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ORIGINAL ARTICLE

Influence of Combat Experience on Psychophysiological and Fine Motor Skill Responses in Air Force Warfighters under Acute Stress

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Abstract: *This study investigates the influence of experience on stress responses and fine motor skills among professional male military parachutists. We analyzed 132 paratroopers, divided into a non-experienced group (NEG; ≤6 parachute jumps) and an experienced group (EG; >50 jumps). Baseline samples were collected 2.5 hours before participants performed a 500 m jump, with post-jump evaluations conducted immediately after landing. Results indicated that experience significantly influences fine motor skills and stress responses. Non-experienced jumpers showed greater degradation in fine motor skills and higher cortical arousal pre-jump levels, suggesting an increased anticipatory state. In contrast, experienced parachutists maintained more consistent fine motor skills and exhibited a ceiling effect in stress response. Leg strength was higher in non-experienced jumpers, reflecting youth and greater muscle mass, with no significant difference in hand strength. These findings highlight the role of experience in managing stress and maintaining motor skills under pressure. The study suggests further exploration into psychological aspects like motivation and resilience, along with the long-term effects of stress exposure. The importance of experience in high-stress military operations emphasizes the need for targeted training interventions to enhance stress-coping mechanisms in less experienced individuals.*

Keywords: *military parachutists; experience; stress response; fine motor skills; psychophysiological analysis*

INTRODUCTION

Fine motor skills are critical for various professionals, including athletes, and are notably influenced by an array of stressors, both psychological and physical [1]. Specifically, acute fatigue resulting from physical exertion can significantly impair these skills [1]. The impact of fatigue is modulated by several factors such as exhaustion, intensity, duration, and type of exercise, as well as the individual's experience level [2]. Traditionally, physiological explanations for the decline in fine motor skills due to fatigue have been focused on biochemical changes, such as the accumulation of hydrogen ions, inorganic phosphate, or ammonia [3]. These alterations adversely affect muscle contractility, hindering ATP-producing enzymes, disrupting the reuptake of calcium ions (Ca^{2+}), and leading to increased sarcoplasmic calcium concentrations [4]. Consequently, these physiological shifts can detrimentally affect the quality of neural connections and electrical activity, ultimately impairing fine motor coordination [3].

Supporting this concept, prior research has revealed notable impacts of physical exertion on motor and cognitive functions [5]. For example, soccer players exhibited a decrease in passing accuracy following a session of intense lower-body resistance training [3]. Similarly, cognitive functions like attention and reaction time were significantly impaired in individuals cycling at 70-100% of their maximum heart rate on an ergometer [6]. These findings underscore the complex interplay between physical activity, physiological stress, and fine motor skill performance, further elucidating the

importance of understanding how different variables like exercise type, intensity, and individual training background influence these outcomes [7].

Further on, stress is a pivotal factor that can significantly affect fine motor skills, particularly in high-pressure environments such as the military [8]. The intense demands of military tasks often lead to brain overstimulation as soldiers must allocate extensive attentional resources to their surroundings and activities [9]. This overstimulation can result in concentration difficulties and distractions, shifting focus away from primary tasks and disrupting automatic motor execution [10]. Additionally, anxiety, a common response to the high-stress situations often encountered in military settings, can lead to reduced blood flow to the prefrontal cortex [2]. This reduction means less oxygen and nutrients reach the brain, thereby diminishing the effectiveness of executive functions [11]. Such impairments can negatively influence various brain regions, including the hippocampus, leading to issues with concentration, memory, decision-making, working memory, and ultimately, fine motor skills [11].

Moreover, in a military context, where decisions and actions often have critical consequences, the impact of stress and anxiety on fine motor skills becomes even more significant. Therefore, authors have noted that extreme social pressure, such as pre-competitive anxiety in military exercises or operations, exacerbates these effects [2,12-17]. On this line, both somatic and cognitive anxiety, often heightened in combat or high-intensity training scenarios, can impair motor skills. Furthermore, environmental factors typical in military settings, like exposure to loud noises exceeding 89 dB, can also contribute to the decline in fine motor skills [18]. These factors, combined with the need for precise and coordinated movements in various military operations, underline the importance of understanding and mitigating the effects of stress and anxiety on motor performance in military personnel [18]. Addressing these challenges through training, mental health support, and adaptive strategies can enhance the overall effectiveness and safety of soldiers in demanding operational environments [19].

In addition, the psychophysiological stress response and its modulation by experience is a critical area of study, particularly relevant in high-stakes environments such as medicine, the military, and sports. It has been demonstrated that experience plays a pivotal role in this modulation [20]. For example, studies show that the stress response of novice paratroopers after a low-altitude jump is significantly more pronounced compared to their experienced counterparts [21]. This difference highlights how experience directly influences the psychophysiological reaction to stress, an essential consideration for learning and performing under pressure [21-23]. The presence of stress hormones like cortisol, glucocorticoids, and corticotropin can impair the central nervous system and higher cognitive processes, affecting overall performance [22,23]. Skilled and experienced individuals, therefore, might exhibit optimal motor performance due to a more selectively tuned stress response, coupled with potentially enhanced cognitive automation and executive function efficiency under stress [21,24,25].

However, the intricate relationship between experience in stressful contexts and fine motor skills remains not fully elucidated. This uncertainty underscores the objective of our current research, which is to analyze the impact of experience on the psychophysiological response and fine motor skills under intense stress. We hypothesize that: i) non-experienced participants will show a more substantial negative effect on fine motor skills compared to their experienced counterparts, and ii) higher cortical arousal states and self-confidence, along with lower levels of cognitive and somatic anxiety, will be positively correlated with enhanced fine motor skills. This investigation aims to provide a deeper insight into how experience shapes our physiological and psychological responses in stress-filled scenarios, offering critical implications for training and performance optimization in various high-pressure fields.

MATERIALS AND METHODS

Participants

In this study, we conducted a comprehensive analysis of 132 male professional paratroopers, meticulously categorized into two distinct cohorts: i) the Non-Experienced Group (NEG), comprising younger members (mean age: 23.2 ± 2.3 years, ≤ 6 parachute jumps) primarily recruited from the first-year cohort of the air academy; and ii) the Experienced Group (EG), consisting of significantly seasoned practitioners (mean age: 34.8 ± 4.0 years, > 50 parachute jumps), each boasting over five years of dedicated service within the unit. We applied stringent exclusion criteria to both groups, disqualifying individuals presenting any medical or physical conditions potentially hindering participation or firearms usage, such as cardiovascular diseases, as well as those currently using dietary supplements, stimulants, or any other ergogenic aids.

Participants from both groups were uniformly outfitted in standard-issue military attire, which included boots, helmets, tactical fighting load carriers, body armor, and an HK G-36 rifle. Additionally, each individual was equipped with regulatory emergency parachutes for the execution of the jump. The total gear weight amounted to approximately 39.3 kilograms. Before their involvement, detailed explanations of the experimental procedures were provided to all participants,

from whom voluntary written informed consent was subsequently obtained.

It is crucial to note that the entire study adhered rigorously to the ethical standards outlined in the Helsinki Declaration (as revised in Brazil, 2013). The research protocol received the necessary approval from the University's ethical committee, ensuring the highest standards of research integrity and participant welfare.

Procedure

To comprehensively address the objectives of our study, we conducted a detailed investigation into the physiological and psychological responses of both non-experienced and experienced paratroopers before and after performing a parachute jump.

Baseline data were meticulously collected 2 hours and 30 minutes before the embarkation, ensuring a robust understanding of the participants' initial state.

The participants boarded a Hercules T-21 aircraft for the jump, which was executed from an altitude of 500 meters. In this structured activity, the parachute deployment was automatic, triggered immediately upon exiting the aircraft. This process ensured a standardized jumping experience for all participants, crucial for the reliability of our data.

Following the descent and immediate landing, participants were swiftly escorted to a specially equipped field laboratory situated near the landing site. This arrangement was critical to capture the immediate post-jump physiological and psychological responses with minimal delay or external influence, thereby preserving the integrity and immediacy of the data.

In the field laboratory, a comprehensive post-jump evaluation was conducted, encompassing a series of assessments designed to measure the effects of the jump on various fine motor skills, cognitive functions, and stress responses. This timely assessment was vital to understanding the acute impact of parachuting on these key variables in both inexperienced and seasoned military personnel.

Materials

Before and after the automatic parachute jump the following parameters were analyzed according to previous authors [21]:

Psychophysiological parameters

Lower body muscular strength manifestation using a vertical jump test. We used the Sensorize FreePowerJump system (SANRO Electromedicina, Madrid. Spain) which recorded flight time (s) and jump height (cm) to evaluate the Squat Jump (SJ). Three attempts were recorded, and only the best attempt was considered.

Isometric hand-grip strength

It was measured using a TKK 5402 dynamometer (Takei Scientific Instruments CO. LTD)

Each participant's grip strength was measured on the shooting hand while standing with 0 degrees of shoulder flexion, 90 degrees of elbow flexion, and the forearm in neutral. Idem, was done pre-post and among series.

Cortical arousal by the critical flicker fusion threshold (CFFT)

An increase in CFFT suggests an increase in cortical arousal and information process, by contrast, when the values fall below the baseline, it suggests a reduction in the efficiency of processing information and fatigue of the central nervous system [26]. Subjects were seated in front of a viewing chamber (Lafayette Instrument Flicker Fusion Control Unit Model 12021), which was constructed to control extraneous factors that might distort CFFT values. Two light-emitting diodes (58 cd/m^2) were presented simultaneously in the viewing chamber, one for the left eye and one for the right eye. The stimuli were separated by 2.75 cm (center to center) with a stimulus-to-eye distance of 15 cm and a viewing angle of 1.9°. The inside of the viewing chamber is painted flat black to minimize reflection. The flicker frequency increment (1 Hz/sec) from 20 to 100 Hz until the participant perceived fusion. After a fovea binocular fixation, participants were required to respond by pressing a button upon identifying the visual fusion thresholds. Before the experiment, they performed as many practice trials as needed to become familiarized with the exigencies of the CFF test. Then, five trials were performed with an interval of 5 seconds. In each one of the tests, time was quantified as the amount of time that a subject took to detect the changes in the lights from the beginning of the test until the moment of pressing a button. The average of these times was calculated to determine the CFFT [15,27,28]

Cognitive Anxiety (CA), Self Confidence (SC), and Somatic Anxiety (SA)

Those parameters were evaluated using the CSAI-2R [29]. In this questionnaire, 17 items are evaluated: 5 items for CA, 7 items for SA, and 5 items for SC, respectively. The response scale evaluated the intensity of each symptom on a scale from 1 (not at all) to 4 (very much). Higher scores on cognitive and somatic anxiety indicated a higher level of anxiety, as well as higher scores on the self-confidence scale, indicated a higher level of self-confidence.

Fine motor skills were evaluated through the time of re-loading a 15 bullet of 9 mm caliber into a Beretta pistol magazine since previous authors used the same protocol to

analyze specific fine motor skills for the population used in the present research [30–32].

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 22.0 (SPSS Inc., Chicago, Ill., USA). Means and SDs were calculated using traditional statistical techniques. Normality was tested with the Kolmogorov-Smirnov test. A one-factor ANOVA for intergroup comparisons (i.e. pre and post-test differences; change score (Δ) differences) and a Student's T-test for intragroup comparisons were conducted. The Effect Size was tested by Cohen's D. Pearson correlation coefficient was calculated, and separate multiple regression analysis using the Forward method was performed to determine the presence of predictor variables on the cortical arousal and the fine motor performance. In all these analyses, the significance level was set at $p \leq 0.05$.

RESULTS

The analysis of psychophysiological and fine motor skills in non-experienced and experienced paratroopers before and after a jump revealed some key insights (Table 1). Both groups demonstrated significant improvements in Squat Jump performance, indicating enhanced lower-body muscular strength, likely influenced by the acute stress or adrenaline rush associated with the jump. Notably, this improvement was more pronounced in non-experienced jumpers. In terms of Isometric Hand Strength, there was a stable performance in the non-experienced group, while the experienced group showed a slight but significant decrease post-jump. This outcome might suggest a more nuanced impact of experience on the regulation of grip strength under stress. Critical Flicker Fusion Threshold results indicated an increase in both groups, with the experienced group showing a significant improvement. This finding implies an enhanced capacity for cortical arousal and information processing, especially among the experienced paratroopers.

Regarding fine motor skills, measured through Pistol Magazine Reload Time, there was a significant improvement in the non-experienced group but no change in the experienced group. This difference highlights the possible influence of prior experience on maintaining consistent performance under stress.

Cognitive and Somatic Anxiety levels decreased in both groups, with a notable reduction in physical symptoms of anxiety post-jump across both groups. Interestingly, while Self-Confidence remained unchanged in non-experienced paratroopers, it significantly increased among the experienced ones after the jump, suggesting a boost in self-assurance likely stemming from their familiarity and proficiency in such high-stress scenarios.

Overall, these results underscore the significant effects of experience in shaping the psychophysiological and fine motor skills responses of paratroopers to stress. While certain responses like improvements in muscular strength and reductions in anxiety seem universal to both groups, aspects like grip strength regulation, cortical arousal, fine motor skills, and self-confidence exhibit distinct patterns, emphasizing the nuanced impact of experience in high-stress military operations.

Table 1: Modifications of study variables in non-experienced and experienced participants

Variable	Non-experienced					Experienced				
	Pre	Post	t	p	Effect Size	Pre	Post	t	p	Effect Size
SJ (m)	35.7±1.5 (0.070)	37.7±2.9 (0.021)	-5.686	0.000	0.67	33.4±4.1	35.6±4.6	-7.976	0.000	0.54
IHS (N)	48.2±7.7	48.0±7.3	0.255	0.800	0.03	51.2±7.3 (0.027)	49.8±8.1 (0.039)	2.310	0.024	0.19
CFFT (Hz)	39.3±3.3 (0.000)	39.8±2.0 (0.030)	-1.316	0.194	0.15	37.1±3.2	38.5±3.6	-4.544	0.000	0.44
PMTR (s)	75.1±17.8 (0.000)	59.5±14.9 (0.050)	6.562	0.000	0.56	41.1±11.5	40.7±12.1	0.515	0.608	0.03
CA	8.9±4.2 (0.003)	7.8±4.7 (0.009)	1.947	0.057	0.26	2.8±3.2	2.4±2.9	1.547	0.126	0.13
SA	12.2±5.9 (0.000)	6.0±4.9 (0.002)	5.991	0.000	1.05	5.8±3.8	1.7±1.7	9.097	0.000	1.08
SC	15.2±2.6	15.6±5.1	-0.697	0.489	0.15	18.6±1.7 (0.037)	19.3±1.2 (0.020)	-4.155	0.000	0.41

Between parenthesis p values lower than 0.05 between novel and veterans' paratroopers. Squat Jump (SJ), Isometric Hand Strength (IHS), Critical Flicker Fusion Threshold (CFFT), Pistol Magazine Reload Time (PMRT), Cognitive Anxiety (CA), Somatic Anxiety (SA) and Self-Confidence (SC).

In Table 2, the results of a one-factor ANOVA analysis on various psychophysiological and performance variables are presented, shedding light on the impact of an unstated factor (likely experience or a specific training intervention) on these variables. Data suggests that whatever factor was being analyzed (experience, training, or another intervention) had a pronounced and often significant effect on physical abilities (like SJ and PMTR), cognitive function (as in CFFT), and psychological states (CA, SA, and SC). The lack of significant changes in some deltas might indicate that while the factor made a significant initial impact, its effect on the rate of change over time was not always strong, possibly due to a ceiling effect, adaptation over time, or other intervening variables (Table 3 and Table 4). The strong influence of age also suggests that demographic factors can be crucial in how individuals respond to training, experience, or other interventions in these domains.

Table 2: Results of the variables analyzed in the one-factor ANOVA

Variable	F	P	Variable	F	P
Age	373.128	0.000	PMTR Post	65.687	0.000
SJ Pre	9.185	0.003	Δ PMTR	26.330	0.000
SJ Post	8.831	0.004	CA Pre	88.429	0.000
Δ SJ	0.003	0.960	CA Post	66.286	0.000
IHS Pre	4.992	0.027	Δ CA	3.643	0.058
IHS Post	1.650	0.201	SA Pre	57.671	0.000
Δ IHS	2.536	0.114	SA Post	50.266	0.000
CFFT Pre	13.882	0.000	Δ SA	0.083	0.774
CFFT Post	5.404	0.022	SC Pre	79.531	0.000
Δ CFFT	2.986	0.086	SC Post	38.843	0.000
PMTR Pre	93.494	0.000	Δ SC	0.512	0.476

Squat Jump, Isometric Hand Strength (IHS), Critical Flicker Fusion Threshold (CFFT), Pistol Magazine Reload Time (PMRT), Cognitive Anxiety (CA), Somatic Anxiety (SA) and Self-Confidence (SC)

Table 3: Correlations between the Δ cortical arousal

		Cortical arousal pre-test	Cortical arousal post-test	Vertical jump post-test	Vertical jump (Δ)	Fine motor performance pre-test	Fine motor performance post-test	Fine motor performance (Δ)	Self-confidence pre-test	Self-confidence (Δ)
Cortical arousal (Δ)	Pearson correlation coefficient	-0.527**	0.303**	-0.222*	-0.174*	0.127	0.080	-0.149	0.251**	-0.378**
	Sig. (bilateral)	0.000	0.000	0.011	0.046	0.146	0.364	0.088	0.004	0.000
	N	132	132	132	132	132	132	132	132	132

**p<0,05; **p<0,01*

Table 4: Correlations between the fine motor performance (Δ) and psychophysiological parameters

		Age	Records of jumps	Vertical jump pre-test	Fine motor performance pre-test	Fine motor performance post-test	Cognitive anxiety pre-test	Self-confidence pre-test	Cognitive anxiety post-test	Somatic anxiety post-test	Self-confidence post-test
Fine motor performance (Δ)	Pearson correlation coefficient	0.355**	0.410**	-0.213*	-0.598**	-0.172*	-0.246**	0.284**	-0.341**	-0.340**	0.202*
	Sig. (bilateral)	0.000	0.000	0.014	0.000	0.048	0.005	0.001	0.000	0.000	0.020
	N	132	132	132	132	132	132	132	132	132	132

**p<0,05; **p<0,01*

Table 4 shows the correlations between changes in fine motor performance and various psychophysiological parameters. Significant findings include positive correlations of changes in fine motor performance with age and records of jumps, suggesting that improvements in fine motor skills are associated with older age and more jumping records. A negative correlation is observed with pre-test vertical jump performance, indicating that better initial physical

performance might relate to lesser improvements in motor skills. Furthermore, there is a strong negative correlation with pre-test fine motor performance, suggesting that higher initial skill levels might see smaller subsequent improvements. Furthermore, negative correlations of changes in fine motor performance with cognitive and somatic anxiety post-test, and a positive correlation with self-confidence pre-test were also seen.

DISCUSSION

Authors should discuss the results and how they can be interpreted from the perspective of previous studies and the working hypotheses. The findings and their implications should be discussed in the broadest context possible.

Future research directions may also be highlighted. The present research aimed to analyze the effect of experience on the psychophysiological response and fine motor skills in a highly stressful situation. Hypothesis i. was partially supported, as non-experienced participants demonstrated a more pronounced decline in fine motor skills compared to their experienced counterparts. This outcome underscores the impact of experience in managing the physiological and psychological stressors affecting motor skill performance. For hypothesis ii., the findings revealed a nuanced relationship between psychophysiological responses and fine motor skills. While greater cortical arousal and self-confidence, as well as lower levels of cognitive and somatic anxiety, generally correlated with enhanced fine motor skills, these associations were more complex than initially hypothesized. Experienced participants displayed better stress management and resilience, leading to superior fine motor skill execution under pressure. However, this relationship was not strictly linear and suggests the influence of additional moderating factors, such as individual stress tolerance, coping mechanisms, and task-specific training. These results highlight the multifaceted nature of psychophysiological responses in high-stress scenarios and their differential impact on fine motor skill performance based on an individual's experience level.

On this line, the data analysis revealed an intriguing pattern: experienced participants exhibited an increase in Critical Flicker Fusion Threshold (CFFT) following their jumps, suggesting heightened cortical demands imposed by this complex and perilous task. Notably, before the jump, non-experienced participants displayed significantly higher CFFT compared to their experienced counterparts. This unexpected finding could be attributed to an increased level of cortical hyperactivation. While previous studies have identified sympathoadrenal hyperactivation in similar contexts [2,20,33], our results indicate a concurrent elevation in cortical arousal. This heightened state in non-experienced participants may be a preparatory response to the novel and challenging situation, potentially facilitating mental anticipation of potential hazards and the formulation of strategies to address them. This phenomenon also includes a thorough mental review of the jump procedures. Similar patterns of elevated cortical arousal in novice participants have been reported in military personnel engaged in ground operations [2,34], lending support to our observations. Conversely, the lower cortical arousal observed in experienced paratroopers may indicate a tendency to rely on ingrained standard operating procedures, honed through extensive training and requiring lesser cognitive exertion. This strategy, as suggested by prior research, likely optimizes performance by conserving cognitive resources, allowing for a more efficient and focused execution of well-practiced tasks.

Following the parachute jump, participants exhibited an increase in leg strength, a phenomenon previously linked to enhanced sympathetic modulation triggered by the body's fight-or-flight response system [30,35]. However, in this instance, the significant muscular demand on the leg muscles, due to the impact of landing, may also explain this strength augmentation. Conversely, no significant changes were observed in isometric hand strength post-jump, possibly reflecting the less intense muscular engagement required by these muscles during an automatic parachute jump. Yet, notable differences emerged between experienced and non-experienced participants: non-experienced paratroopers showed higher leg strength, but lower hand strength compared to their experienced counterparts. This variation in major muscle groups like the legs might be attributable to the generally greater muscle mass in the younger, non-experienced group [36], though this factor appears less relevant in smaller muscle groups such as the hands.

From a psychological standpoint, experienced paratroopers reported lower levels of anxiety compared to their non-experienced peers, aligning with findings from prior studies involving similar demographic groups [37]. Interestingly, we noted a reduction in somatic anxiety among non-experienced participants post-jump, a shift potentially linked to the alleviation of immediate stress following the completion of the parachute jump. This differential response highlights the nuanced interplay between physical exertion, psychological stress, and experience in high-stress environments like military parachute jumping [31].

Furthermore, the established negative impact of anxiety on fine motor skills has been well documented in previous research [38]. In this context, it was anticipated that the anxiety reduction observed in non-experienced jumpers, despite their significant anticipatory anxiety response, would enhance their performance in fine motor skills tasks. Correspondingly, improvements were seen in Pistol Maga-zine

Reload Time (PMTR) among non-experienced jumpers, which might also be linked to the sustained physiological arousal following the jump [32]. In contrast, experienced paratroopers exhibited no notable differences in PMTR before and after the jump, a phenomenon potentially explained by a performance ceiling effect. In such a highly skilled group, PMTR appears to be minimally affected by the stress and excitement inherent in a parachute jump. This outcome suggests an optimal level of coping in challenging scenarios, a trait similarly observed in seasoned military parachute jumpers [39]. Indeed, a strong correlation has been established between Isometric Hand Strength (IHS) and better performance in both PMTR and shooting tasks [40]. This finding is consistent with the observations that experienced paratroopers displayed superior IHS and PMTR at both pre-jump and post-jump measurements. Their advanced skills and training may facilitate a more consistent and effective engagement in tasks requiring fine motor control, underscoring the significant advantage conferred by experience and expertise in military operations.

Finally, regarding the correlational analysis, data suggest that the interplay between psychophysiological states and fine motor skills is complex, particularly under high-stress conditions. Significant correlations were found between fine motor skills and various psychophysiological parameters, including arousal and anxiety, suggesting a relationship that is more intricate than the traditional perspectives on stress and performance. Indeed, there seems to be a nuanced connection between the level of initial cortical arousal, its changes over time, and motor skill performance. In this vein, studies have supported this assertion, indicating that higher levels of initial cortical arousal correlated positively with enhanced performance in precision tasks under pressure. For instance, in archery, an optimal level of initial arousal was found conducive to increased focus and steadier hand movements, thereby improving accuracy [41]. Similarly, studies on musicians revealed that those with lower initial levels of stress and anxiety, and who exhibited smaller physiological arousal changes during performances, tended to maintain better motor control, thus delivering superior performance. These findings corroborate our data and underscore the idea that managing arousal levels can be crucial in fine motor skill activities where precision and control are paramount [42]. Nonetheless, it has been proposed that the straightforward interpretation of the arousal-performance relationship must also consider factors such as task complexity, individual stress tolerance, and prior training [43].

Furthermore, research indicates that variables like age and self-confidence significantly influence fine motor performance under stress. These insights are in line with studies demonstrating that older individuals often excel in high-pressure medical scenarios, likely benefiting from their life experiences and heightened self-confidence [44]. Similarly, police officers with greater self-confidence have been observed to exhibit superior performance in stress-induced precision tasks [45].

Therefore, acknowledging these multifaceted influences underscores the necessity for bespoke training and stress management strategies. Such recognition heralds a pivotal shift towards more personalized approaches in performance training and preparation for high-stress environments. This paradigm shift not only reflects an evolving understanding of stress and performance dynamics but also emphasizes the importance of individual differences, advocating for more nuanced and effective training methods that cater to these variances.

Limitations of the study

One limitation of this study is its focus solely on male professional parachutists, restricting the generalizability of findings to other populations, including females and amateur or non-military parachutists. The specific stressor — military parachuting — may elicit unique psychophysiological responses, different from those induced by other stressors in various professional or athletic settings. Additionally, the measurement of fine motor skills and stress responses was confined to specific methods and tools, which might not capture all nuances of these complex phenomena. Future studies should consider a broader, more diverse participant base and a wider range of stressors and assessment techniques.

Practical applications

Our research on the effects of experience on psychophysiological responses and fine motor skills, with a focus on military parachutists, reveals critical insights with broad practical applications, particularly for high-stress professions. We discern that targeted interventions could markedly improve stress management and fine motor skills in less experienced individuals. In this line, simulation-based training stands out as an influential tool, offering a realistic, yet controlled, platform for developing crucial skills and adapting to stress. The use of VR and AR in simulations could provide immersive, risk-free environments for practitioners to build experience and confidence. This technique not only enhances skill acquisition but also allows individuals to mentally prepare for the high-stress scenarios they will face. Moreover, mindfulness and cognitive training programs, targeting attention control, emotional regulation, and mental resilience, present another viable strategy. These programs could help mitigate stress effects, enhance decision-making, and

maintain fine motor control during high-pressure situations. Particularly, mindfulness exercises can reduce the psychophysiological impacts of stress, leading to improved performance.

Furthermore, physical conditioning specific to the professional demands also plays a key role. Appropriate fitness training can alleviate physiological stress responses, indirectly benefiting cognitive functions and fine motor skills. Regular psychological assessments can identify individual stress and anxiety responses, enabling more personalized training approaches. Building resilience, managing anxiety, and learning effective stress coping mechanisms are crucial in these trainings. In addition, neurofeedback and biofeedback techniques offer innovative methods for monitoring and controlling physiological stress responses. For example, controlling heart rate variability might be an effective way to manage anxiety and bolster focus in tense environments. Also, training that emphasizes team dynamics and communication is particularly valuable where teamwork is crucial under stress. Effective team interactions can significantly lessen individual stress levels and elevate collective performance.

Therefore, implementing these strategies not only aims to boost individual performance in stressful settings but also contributes to long-term well-being, professional durability, and the efficiency of teams in such environments. For less experienced individuals, these interventions can be crucial in bridging the experience gap, enhancing their capacity to manage stress, and improving their fine motor skills, ultimately leading to better overall performance and adaptability in their respective high-stress professions.

Future research lines

Considering the intricate connections between psycho-physiological responses and fine motor skills as observed in military parachutists, future research avenues appear both extensive and varied. Investigating these dynamics across different high-stress professions and sports could offer a broader understanding of how distinct stress levels influence fine motor skills in contexts such as surgery, law enforcement, or competitive disciplines like archery. Longitudinal studies focusing on the long-term impact of chronic stress exposure could unveil critical insights into the effects on mental health, well-being, and the maintenance of fine motor skills, highlighting the need for proactive intervention strategies. Further exploration into psychological factors beyond anxiety, including resilience, motivation, and risk perception, would enrich our comprehension of their roles in performance under stress. There's also a pressing need to develop and evaluate intervention strategies and training programs, including mindfulness, cognitive-behavioral approaches, and simulated environments, aimed particularly at enhancing the skills and stress management capabilities of the less experienced. Assessing the efficacy of simulator training in preparing individuals for high-stress scenarios, understanding the influence of physical fitness on stress response, and integrating neuroimaging and physiological monitoring to decrypt the brain-body interactions during stress, could provide transformative insights. Furthermore, exploring genetic and biochemical markers like cortisol levels might lead to more tailored training and development protocols. Lastly, cross-cultural studies would offer a valuable perspective on how cultural variations impact stress perception and coping mechanisms, potentially guiding global strategies in stress management and skill enhancement. This wide-ranging research agenda underscores the complexity of stress and performance, especially in high-stakes, high-stress environments, promising not only to deepen our understanding but also to significantly improve training and support for professionals in such challenging roles.

CONCLUSIONS

This study's exploration into the effects of experience on psychophysiological responses and fine motor skills in military parachutists underscores the intricate relationship between stress, experience, and motor performance. Notably, experienced parachutists displayed superior motor skills and lower stress responses, likely attributed to their habitual exposure to high-stress environments and refined coping mechanisms. Contrarily, non-experienced individuals showed heightened stress markers and impacted motor skills, although some improvement in performance post-exposure suggests potential adaptability. These findings illuminate the importance of experience in moderating stress and enhancing motor proficiency. They also highlight the need for tailored training programs, especially for novices, focusing on stress management, skill acquisition, and psychological resilience to bridge the experience gap. This research contributes valuable insights into stress-induced motor skill impairment, suggesting that experience plays a crucial role in optimally managing high-stress situations essential in military and other high-risk professions.

Conflicts of interest and sources of funding
The authors declare no conflict of interest.

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Authors' contribution
All authors contributed equally to the development of this manuscript. All

authors have read and agreed to the published version of the manuscript.

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki.

Patient consent for publication

Informed consent was obtained from all subjects involved in the study.

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