Objective: Design and develop computational models to understand and analyze acute and chronic neck pain for combat air vehicle pilots and occupants taking into consideration the interaction between seating systems, posture, and body-borne equipment and the generation of neck pain. Included in this effort is the requirement to develop an aircrew specific neck pain scale.

Description: Pilots and crew of combat air vehicles, including fixed-wing attack, fighter, and rotary-wing aircraft, can be exposed to inertial and task position stressors that generate pain. Repeated painful exposures with or without tissue damage are precursors to pain sensitization and chronic pain. Chronic pain leads to reduced operational readiness and long-term medical treatment. In his 25 SEPT 2017 letter, VADM Shoemaker called for "research to better understand, prevent and treat the musculoskeletal consequences of helicopter service." The Navy needs a means of protection to minimize the development of chronic neck pain while maintaining short duration, high onset acceleration protection afforded by ejection and crashworthy seating. Equally important, though less well understood, is the contribution of long-duration, static/quasi-static loading to chronic pain development. Current seating systems designed to be a 'one-size-fits-all' with minimal adjustability were intended for short and moderate duration exposures. Aircraft seating systems encompass a range of seat back angles from 0 degrees (vertical) to 17 degrees pitched back and seat pan angles from 0 degrees (horizontal) to 12 degrees pitched-up. Seated postures vary ranging from long periods holding the same position while visually scanning the area or instruments through turning to look over their shoulders (“check six” position). All the while, aircrew are restrained in their seats for missions as long as 12 hours and must be able to reach switches and controls overhead, behind, to the side, and in front of them. Aircrews are often outfitted with performance enhancement devices that are mounted to the helmet, e.g., night vision devices, that increase the load and moment on the cervical spine.

An optimal protective approach would take into account variability of operator anthropometry; the physical, inertial loading exposures of air combat vehicles [Ref 3]; the task posture of the operator (often hunched forward with right elbow on the thigh); the relevant specific neck/spinal anatomy; head-support mass and its center of mass; and the mechanisms of pain associated with neck pain. The Navy has a strong need to analyze and quantify the influence of various mechanical stressors (vibration from 1 to 20 Hz, buffeting [Ref 3]) on pilot injury potential and to develop novel designs of occupant seating and restraint systems that reduce spinal injury and chronic pain risk to all aircrew sizes during routine and catastrophic events. Computational models and parametric simulations are required to determine potential contributors to acute and chronic operator neck pain and the specific pain mechanisms involved. Given the challenge of relating mechanical stresses to associated pain, it is suggested that proposers include a neurologist experienced working with pain patients as a consultant. Computational models should be structured such that recommendations toward improvements to seating (position, seat-back angle), helmet (weight and center of mass), and restraint systems (e.g., combined shoulder / lap belt), postures [Ref 6] and operational guidelines are possible. The models should also be able to determine the predicted design(s) efficacy.

Customized versions of rating scales/questionnaires for aircrew, such as an aircrew specific Neck Disability Index (NDI), would be helpful for healthcare providers who serve aviators in order to better and more quickly recognize complaints, identify the problem, and monitor the efficiency and effectiveness of treatment. Unfortunately, NDI does not include any occupation-related neck pain questions and under-reports the severity and disability of flying-related neck pain [Ref 1]. A customized version of a pain rating scale is required due to their occupational challenges in military environment and the need for operational readiness. Higher expectations and needs exist for military aviators with regard to medical fitness compared to civilian aviators due to the many extreme situations they may face, ranging from combat missions requiring helmets with night vision or cuing systems, high-G emergency handling to Survival, Evasion, Resistance, and Escape (SERE) situations.

Phase I: Design, develop, and determine the feasibility of using human biomechanical models to expose a simulated occupant to inertial and positional stressors, simulating the effect on the neck and onset of pain and predicting the spinal sensitization and pain time course. Develop a preliminary aircrew neck-pain scale. The Phase I effort will include plans to be developed under Phase II.

Phase II: Develop a human biomechanical model accounting for anthropometric variation of military population (5th to 95th
percentiles for height and weight), including gender-related factors. Include models of seating (geometry and cushions), restraints, cockpit geometry, and protective clothing / equipment; the target platform includes fast jet tactical aircraft (e.g., F/A-18). Validate the combined model against published data, including but not limited to the references listed below. Use the model to analyze existing operational procedures and propose improved operational guidelines. Validate the aircrew neck-pain scale. Develop a prototype of the most promising protective concept that provides adaptive seating, comfort and adjustability for the maximum range of anthropometric sizes. Conduct experimental testing and evaluation.

PHASE III DUAL-USE APPLICATIONS: Conduct operational unit evaluation of the prototype and implement necessary design changes. Re-evaluate the predicted performance based on implemented changes and revise the prototype based on results of evaluation until desired optimum protection is achieved.

In addition to operators of land and sea combat vehicles, operator neck pain is a problem in the commercial transportation field. Such a protective capability would be valuable in mitigating the development of pain and chronic neck pain for operators of commercial air, land and sea vehicles. Commercial shipping, air and trucking industries could all benefit from the developed technology.

REFERENCES:


KEYWORDS: Neck Pain; Human Modeling; Neck Pain Scale; Anthropometric Variants; Neck Pain Stressors; Adaptive Seating