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Cardiac Biosignal and Adaptation in Confined Nuclear Submarine Patrol

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Abstract : Isolated and confined environments (ICE) present several challenges which may adversely affect human’s psychology and physiology. Submariners in Sub-Surface Ballistic Nuclear (SSBN) mission exposed to these environmental constraints must be able to perform complex tasks as part of their normal duties, as well as during crisis periods when emergency actions are required or imminent. The operational and environmental constraints they face contribute to challenge human adaptability. The impact of such a constrained environment has yet to be explored. Establishing a knowledge framework is a determining factor, particularly in view of the next long space travels. Ensuring that the crews are maintained in optimal operational conditions is a real challenge because the success of the mission depends on them. This study focused on the evaluation of the impact of stress on mental health and sensory degradation of submariners during a mission on SSBN using cardiac biosignal (heart rate variability, HRV) clustering. This is a pragmatic exploratory study of a prospective cohort included 19 submariner volunteers. HRV was recorded at baseline to classify by clustering the submariners according to their stress level based on parasympathetic (Pa) activity. Impacts of high Pa (HPa) versus low Pa (LPa) level at baseline were assessed on emotional state and sensory perception (interoception and exteroception) as a cardiac biosignal during the patrol and at a recovery time one month after. Whatever the time, no significant difference was found in mental health between groups. There are significant differences in the interoceptive, exteroceptive and physiological functioning during the patrol and at recovery time. To sum up, compared to the LPa group, the HPa maintains a higher level in psychosensory functioning during the patrol and at recovery but exhibits a decrease in Pa level. The HPa group has less adaptable HRV characteristics, less unpredictability and flexibility of cardiac biosignals while the LPa group increases them during the patrol and at recovery time. This dissociation between psychosensory and physiological adaptation suggests two treatment modalities for ICE environments. To our best knowledge, our results are the first to highlight the impact of physiological differences in the HRV profile on the adaptability of submariners. Further studies are needed to evaluate the negative emotional and cognitive effects of ICEs based on the cardiac profile. Artificial intelligence offers a promising future for maintaining high level of operational conditions. These future perspectives will not only allow submariners to be better prepared, but also to design feasible countermeasures that will help support analog environments that bring us closer to a trip to Mars.

Keywords : adaptation, exteroception, HRV, ICE, interoception, SSBN
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