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ORIGINAL ARTICLE

Effect of Experience and Professional Role on Psychophysiological Stress Response in an Underwater Evacuation Training

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Abstract: *Background: This research aimed to analyze the effect of experience and professional role on psychophysiological stress response in underwater evacuation training. Methods: We analyzed 36 participants (39.06±9.01 years), divided into two different groups; 17 crew members (38.6±7.2 years) and 19 medical members (39.5±10.5 years). modifications in the rating of perceived exertion, subjective stress perception, heart rate, blood oxygen saturation, cortical arousal, heart rate variability, spirometry, isometric hand strength, and short-term memory before and after underwater evacuation training were analyzed. Results: The maneuver produced a significant increase in SSP, RPE, IHS, FVC, and SatO$_2$ at different moments of the intervention, being higher in crew members. Conclusions: We found that the underwater evacuation training produced an anticipatory anxiety response, and an increase in autonomous sympathetic nervous system modulation not affecting strength capacities, cortical arousal, and memory independently of the aircraft role (medical or crew).*

Keywords: *stress; underwater; military; aircrew; experience; role; cortical arousal; heart rate variability*

INTRODUCTION

Previous studies have shown how military combat situations are one of the most stressful events a human can cope with, due to their unpredictable, dangerousness, and highly demanding context [1]. Independently of the situation, military interventions produce the activation of the autonomic nervous system (ANS), initiating the flight-fight system involved in survival behaviors [2]. The stress produced by these extreme situations negatively impacts cognitive processes like memory, cortical arousal, decision-making, and information processing, reducing their normal functioning and even promoting the appearance of pathologies such as post-traumatic disorder (PTSD) [3-5].

Several types of research have been carried out in the military population, especially in ground military units, and the results show how an acute stress exposition can lead the organism to a downregulation in cortical arousal and high activation of the Sympathetic Nervous System (SNS), and finally modifying the blood pressure (BP), heart rate (HR), cortisol hormones, cortical arousal (CFFT), skin temperature, subjective stress perception (SSP), and heart rate variability (HRV) among others [6-10]. In this line, aircrews and paratroopers researchers have shown an increase in the physiological response by the increase in cortisol hormones, an increase in sympathetic modulation, and a decrease in cortical arousal, which is a symptom of Central Nervous System (CNS) fatigue [1,5,6,11-15].

Another factor that can negatively affect stress response is the possibility of having an aircraft accident [16]. The survival of the aircrew depends extremely on their knowledge of underwater evacuation training and stress management, and little is known about the physical and mental requirements of this specific and demanding situation, but as some researchers have demonstrated previously, the personal experience and professional training could modulate the stress experience and reduce the negative impact on the organism [2,4,11,13,15,17-18]. For this reason, we conducted the present research to analyze and compare the psychophysiological stress response of crew members (4 crew members; 4 jump chiefs; 9 paratroopers) and medical members (15 flight nurses and 4 doctors) in an underwater evacuation training. We hypothesized that 1) the underwater evacuation training would increase the sympathetic autonomic modulation of the crew members, and 2) crew members would present a lower stress response.

MATERIALS AND METHODS

In the present work were analyzed 36 participants (39.06±9.01 years), divided into two different groups; 17 crew members (38.6±7.2 years; 174.9±8.6 cm; 82.1±11.2 kg; 18.1±8.7 years of service; 14.9±13.4 months in mission; 357.9±366.9 flying hours) and 19 medical members (39.5±10.5 years; 173.6±6.14 cm; 71.4±10.5 kg; 15.5±9.99 years of service; 11.5±15.3 months in mission; 25.1±73.8 flying hours). The entire research procedure was conducted by soldiers with the standard flying suit and boots, portable oxygen cylinder, life vest, helmets, and earphones to simulate the equivalent operating equipment for this type of action. None of the participants had previous or recent experience in these underwater simulations.

A pre-intervention-post intervention was conducted, analyzing the following psychological and physiological variables previous to and immediately after an underwater evacuation training.

1. Rating of perceived exertion (RPE). Using Borg 6–20 scale [19];

2. Stress subjective perception (SSP) on a 1–100 scale [15];

3. Blood oxygen saturation ($SatO_2$) and heart rate (HR) by a finger pulse-oximeter system (PO 30 Beurer Medical) [6];

4. Cortical arousal and fatigue of the central nervous system (CNS) were measured by the Lafayette Instrument critical flicker fusion threshold (CFFT) (Model 12.021) by the average of five incremental tests (20 to 100 Hz) according to previous authors [5,16];

5. Isometric handgrip strength (IHS) by a grip dynamometer using the dominant hand and taking the better result of two attempts (Takei Kiki Koyo, Japan);

6. Spirometry: forced vital capacity (FVC), volume exhale at the end of the first second of forced expiration (FEV1) and the peak expiratory flow (PEF) using a QM-SP100 (Quirumed, Spain) spirometer in a maximum inhale-exhale cycle [5,16];

7. Short-term memory (STM). A three-digit number was shown to the participants for one second. After five seconds, they were asked to remember the number and to say it backward [16];

Finally, the heart rate (HR) and heart rate variability (HRV), which refers to the autonomic modulation, were recorded with a Polar V800 heart rate monitor with RR measurement function (POLAR. Finland) and posteriorly analyzed by the Kubios HRV standard 3.2.0 software (University of Kuopio, Kuopio, Finland). The parameters analyzed were:

1. Temporal domain: mean HR; minimum HR (Min HR); maximum HR (Max HR); the square root of the mean value of all sums of square differences of all R-Rs following intervals (RMSSD); the percentage of differences between normal adjacent R-R intervals greater than 50 ms (pNN50);

2. Frequency domain: low-frequency band (LF); high-frequency band (HF); A ratio of low frequency to high frequency (Ratio LF/HF);

3. Nonlinear domain: sensitivity of the short-term variability (SD1); sensitivity of the long-term variability (SD2).

The underwater evacuation training was performed in a swimming pool in the following conditions: 4 × 4 × 3 swimming pool size (m); water characteristic: chlorine 2 (ppm); pH 7.5; turbidity values 0.13 (NTU); temperature: 26°C. The complete training was performed in the presence of two instructors and two water assistants. It was composed of four different stages, with a duration of 30 minutes each one, where the participants had to: 1) use a portable oxygen cylinder and carry out apnea training in several positions; 2) evacuate the submerged aircraft accident through the window; 3) rescue training of a raft and rescue training from a helicopter; and finally 4) underwater evacuation during the turning of a ship.

Statistical analysis was performed with the SPSS 24.0 statistical program. The descriptive statistics used to report the results were the mean (M) ± standard deviation (SD). The normality of the sample was determined with the Kolmogorov-Smirnov test, and all the variables presented a parametric distribution. The repeated measures ANOVA was conducted to test differences in the evaluation moments analyzed. A T-test for independent variables was used to analyze differences between the two groups analyzed (crew and medical). The Effect Size was calculated by Cohen's D. The significance level was $P \leq 0.05$.

RESULTS

The results were reported as M ± SD. SSP showed a significant increase in post-values of both crew and medical members concerning the pre-values, being higher in crew members, but there were no significant differences in pre- or post-values between groups. RPE presented a significant difference in post values, being higher in crew members, and also showed a significant increase in post values of both groups in comparison with pre values. IHS showed a significant difference in pre-values between crew and medical responses, being higher in crew members. FVC showed only a significant increase in post values of crew members in comparison with pre-values of crew members. $SatO_2$ showed a significant difference in post values of crew and medical members, being higher in crew members (Table 1).

Table 1: Role comparison in pre-post variables

Variables	Role	Pre Intervention				Post Intervention			
		M±SD	Bilateral signification	95% confidence interval		M±SD	Bilateral signification	95% confidence interval	
			P	Inferior	Superior		P	Inferior	Superior
SSP	Crew member	16.2±20.9	0.142	-26.71	4.01	60.6±27.2 (0.000)	0.358	-9.70	26.14
	Medical member	27.5±24.1				52.4±25.2 (0.001)			
RPE	Crew member	6.7±1.5	0.075	-0.07	1.38	13.7±2.9 (0.000)	0.023	0.32	4.13
	Medical member	6.1±0.2				11.4±2.7 (0.000)			
IHS (N)	Crew member	50.9±11.4	0.026	1.17	17.24	50.4±10.7	0.084	-1.02	15.53
	Medical member	41.7±12.3				43.2±13.4			
FVC (ml)	Crew member	4.4±0.8	0.412	-0.48	1.13	4.8±0.9 (0.047)	0.374	-0.36	0.94
	Medical member	4.1±1.4				4.5±1.0			
FEV1 (ml)	Crew member	3.7±0.7	0.464	-0.47	1.00	3.8±0.7	0.956	-0.52	0.55
	Medical member	3.4±1.4				3.8±0.8			
PEF (ml)	Crew member	9.8±1.8	0.548	-1.31	2.42	9.8±1.9	0.705	-1.27	1.86
	Medical member	9.3±3.4				9.5±2.6			
$SatO_2$ (%)	Crew member	95.9±1.9	0.186	-2.01	0.41	97.1±2.4	0.040	0.08	3.30
	Medical member	96.7±1.7				95.4±2.4			
HR (bpm)	Crew member	81.5±14.2	0.701	-8.27	12.17	81.4±18.8	0.401	-7.15	17.44
	Medical member	79.6±15.8				76.3±17.5			
STM	Crew member	1.0±0.0	—	—	—	1.0±0.0	—	—	—
	Medical member	1.0±0.0				1.0±0.0			
CFFT (Hz)	Crew member	39.9±3.9	0.365	-1.34	3.55	38.1±3.5	0.840	-2.29	2.80
	Medical member	38.8±3.4				37.8±3.9			

1(M) mean; (SD) standard deviation; (SSP) stress subjective perception; (RPE) rating of perceived exertion; (IHS) isometric hand strength; (FVC; FEV1; PEF) spirometry; (SatO2) blood oxygen saturation; (HR) heart rate; (STM) short term memory; (CFFT) cortical arousal.

The mean HR of medical members presented the lowest value during the intervention and increased post-intervention, being higher than in crew members. Min HR presented similar values in both groups in pre- and during moments, but crew members' values were higher in post-intervention. Max HR of medical members was higher than crew members in all moments, during the intervention the highest. RMSSD presented similar values in both groups in the pre-moment; medical member values were higher during the intervention and decreased in post-intervention in comparison with crew members.

Variable pNN50 presented in both groups an increase during the intervention, being higher in medical members than in crew members, and decreasing in post-intervention in both groups. LF showed high values in all moments in medical members, being higher in pre-moment than post-intervention, and decreasing during the intervention. HF presented higher values in crew members than in medical members pre- and during the intervention, being the highest value during the intervention, and decreasing post-intervention in both groups. LF/HF Ratio showed higher values in medical members than in crew members in pre- and during the intervention, being the highest value in the pre-moment, while crew members presented higher values in post-intervention. SD1 presented similar values in pre-intervention in both groups, being higher during intervention in medical members than in crew members and decreasing in post-intervention in comparison with crew members.

SD2 presented higher values in all moments in medical members than in crew members, being the highest during the intervention and decreasing in both groups in post-intervention in comparison with pre-momentum (Table 2).

Table 2: Role comparison in pre-, during, and post-HRV variables

Variables	Role	Pre-intervention (1)				During intervention (2)				Post-intervention (3)				F	IC
		M±SD	BS	95 % confidence interval		M±SD	BS	95 % confidence interval		M±SD	BS	95 % confidence interval			
			P	Inferior	Superior		P	Inferior	Superior		P	Inferior	Superior		
Mean HR (bpm)	Crew member	84.9±10.6	0.179	-16.49	3.19	90.8±7.7	0.837	-8.08	6.59	97.4±13.8	0.919	-9.66	8.73	9.942	1<3;2<3;3>1<2
	Medical member	91.6±17.3				54.3±18.1				97.9±13.4				5.711	2<3; 3>2
Min HR (bpm)	Crew member	67.1±10.8	0.983	-8.67	8.48	54.9±13.9	0.906	-10.38	11.68	71.4±9.9	0.265	-3.45	12.15	13.639	1>2; 2<1<3; 3>2
	Medical member	67.2±14.1				54.3±18.1				67.1±12.8				5.637	1>2; 2<1>3; 3>2
Max HR (bpm)	Crew member	116.0±18.1	0.111	-36.68	3.95	165.2±25.1	0.351	-53.56	19.54	131.7±23.9	0.162	-42.48	7.41	24.432	1<2; 2>1<3; 3<2
	Medical member	132.4±37.4				182.2±70.1				149.2±45.2				4.710	1<2; 2>1
RMSSD (ms)	Crew member	33.1±19.2	0.989	-12.98	12.80	41.7±19.8	0.523	-15.34	7.95	36.8±24.2	0.743	-10.89	15.13	3.948	—
	Medical member	33.2±18.9				45.4±14.4				34.7±13.1				10.764	1<2; 2>1<3; 3<2
pNN50 (%)	Crew member	7.8±7.9	0.768	-4.27	5.74	8.1±5.3	0.051	-7.29	0.02	6.5±6.1	0.790	-4.07	3.12	1.102	—
	Medical member	7.1±6.9				11.7±5.5				6.9±4.4				15.047	1<2; 2>1>3; 3<2
LF (n.u)	Crew member	77.4±13.8	0.408	-11.19	4.65	72.6±11.1	0.756	-7.22	5.29	76.1±11.2	0.992	-6.98	6.91	1.081	—
	Medical member	80.6±9.5				73.5±7.2				76.2±9.3				4.296	1>2; 2<1
HF (n.u)	Crew member	22.6±13.7	0.409	-4.64	11.14	27.3±11.0	0.762	-5.28	7.15	23.7±11.1	0.990	-6.94	6.85	1.085	—
	Medical member	19.3±9.4				26.4±7.1				23.8±9.3				4.286	1<2; 2>1
LF/HF Ratio (ms^2)	Crew member	5.2±3.9	0.942	-2.32	2.16	3.4±2.4	0.888	-2.21	1.92	4.8±4.3	0.521	-1.61	3.11	3.028	—
	Medical member	5.3±2.7				3.6±3.5				4.0±2.5				2.730	—
SD1 (ms)	Crew member	23.4±13.6	0.969	-9.44	9.08	29.5±14.0	0.516	-10.96	5.61	26.1±17.2	0.751	-7.82	10.73	3.912	—
	Medical member	23.6±13.7				32.2±10.4				24.6±9.5				10.780	1<2; 2>1<3; 3<2
SD2 (ms)	Crew member	54.8±17.8	0.507	-20.23	10.19	58.5±13.1	0.138	-19.55	2.83	51.6±17.8	0.276	-19.56	5.76	1.768	—
	Medical member	59.8±25.9				66.9±19.0				58.5±19.4				5.168	2>3; 3<2

2(M) mean; (SD) standard deviation; (BS) bilateral signification; (IC) intermoment comparison; (Mean HR) mean heart rate; (Min HR) minimum heart rate; (Max HR) maximum heart rate; (RMSSD) square root of the mean of the sum of the squared differences between adjacent normal R-R intervals; (pNN50) percentage of differences between normal adjacent R-R intervals greater than 50 ms; (LF) low frequency; (HF) high frequency; (Ratio LF/HF) A ratio of low frequency to high frequency; (SD1; standards deviations of the scattergram 1; (SD2) standards deviations of the scattergram 2; (n.u) normalized unit.

DISCUSSION

This study aimed to analyze and compare the psychophysiological stress response of crew members (4 crew members, 4 jump chiefs, 9 paratroopers) and medical members (15 flight nurses and 4 doctors) in an Underwater Evacuation Training. Hypothesis 1) was confirmed since underwater evacuation training increased the sympathetic autonomic modulation of crew members. Hypothesis 2) was not confirmed, since the stress response was similar in both crew member and medical member groups, independently of the professional role.

The underwater evacuation training includes apnea periods, in which aircrew members have to deal with a lack of oxygen that produces a lower oxygen partial pressure in the alveolus and affects the oxygen that the arterial blood can deliver to the brain [20]. In both hypoxia and underwater training, the lack of oxygen impacts the RPE, although in underwater training SSP and SatO2 values are generally higher than those in hypoxia [3,21-24]. These results suggest that for underwater training, the exertion mechanism is produced by short acute periods of apnea instead of larger periods with progressively less oxygen partial pressure if compared to hypoxia training. IHS has also been previously studied in military aircrew with different results depending on the previous training and roles [3], which coincides with the pre-results of this study with aircrew members having more initial strength capacity than medical personnel. If we analyze the breath capacity, PEF, and FEV1 have traditionally been the most affected variables in contexts of sustained hypoxia as specific training in these conditions, special operation selection course, and maneuvers, or real flight conditions [1,3,14,15,26]. Whilst FVC was the most activated variable in underwater training: a constant need to store oxygen in the alveolus before an acute period of apnea activates the lunges to store more air as a physiological adaptation. Autonomic modulation has been previously evaluated in military aircrews by the HRV in contexts of hypoxia, finding an increased sympathetic autonomic modulation as expected, since the lack of oxygen acts as a stressor of the central nervous system [21,24,26,27]. Hypoxia symptoms have been previously studied in military crews through cortical arousal with different results: the decrease of oxygen saturation had a negative [27] or neutral [3] impact in cortex performance, which are similar results to those found in this study.

The underwater evacuation training simulates an extreme situation in which aircrew and medical members first try to survive. This fact could be the reason the post measures were not different for each group, since the responses in these extremely hazardous situations tend to be maximal and could equal the response in both groups. This large stress response independently of the role was also measured in different military units in combat maneuvers where, contrary to the present study, there were changes in respiratory musculature, memory, and cortical activation [2,28-30]. Medical members had less RPE and SatO2 after the training, maybe because of shorter periods of physical activity during some maneuvers. The most expected difference was found in the measures before the training, where the aircrew members were able to develop more strength capacity due to their previous training, more oriented to physical fitness.

Regarding the HRV analysis, we observed an increase in vagal tone (RMSSD, HF, HF/LF ratio, and SD2) of participants, a result probably due to the 2h training in the water and the possible induced hypothermia [31]. Increases in the HF values under these hypothermia conditions may reflect a reduced delay in baroreflex response, enabling lower resonant frequency in blood pressure and RR interval, which may be a consequence of temperature-mediated increase in peripheral sympathetic activity and myogenic reactivity due to increased vascular tone and transmural pressure caused by peripheral vasoconstriction to prevent heat dissipation [32]. LF/HF ratio is a controversial marker of sympathovagal balance, and is difficult to interpret due to the complexity of the origin of LF oscillations, along with the effects of varying breathing pattern on HF oscillations, which may present low accuracy and physiological confidence. However, it presents the same trend as RMSSD which is a stronger marker of cardiac vagal activity, independent of the breathing pattern, consequent with SD2 values which reflect the long-term fluctuations of RR intervals, an inverse indicator of sympathetic activity. This autonomic response was similar to crew or medical members in the underwater evacuation training.

The cardiovascular response measured was higher compared to the effort developed, mean HR among training is likely produced due to the shifts of blood volume from the periphery to the central circulation due to peripheral vasoconstriction and major cardiovascular output, to reduce heat loss and defend core body temperature by increasing the thickness of the insulative layer between the ambient air and perfused blood vessels [33]. The fact that HR response increased despite a likely augmented venous return highlights the fact that significant thermogenesis was occurring, requiring an increased HR to support the metabolic activity.

When basal HRV values analyzed are compared to reference basal values [34], it suggests an anticipatory anxiety response, which may be explained as the training was an evaluative test/training for soldier's professional careers, in addition to the risk, demands, and specific implications of the training. This response is consequent with the pre-SSP values evaluated, showing the large stress of this eliciting training, in line with other military operations such as underground combat, parachute jumps, urban combat, or even air combat jet maneuvers and disorientation training [2,6,13,14,31,35, 36]. In addition, a reminiscence of the sympathetic activation produced by the training was found in the decrease of RMSSD or the increases in HR parameters, highlighting the psychophysiological demands of the task.

Limitations of the study and future research lines

The small number of subjects analyzed has been one of the main limitations of the present work. A greater number of participants would provide more reliable results. However, the difficulty of accomplishing these types of actions due to this complexity, hazard, and economic and human resources needed were a limiting factor. Another limitation was the use of indirect measurement instruments such as the fusion flicker system. Logistics and economic difficulties have limited the use of more modern systems, but the fact that the evaluations were conducted in a very limiting environment, made nearly impossible the use of other instruments such as electroencephalography. Finally, a lack of control of hormones such as alpha-amylase and cortisol to control the hormonal stress response. Future research might seek to address these issues. Given the importance of operational and specific training to allow better survival in air accidents in open water areas, further research should try to design an optimal stimulus and protocol to improve the habituation process.

Practical applications

The present study highlights the psychophysiological response of both crew and medical members undergoing underwater rescue training. This information leads us to a better understanding of the physiological and psychological stress response to this specific and demanding situation in which there is a life risk. The application of this information could contribute to a better design of underwater evacuation training and for both civil and military air personnel preparation.

CONCLUSION

We found that underwater evacuation training produced an anticipatory anxiety response, and an increase in autonomous sympathetic nervous system modulation not affecting strength capacities, cortical arousal, and memory independently of the aircraft role (medical or crew).

Conflicts of interest and sources of funding
The authors declare no conflict of interest. This research received no external funding.

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Authors' contribution
Conceptualization, Marta Vicente-Rodríguez, Álvaro Bustamante-Sanchez, and Jose Alberto Parraca.; methodology, Marta Vicente Rodríguez, and Jose Tornero-Aguilera.; software, Vicente Javier Clemente-Suárez.; validation, Vicente Javier Clemente-Suárez, and Jose Tornero-Aguilera.; formal analysis, Jose Tornero-Aguilera, and Álvaro Bustamante-Sanchez.; investigation, Marta Vicente-Rodríguez, and Jose Alberto Parraca.; resources, Vicente Javier Clemente-Suárez.; data curation, Marta Vicente-Rodríguez, and Vicente Javier Clemente-Suárez.; writing—original draft preparation, Marta Vicente-Rodríguez and Jose Alberto Parraca.; writing—review and editing, Marta Vicente-Rodríguez.; visualization, Jose Tornero-Aguilera.; supervision, Vicente Javier Clemente-Suárez.; project administration, Álvaro Bustamante-Sanchez and Vicente Javier Clemente-Suárez.; funding acquisition, Vicente Javier Clemente-Suárez. All authors have read and agreed to the published version of the manuscript.

Ethics approval and consent to participate
The study was conducted following the Declaration of Helsinki, and approved by the Ethics Committee of European University of Madrid (CIPI/18/093). Informed consent was obtained from all subjects involved in the study.

References:

1. Bustamante-Sánchez, Á.; Clemente-Suárez, V.J. Psychophysiological Response in Night and Instrument Helicopter Flights. Ergonomics 2020, 63, 399–406, doi:10.1080/ 00140139.2020.1718772.

2. Sánchez-Molina, J.; Robles-Pérez, J.J.; Clemente-Suárez, V.J. Psychophysiological and Fine Motor Skill Differences of Elite and Non-Elite Soldiers in an Urban Combat Simulation. Mil Psycho 2019, 31, 425–432, doi:10.1080/08995605.2019.1654293.

3. Bustamante-Sánchez, Á.; Delgado-Terán, M.; Clemente-Suárez, V.J. Psychophysiological Response of Different Aircrew in Normobaric Hypoxia Training. Ergonomics 2019, 62, 277–285, doi:10.1080/ 00140139.2018.1510541.

4. Delgado-Moreno, R.; Robles-Pérez, J.J.; Aznar-Laín, S.; Clemente-Suárez, V.J. Effect of Experience and Psychophysiological Modification by Combat Stress in Soldier's Memory. J Med Syst 2019, 43, 1–8, doi:https://doi.org/10.1007/s10916-019-1261-1.

5. Vicente-Rodriguez, M.; Clemente-Suárez, V.J. Psychophysiological Anxiety Response of a Rescue Helicopter Crew in a Crane Rescue Manoeuvre. BMJ Mil Health 2021, 167, 413–417, doi:10.1136/ bmjmilitary-2019-001345.

6. Clemente-Suárez, V.J.; Robles-Pérez, J.J.; Herrera-Mendoza, K.; Herrera-Tapias, B.; Fernández-Lucas, J. Psychophysiological Response and Fine Motor Skills in High-Altitude Parachute Jumps. High Altitude Med & Bio 2017, 18, 392–399, doi:https://doi.org/10.1089/ ham.2017.0071.

7. Curiel-Regueros, A.; Fernández-Lucas, J.; Clemente-Suárez, V.J.

Effectiveness of an Applied High Intensity Interval Training as a Specific Operative Training. Physiology & Behavior 2019, 201, 208–211, doi:https://doi.org/10.1016/j.physbeh.2019.01.009.

8. Delgado-Moreno, R.; Robles-Pérez, J.J.; Clemente-Suárez, V.J. Combat Stress Decreases Memory of Warfighters in Action. J Med Syst 2017, 41, 124, doi:https://doi.org/10.1007/s10916-017-0772-x.

9. Nation, D.A.; Bondi, M.W.; Gayles, E.; Delis, D.C. Mechanisms of Memory Dysfunction during High Altitude Hypoxia Training in Military Aircrew. J Int Neuropsychol Soc 2017, 23, 1–10, doi:10.1017/S1355617716000965.

10. Nindl, B.C.; Leone, C.D.; Tharion, W.J.; Johnson, R.F.; Castellani, J.W.; Patton, J.F.; Montain, S.J. Physical Performance Responses during 72 h of Military Operational Stress. Med Sci Sports Exerc 2002, 34, 1814–1822, doi:10.1097/00005768-200211000-00019.

11. Clemente-Suárez, V.J.; de la Vega, R.; Robles-Pérez, J.J.; Lautenschlaeger, M.; Fernández-Lucas, J. Experience Modulates the Psychophysiological Response of Airborne Warfighters during a Tactical Combat Parachute Jump. Int J Psychophysiology 2016, 110, 212–216, doi:https://doi.org/10.1016/j.ijpsycho.2016.07.502.

12. Clemente-Suárez, V.J.; Robles-Pérez, J.J.; Fernández-Lucas, J. Psycho-Physiological Response in an Automatic Parachute Jump. J Sports Sci 2017, 35, 1872–1878, doi:https://doi.org/10.1080/02640414.2016.1240878.

13. Clemente-Suárez, V.J.; Robles-Pérez, J.J.; Fernández-Lucas, J. Psychophysiological Response in Parachute Jumps, the Effect of Experience and Type of Jump. Physiology & Behavior 2017, 179, 178–183, doi:10.1016/j.physbeh.2017.06.006.

14. Hormeño-Holgado, A.J.; Clemente-Suárez, V.J. Effect of Different Combat Jet Manoeuvres in the Psychophysiological Response of Professional Pilots. Physiology & Behavior 2019, 208, 112559, doi:10.1016/j.physbeh.2019.112559.

15. Hormeño-Holgado, A.J.; Perez-Martinez, M.A.; Clemente-Suárez, V.J. Psychophysiological Response of Air Mobile Protection Teams in an Air Accident Manoeuvre. Physiology & Behavior 2019, 199, 79–83, doi:10.1016/j.physbeh.2018.11.006.

16. Vicente-Rodríguez, M.; Fuentes-Garcia, J.P.; Clemente-Suárez, V.J. Psychophysiological Stress Response in an Underwater Evacuation Training. IJERPH 2020, 17, 2307, doi:10.3390/ijerph17072307.

17. Van den Oord, M.H.A.; Sluiter, J.K.; Frings-Dresen, M.H.W. Differences in Physical Workload between Military Helicopter Pilots and Cabin Crew. Int Arch Occup Environ Health 2014, 87, 381–386, doi:10.1007/s00420-013-0876-7.

18. Bustamante Sánchez, Á.; Loarte Herradón, V.M.; Gallego Saiz, J.F.; Trujillo Laguna, T.; Clemente Suárez, V.J. Psychophysiological Response of Fighter Aircraft Pilots in Normobaric Hypoxia Training. Arch med deporte: revista de la Federación Española de Medicina del Deporte y de la Confederación Iberoamericana de Medicina del Deporte 2018, 35, 99–102.

19. Borg, G.A.V.; Noble, B.J. Perceived Exertion. Exer Sport Sci Reviews 1974, 2, 131–154.

20. Neuhaus, C.; Hinkelbein, J. Cognitive Responses to Hypobaric Hypoxia: Implications for Aviation Training. PRBM 2014, 297, doi:10.2147/PRBM.S51844.

21. Barak, Y.; David, D.; Akselrod, S. Autonomic Control of the Cardiovascular System during Acute Hypobaric Hypoxia, assessed by Time-Frequency Decomposition of the Heart Rate. In Proceedings of the Computers in Cardiology, 1999. Vol.26 (Cat. No.99CH37004); September 1999; pp. 627–630.

22. Legg, S.; Hill, S.; Gilbey, A.; Raman, A.; Schlader, Z.; Mündel, T. Effect of Mild Hypoxia on Working Memory, Complex Logical Reasoning, and Risk Judgment. Int J Aviation Psycho 2014, 24, 126–140, doi:10.1080/10508414.2014.892751.

23. Truszczyński, O.; Wojtkowiak, M.; Biernacki, M.; Kowalczuk, K. The Effect of Hypoxia on the Critical Flicker Fusion Threshold in Pilots. Int J Occup Med Environ Health 2009, 22, 13–18, doi:10.2478/v10001-009-0002-y.

24. Vigo, D.E.; Pérez Lloret, S.; Videla, A.J.; Pérez Chada, D.; Hünicken, H.M.; Mercuri, J.; Romero, R.; Nicola Siri, L.C.; Cardinali, D.P. Heart Rate Nonlinear Dynamics During Sudden Hypoxia at 8230 m Simulated Altitude. Wilderness & Environ Med 2010, 21, 4–10, doi:10.1016/j.wem.2009.12.022.

25. Hormeño-Holgado, A.J.; Nikolaidis, P.T.; Clemente-Suárez, V.J. Psychophysiological Patterns Related to Success in a Special Operation Selection Course. Frontiers in Physiology, 2019, 10.

26. Zhang, D.; She, J.; Zhang, Z.; Yu, M. Effects of Acute Hypoxia on Heart Rate Variability, Sample Entropy and Cardiorespiratory Phase Synchronization. BioMed Engineering OnLine 2014, 13, 73, doi:10.1186/1475-925X-13-73.

27. Zużewicz, K.; Biernat, B.; Kempa, G.; Kwarecki, K. Heart Rate Variability in Exposure to High Altitude Hypoxia of Short Duration. Int J Occup Safety Ergonomics 1999, 5, 337–346, doi:10.1080/10803548.1999.11076424.

28. Sánchez-Molina, J.; Robles-Pérez, J.J.; Clemente-Suárez, V.J. Assessment of Psychophysiological Response and Specific Fine Motor Skills in Combat Units. J Med Syst 2018, 42, 67, doi:10.1007/s10916-018-0922-9.

29. Tornero-Aguilera, J.F.; Robles-Pérez, J.J.; Clemente-Suárez, V.J. Use of Psychophysiological Portable Devices to Analyse Stress Response in Different Experienced Soldiers. J Med Syst 2018, 42, 75, doi:10.1007/s10916-018-0929-2.

30. Tornero-Aguilera, J.F.; Clemente-Suárez, V.J. Effect of Experience, Equipment, and Fire Actions in Psychophysiological Response and Memory of Soldiers in Actual Underground Operations. Int J Psychophysiology 2018, 128, 40–46, doi:10.1016/j.ijpsycho.2018.03.009.

31. Nieto Jimenez, C.; Cajigal Vargas, J.; Triantafilo Vladilo, V.S.; Naranjo Orellana, J. Impact of Hypothermic Stress During Special Operations Training of Chilean Military Forces. Mil Med 2018, 183, e193–e199, doi:10.1093/milmed/usx131.

32. Masashi, I. Modulation of the Spontaneous Beat-to-Beat Fluctuations in Peripheral Vascular Resistance during Activation of Muscle Metaboreflex | American J Physiology-Heart and Circulatory Physiology Available online: https://journals.physiology.org/doi/full/10.1152/ajpheart.01196.2006 (accessed on 6 February 2023).

33. Castellani, J.; Tipton, M. Cold Stress Effects on Exposure Tolerance and Exercise Performance. Comprehensive Physiology, 2015, doi:10.1002/cphy.c140081.

34. Bauer, A.; Camm, A.J.; Cerutti, S.; Guzik, P.; Huikuri, H.; Lombardi,

F.; Malik, M.; et al. Reference Values of Heart Rate Variability. Heart Rhythm 2017, 14, 302–303, doi:10.1016/j.hrthm.2016.12.015.

35. Tornero Aguilera, J.F.; Gil-Cabrera, J.; Clemente-Suárez, V.J. Determining the Psychophysiological Responses of Military Aircrew When Exposed to Acute Disorientation Stimuli. BMJ Mil Health 2022, 168, 112–116, doi:10.1136/bmjmilitary-2020-001417.

36. Sánchez-Molina, J.; Robles-Pérez, J.J.; Clemente-Suárez, V.J. Psychophysiological and Specific Fine Motor Skill Modifications in a Checkpoint Action. J Med Syst 2019, 43, 90, doi:10.1007/s10916-019-1216-6