrior Experiment were recruited and enrolled. Subjects ($n$ = 12; 10 male, 2 female) were gender and height paired into six litter teams (two subjects per team) to complete carries around a 160-meter (m) long course.

Three litter carry conditions were tested: unassisted (UA), shoulder harness (SH) assisted, and wrist hooks (WH) assisted. Carry conditions were counterbalanced and separated by rest periods. Each attempt ended after 20 minutes (min) or upon releasing the litter due to fatigue of either subject. Total carry time and distance were measured and recorded at the end of the carry attempt.

Results: Average litter carries were 158.6 m and 2.36 min for UA, 1071.3 m and 15.8 min for SH, and 303.6 m and 4.34 min for WH. These two-person carries showed similar trends as the previous laboratory-based study: both assistive devices showed improvements during assisted carries over UA carries; however, only SH was statistically significant compared to the other carry conditions.

Conclusion: This study built on the previous laboratory-based study, showing litter carry distance and time can be increased with assistive devices like the SH and WH by more than 6.5 and 1.8 times, respectively, in two-person field litter carries. While these findings suggest assistive devices could benefit SMs, additional field testing and analyses are needed to fully evaluate the feasibility and practicality of the devices in operational settings through use of subjective, biomechanical, and physiological data. The next steps of this research aim to inform the development of solutions that reduce fatigue and ultimately enhance SM wellbeing and combat readiness.

USAARL-TECH-AR--2024-40. **U.S. Army Aeromedical Research Laboratory fiscal year 2023 annual historic report.** August 2024.
AD1306505

By Science Information Center

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USAARL-TECH-SR--2024-41. **Rotary-wing airworthiness certification and evaluation of the Vita Rescue System – Litter Attachment Block 1C+.** September 2024.
AD1308277

By Jones, S. D. & Lawson, C.

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USAARL-TECH-FR--2024-42. **Assessment of remote control monitoring in an airborne casualty evacuation transport environment.** September 2024.

By Lloyd, A., Kinsler, N., Kroening, L., Snyder, S., Buono, Z., & Sieling-Mondora, N.

## Technical Memorandums

2024-01. **Test results for the rotary-wing airworthiness certification evaluation of the ZOLL Medical Corporation, Propaq Configuration Management (4th edition system board and updated ECG board).** October 2023.

Delivered to: U.S. Army Medical Materiel Development Activity, Medical Modernization Product Management Office

Technical Point of Contact (POC): Robert Eshelman

2024-02. **Lot acceptance blunt impact evaluation of Head Gear Unit Number 56 Personal rotary-wing helmets (size small).** December 2023.

Delivered to: Gentex Corporation

Technical POC: Katie Logsdon

2024-03. **Airworthiness certification evaluation of patient movement items on UH-60V aircraft.** February 2024.

Delivered to: U.S. Army Medical Materiel Development Activity, Medical Modernization Product Management Office

Technical POC: David Jones

2024-04. **Test results for the SKEDKO Rapid Extraction Sked and the SKEDKO Rapid Extraction Sked Low Profile.** February 2024.

Delivered to: U.S. Army Medical Materiel Development Activity

Technical POC: David Jones

2024-05. **Test results for the airworthiness test and evaluation of training manikins.** February 2024.

Delivered to: Department of Aviation Medicine

Technical POC: David Jones

2024-06. **Physiological Findings for the V6.5 Human Factors Evaluation Event #2, 4-15 December 2023.** February 2024.

Delivered to: U.S. Army Development Command Aviation and Missiles Center Systems Readiness Directorate

Technical POC: Katie Feltman

2024-07. **Test results for the airworthiness certification and evaluation of the RINI Technologies Expeditionary Refrigerator (xFridge).** June 2024.

Delivered to: U.S. Marine Corps Systems Command, Product Manager, Combat Service Support Equipment

Technical POC: Robert Eshelman

2024-08. **Test results for the airworthiness certification and evaluation of the RINI Technologies Expeditionary Freezer (xFreezer).** June 2024.

Delivered to: U.S. Marine Corps Systems Command, Product Manager, Combat Service Support Equipment

Technical POC: Robert Eshelman

2024-09. **Assessment of remote control monitoring in an airborne casualty evacuation transport environment.** July 2024.

Delivered to: U.S. Army Telemedicine & Advanced Technology Research Center

Technical POC: Amy Lloyd

2024-10. **Test results for the Infrascan Incorporated, Infrascanner Model 2500.** August 2024.

Delivered to: Warfighter Readiness, Performance and Brain Health Project Management Office

Technical POC: Robert Eshelman

2024-11. **Test results for United States Special Operations Command, Med-Eng Holdings ULC, BEMO Sensor.** August 2024.

Delivered to: United States Special Operations Command, Program Manager, Protection & Integration, Tactical Combat Casualty Care Program

Technical POC: Robert Eshelman

2024-12. **Test results for United States Special Operations Command, BlackBox Biometrics B3 GEN 7 Flex Sensors.** August 2024.

Delivered to: United States Special Operations Command, Program Manager, Protection & Integration, Tactical Combat Casualty Care Program

Technical POC: Robert Eshelman

2024-13. **Test results for the SKEDCO Rapid Extraction Sked (Low Profile).** August 2024.

Delivered to: United States Army Medical Materiel Development Activity, Product Manager

Technical POC: Robert Eshelman

## Oral Presentations

Aura, C., Feltman, K., Duffy, M., Yue, X., & Persson, I. (2024). *Evaluation the impact of cueing modality and sensitivity on pupil diameter and eye movement during simulated rotary-wing flight* [Oral presentation]. Military Health System Research Symposium, Kissimmee, FL.

Baus, J., Rooks, T., Tharion, W., Hoyt, W., French-Krahn, H., & Yang, J. (2023). *Inverse kinematics analysis based on parachute jumpers' inertial measurement units (IMUs) data* [Oral presentation]. SAFE Association Symposium, Virginia Beach, VA.

Baus, J., Rooks, T., Tharion, W., Hoyt, W., French-Krahn, H., & Yang, J. (2023). *Musculoskeletal model-based neck generalized force estimation during parachute opening shock with and without a bundle* [Oral presentation]. SAFE Association Symposium, Virginia Beach, VA.

Berthelson, P., McMahon, J., Stotka, A., McEntire, B., & Salzar, R. (2024). *Liver injuries in porcine due to behind armor blunt trauma* [Oral presentation]. Summer Biomechanics, Bioengineering, and Biotransport Conference, Lake Geneva, WI.

Brozoski, F. T., & Chancey, V. C. (2024). *U.S. Army Aeromedical Research Laboratory behind armor blunt trauma research overview: Development of injury-based criteria for future helmet designs* [Oral presentation]. Blast and Conflict Injury Conference – 2024, London, UK.

Brozoski, F., Dudek, J., Chancey, V. C., Conti, M., & Crowley, J. (2024). *Direct combat-related U.S. Army aviation injuries 2003-2014* [Oral presentation]. Aerospace Medical Association Annual Meeting, Chicago, IL.

Brozoski, F., Ganz, G., & Crowley, J. (2024). *Combat-related direct injury trends in U.S. Army aviators during Operations Enduring and Iraqi Freedom: Historical trends* [Oral presentation]. Military Health System Research Symposium, Kissimmee, FL.

Crowley, J. (2024). *What's new in vertical flight technology: Implications for aviation medicine professionals* [Oral presentation]. Ramstein Aerospace Medicine Summit/North Atlantic Treaty Organization (RAMS/NATO) Science & Technology Organization (STO) Technical Course 2024, Garmisch, Germany.

Crowley, J., & McGhee, J. (2023). Selective serotonin reuptake inhibitor (*SSRI) use in U.S. Army aviators 2017-2021* [Oral presentation]. International Congress of Aviation and Space Medicine, Abu Dhabi.

Curry, I., & Duffy, M. (2024). *HFACS as a potential confounder in Army aviation mishap analysis* [Oral presentation]. Military Health System Research Symposium, Kissimmee, FL.

Curry, I., & Gaydos, S. (2024). *High-speed tilt-rotor terrain flight, assessment of night vision goggles* [Oral presentation]. Aerospace Medical Association Annual Meeting, Chicago, IL.

Feltman, K., & Kelley, A. (2024). *Evaluation of helicopter performance indicators for use in development of digital twin based on physiological sensor data from the aviator* [Oral presentation]. Applied Human Factors and Ergonomics, Nice, France.

French-Krahn, H., Johnson, B., & Rooks, T. (2023). *Immediate musculoskeletal effects of increased all-up weight in military tethered tandem bundle operations* [Oral presentation]. SAFE Association Symposium, Virginia Beach, VA.

French Krahn, H. A., Johnson, B., A., & Rooks, T. F. (2024). *Parachute health hazard effects: Military tethered tandem bundle operations* [Oral presentation]. Aerospace Medical Association Annual Meeting, Chicago, IL.

Hughes, C., Clark, J., Rupert, A., Scheuring, R., & Wood, S. (2024). *Lessons learned for sustained microgravity exposure preceding extravehicular activities on lunar surface operations* [Oral presentation]. Bárány Society Meeting 2024, Uppswala, Sweden.

Jones, H. (2024). *Validating auditory damage risk criteria for blast exposure using a noise dose escalation approach* [Oral presentation]. Blast and Conflict Injury Conference, London, UK.

Kinsler, R. (2024). *En route care research at the U.S. Army Aeromedical Research Laboratory* [Oral presentation]. Joint Trauma System Committee on EnRoute Combat Casualty Care, San Antonio, TX.

Kinsler, R. (2024). *Novel method for evaluation of the effects of rotary wing transport on a large animal polytrauma model* [Oral presentation]. Military Health System Research Symposium, Kissimmee, FL.

Lloyd, A., Kinsler, R., Kroening, L., Snyder, S., Buono, Z., & Sieling-Mondora, N. (2024). *Assessment of a remote patient management system clinical monitoring in a ground simulation of an airborne casualty evacuation transport environment* [Oral presentation]. Military Health System Research Symposium, Kissimmee, FL.

Mackie, R., D'Alessandro, M., Berger, T., Ott, C., Sullivan, C., & Curry, I. (2024). *Assessing reliability and validity of real-time neurophysiological indices and subjective ratings for monitoring of pilot cognitive engagement* [Oral presentation]. Human Center of Gravity Meeting, Fort Novosel, AL.

Madison, A. M., Ballard, M., & Chancey, V. C. (2023). USAARL: *Human performance research data collection and analysis capabilities* [Oral presentation]. Aviation Human Performance Working Group.

Madison, A. M., Brozoski, F. T., McEntire, B. J., & Chancey, V. C. (2024). *USAARL HSM research program overview: Development of injury and performance guidance for military populations* [Oral presentation]. Blast and Conflict Injury Conference, London, UK.

McEntire, B. J. (2024). *Medical-behind armor blunt trauma research program* [Oral presentation]. Blast and Conflict Injury Conference, London, UK.

McGovern, S., Olszko, A., Abraczinskas, A., Beltran, C., Vasquez, K., & Chancey, V. C. (2024). *Methodology for matching legacy accelerative exposures across multiple subject types* [Oral presentation]. Aerospace Medical Association Annual Meeting, Chicago, IL.

Noetzel, J. (2024). *Research efforts overview from the U.S. Army Aeromedical Research Laboratory* [Oral presentation]. Collaborative Auditory & Vestibular Research Network, Virtual.

Op ‘t Eynde, J., Shah, A., McMahon, A., Pang, D. Salzar, R., Bass, C., Yoganandan, N., & McEntire, B. J. (2023). *Elucidating behind armor blunt trauma injury risks, risk curves, and injury criteria using cadaver and animal surrogates* [Oral presentation]. SAFE Association Symposium, Virginia Beach, VA.

Op 't Eynde, J., Shah., A., McMahon, J., Stemper, B., Yogananadan, N., Salzar, R., McEntire, J., & Bass, C. (2024). *Structural scaling between human and swine cadaver for behind armor blunt trauma injury criteria* [Oral presentation]. Military Health System Research Symposium, Kissimmee, FL.

Op 't Eynde, J., Yoganandan, N., McEntire, B. J., & Bass, C. R. (2024). *Unexpected source of BABT lung injury* [Oral presentation]. Blast and Conflict Injury Conference, London, UK.

Ranes, B., Wilkins, J., Kenser, E., & Caid-Loos, M. (2024). *Measuring trust in automation (TIA) in operational aviation settings: Findings and recommendations from the existing literature* [Oral presentation]. Human Center of Gravity Meeting, Fort Novosel, AL.

Rhodes, D., Johnson, B., Logsdon, K., Brozoski, F., & Chancey, V. C. (2024). *Outcome comparison of laboratory-induced and operationally occurring spinal injuries in rotary-wing mishaps* [Oral presentation]. Aerospace Medical Association Annual Meeting, Chicago, IL.

Rhodes, D., Logsdon, K., & McEntire, B. J. (2024). *Assessment of the currently available female anthropomorphic testing devices for use in dynamic testing for military crashworthiness: Anthropometry and body mass distribution* [Oral presentation]. Biomechanical Engineering and Anthropometry Meeting, Fairborn, OH.

Rhodes, D., & McEntire, B. J. (2023). *Critical review of anthropomorphic testing device anthropometry, body mass distribution, and injury risk assessment for use in the military environment* [Oral presentation]. SAFE Association Symposium, Virginia Beach, VA.

Rhodes, D., & McEntire, B. J. (2023). *Critical review of injury assessment reference value applications in the military environment* [Oral presentation]. SAFE Association Symposium, Virginia Beach, VA.

Rooks, T., French-Krahn, H., & Johnson, B. (2023). *Novel use of inertial measurement units to capture motion during military tethered tandem bundle operations* [Oral presentation]. SAFE Association Symposium, Virginia Beach, VA.

Rooks, T. F., French Krahn, H., McGovern, S. M., Johnson B. (2024). *Tandem system heavy parachute operations health hazards study update* [Oral presentation]. Joint Military Free Fall Working Group, Virtual.

Rupert, A. (2024). *A vector analysis of acceleration events resulting in somatogravic illusions* [Oral presentation]. Aerospace Medical Association Annual Meeting, Chicago, IL.

Rupert, A. (2024). *Future medical screening tests for spatial disorientation* [Oral presentation]. Human Center of Gravity Meeting, Fort Novosel, AL.

Rupert, A. (2024). *Multisensory cueing* [Oral presentation]. Capability Days 2024, Fort Detrick, MD.

Rupert, A., & Sullivan, C. (2024). *Multisensory cueing to reduce spatial disorientation in degraded visual environments (DVE)* [Oral presentation]. DVE Summit, Huntsville, AL.

Salzar, R., Berthelson, P., McMahon, J., Gatesman, J., Stotka, A., & McEntire, B. J. (2024). *Factors to consider when selecting an animal model* [Oral presentation]. Blast and Conflict Injury Conference, London, UK.

Stewart, A. S., Ballard, M. T., Robinette, A. M., Perkins, S. M., Prusia, M., Fjerstad, M., Watts, L., Oldham, R., Wagner, C., Arntzen, S., Brozoski, F., Barazanji, K., Madison, A. M., & Chancey, V. C. (2024). *Preliminary field evaluation of assistive devices on carry distance and time during two-person litter transport scenarios* [Oral presentation]. Military Health System Research Symposium, Kissimmee, FL.

Stotka, A., McMahon, J., Berthelson, P., Burke, H., Tufts, R., Panzer, M., McEntire, B. J., & Salzar, R. (2024). *Analyzing deep tissue contusions resulting from behind armor blunt trauma* [Oral presentation]. International Research Council on Biomechanics of Injury, Stockholm, Sweden.

Stotka, A., McMahon, J., Berthelson, P., Burke, H., Tufts, R., Panzer, M., McEntire, B. J., & Salzar, R. (2024). *Characterization of deep tissue contusions from behind armor blunt trauma* [Oral presentation]. Military Health System Research Symposium, Kissimmee, FL.

Temme, L. (2024). *Metrology of VR vection* [Oral presentation]. Human Center of Gravity Meeting, Fort Novosel, AL.

Temme, L., St. Onge, P., Bowers, B., Andres, K., & Mackie, R. (2024). *Hypoxia and extended time on task: Effects on dynamic stereoscopic depth tracking* [Oral presentation]. Aerospace Medical Association Annual Meeting, Chicago, IL.

Temme, L., St. Onge, P., Bowers, B., Andres, K., McAtee, A., Mackie, R., & Wittels, H. (2024). *Effects of hypoxia and extended time on task on dynamic stereoscopic depth tracking and related tasks* [Oral presentation]. Military Health System Research Symposium, Kissimmee, FL.

Trinh, T. (2024). *Congenital simple hamartoma of the retinal pigment epithelium in an Army aviator* [Oral presentation]. Aerospace Medical Association Annual Meeting, Chicago, IL.

Willet, J., Rhodes, D., & McEntire, B. J. (2023). *Critical review of civilian and military rotorcraft crashworthy seat standards and crash protection* [Oral presentation]. SAFE Association Symposium, Virginia Beach, VA.

Yoganandan, N., Bass, C., Salzar, R., Chancey, V. C., & McEntire, B. J. (2024). *BABT lung injury criteria* [Oral presentation]. Blast and Conflict Injury Conference, London, UK.

Yoganandan, N., Bass, C., Salzar, R., McEntire, B. J., & Chancey, V. C. (2024). *Review of impact systems to develop generalized injury risk curves related to behind armor blunt trauma* [Oral presentation]. Military Health System Research Symposium, Kissimmee, FL.

Yoganandan, N., Shah, A., Koser, J., Somberg, L., Stemper, B., Chancey, V. C., & McEntire, B. J. (2024). *Lung injury risk curves from behind armor blunt trauma using a live swine model* [Oral presentation]. Military Health System Research Symposium, Kissimmee, FL.

Yoganandan, N., Shah, A., Koser, J., Stemper, B., Somberg, L., Chancey, V. C., & McEntire, B. J. (2024). *Lung injury criterion for behind armor blunt trauma using live swine tests* [Oral presentation]. International Research Council on Biomechanics of Injury, Stockholm, Sweden.

Yoganandan, N., Somasundaram, K., Devaraj, K., Harinathan, B., Shah, A., Koser, J., Stemper, B., Somberg, L., Chancey, V. C., & McEntire, B. J. (2024). *Role of indenter design on lung and liver impact kinematics and injuries in behind armor blunt trauma* [Oral presentation]. International Research Council on Biomechanics of Injury, Stockholm, Sweden.

Yue, X. (2024). *A framework for real-time flight performance assessment* [Oral presentation]. Human Center of Gravity Meeting, Fort Novosel, AL.

## Poster Presentations

D'Alessandro, M., Mackie, R., Duffy, M., Aura, C., & Feltman, K. (2024). *Evaluating aviators' situational awareness and workload using physiological metrics* [Poster presentation]. Military Health System Research Symposium, Kissimmee, FL.

D'Alessandro, M., Mackie, R., Wolf, S., McGhee, J., & Curry, I. (2024). *Physiological fitness of U.S. Army aviators compared to the U.S. general population* [Poster presentation]. Aerospace Medical Association 94th Annual Scientific Meeting, Chicago, IL.

Duffy, M., Mackie, R., Kelley, A., & Rooks, T. (2024). *Evaluation of environmental sensors in Combatives Master Trainer Course: Correlating head impact kinematics and vestibular sensory performance* [Poster presentation]. Military Health System Research Symposium, Kissimmee, FL.

Evangelista, C., Trinh, T., Harris, J., Capo-Aponte, J., Kohler, D., Mackie, R., Turovets, S., & Aden J. (2024). *Comparing visual outcomes of SMILE, PRK, and LASIK procedures in the military population* [Poster presentation]. Military Health System Research Symposium, Kissimmee, FL.

Feltman, K., Mackie, R., & Basso, J. (2024). *The effects of individual differences and tDCS on aviation task performance* [Poster presentation]. Military Health System Research Symposium, Kissimmee, FL.

Kroening, L., Snyder, S., Molles, J., Toelle, R., Kinsler, R., & Lloyd, A. (2024). *Methodology for developing realistic patient scenarios for research applications* [Poster presentation]. Military Health System Research Symposium, Kissimmee, FL.

Jones, H., Hale, K., Lee, K., Henry, P., Stefanson, JR, Mackie, R., & Noetzel, J. (2023). *The effects of simulated hearing loss on aviator performance and cognitive workload during simulated flight* [Poster presentation]. Acoustical Society of America, Sydney, Australia.

Logsdon, K., Daniel, R., McGovern, S., Rooks, T., Fralish, V., Gomez, J., Hasapes, S., Chancey, V. C., & Brozoski, F. (2024). *Evaluation of skull fracture risk associated with helmet back-face deformation* [Poster presentation]. Military Health System Research Symposium, Kissimmee, FL.

Madison, A., Pascoe, N., Pederson, T., Barazanji, K., Ballard, M., & Barazanji, K. (2024). *Development of a U.S. Army ASCRP for military rotary-wing populations* [Poster presentation]. Military Health System Research Symposium, Kissimmee, FL.

McGovern, S., Olszko, A., Abraczinskas, A., Beltran, C., Vasquez, K., & Chancey, V. C. (2024). *Methodology for matching legacy accelerative exposures across multiple subject types* [Poster Presentation]. Aerospace Medical Association 94th Annual Scientific Meeting, Chicago, IL.

McMahon, J., Berthelson, P. R., Stotka, A., McEntire, B. J., & Salzar, R. (2024). *In vivo pulmonary and thoracic wall injury risk from behind armor blunt trauma* [Poster presentation]. Summer Biomechanics, Bioengineering, and Biotransport Conference, Lake Geneva, WI.

Ranes, B., Wilkins, J., Kenser, E., & Caid-Loos, M. (2024). *Measuring trust in automation in aeromedical settings: A systematic literature review* [Poster presentation]. Military Health System Research Symposium, Kissimmee, FL.

Sieling-Mondora, N., Buono, Z., Fisher, N., Lloyd, A., Kinsler, R., & Kroening, L. (2024). *Evaluating autonomous and remote management strategies for enhanced casualty care* [Poster presentation]. Military Health System Research Symposium, Kissimmee, FL.

Snyder, S. & Kroening, L. (2024). *Critical care flight paramedic medical evacuation in the Arctic* [Poster presentation]. Military Health System Research Symposium, Kissimmee, FL.

Snyder, S., & Kroening, L. (2024). *Suitability of Army ambulance medical equipment sets & consumable supplies for Arctic operations* [Poster presentation]. Aerospace Medical Association 94th Annual Scientific Meeting, Chicago, IL.

Temme, L., Nagy, R., & Persson, I. (2024). *Vection measured during the 2023 MHSRS* [Poster presentation]. Military Health System Research Symposium, Kissimmee, FL.

Vogl, J., McCurry, C., Bommer, S., & Temme, L. (2024). *A validation of task demand level training procedures implemented in the United States Army Aeromedical Research Laboratory multi-attribute task battery* [Poster presentation]. Aerospace Medical Association (AsMA) 94th Annual Scientific Meeting, Chicago, IL.

Wolf, S., Persson, I., Mackie, R., Kelley, A. M. (2024). *Evaluation of cognitive enhancement effects of donepezil in military rotary-wing aviation* [Poster presentation]. Aerospace Medical Association 94th Annual Scientific Meeting, Chicago, IL.

Wittels, H., Wishon, M., Davilla, H., Lee, S., McDonald, S., Temme, L., & Wittels, H. (2024). *Autonomic nervous system response while executing specific aviation combat drills in the UH-60 helicopter* [Poster presentation]. Military Health System Research Symposium, Kissimmee, FL.

Wittels, H., Wishon, M., Davilla, H., Lee, S., McDonald, S., Temme, L., & Wittels, H. (2024). *Core body temperature elevation in Army aviators during in-flight combat*

*exercise training* [Poster presentation]. Military Health System Research Symposium, Kissimmee, FL.

Wittels, H., Wishon, M., Davilla, H., Lee, S., McDonald, S., Temme, L., & Wittels, H. (2024). *Effects of mild continuous normobaric hypoxia and high cognitive load on autonomic nervous system function in military aircrew* [Poster presentation]. Military Health System Research Symposium, Kissimmee, FL.

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