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Decoding air sickness: Predictive factors and psychological insights

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ABSTRACT

Objectives: The pursuit of aviation necessitates a comprehensive and disciplined training regimen for individuals hoping to navigate the vast expanse of the skies. During the course of this training, a significant challenge presents itself in the form of air sickness, which is a physiological reaction that occurs due to sensory incongruity and/or psychological distress experienced during flight. The aim of this paper is to retrospectively analyze the psychological characteristics of air sickness among air force cadets and aviators' successful and unsuccessful attempts to air sickness desensitization therapy (ASDT) protocol, thereby examining the predictive factors associated with effective outcomes.

Material and Methods: During a span of 5 years (2019–2023), a total of 35 cases were referred for ASDT at the Institute of Aerospace Medicine. They were administered with a psychological protocol with the study variables of motion sickness assessment, motivation, and personality. Subsequently ASDT was offered consisting of relaxation therapy, cognitive behavioral therapy as per "caseness," and yielded a success rate of 13 out of 35.

Results: Significant differences were found between successful and unsuccessful cases in age, motion sickness assessment questionnaire (MSAQ) scores, and specific personality traits (Modesty and Activity). Logistic regression indicated MSAQ scores as a significant predictor of treatment outcome.

Conclusion: The findings highlight the importance of tailored interventions for air sickness management, emphasizing the role of MSAQ scores and certain psychological traits in predicting ASDT success. This study underscores the need for comprehensive diagnostic and personalized treatment strategies to enhance aviation training outcomes.

Keywords: Air sickness desensitization therapy, Air sickness, Cognitive behavioral therapy, Motivation, Personality

INTRODUCTION

In military aviation, air travel is pivotal for strategic mobility and operational agility across vast theatres of operation. The aerial operations rely on highly trained aviators who undergo rigorous instruction to ensure mission effectiveness and safety. However, challenges abound. "To soar is human, to handle air sickness divine" – this aphorism captures the paradox of commanding the skies while contending with air sickness, a distinctly human obstacle. Amidst the trials faced by aspiring military pilots, air sickness emerges as a formidable physiological adversary, demanding focused investigation.

This phenomenon, rooted in the incongruity between visual and vestibular cues, gives rise to symptoms such as nausea, dizziness, and discomfort during flight. These symptoms profoundly impact the training experience, potentially influencing future aviation endeavors.[1] As pilots navigate through three-dimensional space, their ability to manage physiological responses becomes pivotal. Air sickness, also known as motion sickness, results from a complex interplay of factors, including psychological ones. The sensory conflict[1] triggers a cascade of symptoms, severely compromising pilot performance. Moreover, psychological factors, such as stress and anxiety, can exacerbate the physiological response to motion, contributing to overall susceptibility to air sickness.[2,3]

The susceptibility to air sickness has been a subject of scientific inquiry for decades. Reason and Brand[1] laid the groundwork for understanding motion sickness as a response to sensory incongruity, emphasizing the significance of discordant visual and vestibular cues. Subsequent studies by Treisman[4] extended this understanding by proposing the evolutionary discordance hypothesis, suggesting that motion sickness is a result of an adaptive trait misapplied in modern contexts, such as flight. Investigations by Diels and Howarth[5] delved into age-related variations in susceptibility to motion sickness, revealing an intricate interplay between sensory integration and age-related factors.

Furthermore, studies, including those by Golding,[2] have developed assessment tools like the motion sickness assessment questionnaire (MSAQ) to quantify susceptibility to air sickness and its related symptoms. These instruments have facilitated the identification of individuals prone to air sickness and provided insights into potential predictors. In parallel, Furnham and Petrides[6] investigated the link between emotional intelligence and well-being, highlighting the role of emotional regulation in moderating stress responses. Salgado[7] explored the impact of the five-factor model personality traits on job performance, providing insights into how personality might influence coping mechanisms in demanding situations.

Cognition and motion sickness further complicate this intricate interplay. Conflict between sensory signals and our brain's predictions about self-motion, as explored by Nooij *et al.*,[8] highlights the intricate nature of the challenge. In addition, Golding *et al.*[9] shed light on the unclear and ambiguous higher-order cognitive cues in the visual scene, especially during motion. Cognitive dimensions at play involve identifying and modifying maladaptive beliefs and perceptions related to motion, aligning them more closely with actual sensory input. Practices such as relaxation therapies such as Jacobson's progressive muscle relaxation, intertwined with cognitive behavioral therapy (CBT), contribute significantly to addressing these cognitive dimensions, making a substantial difference in the battle against motion sickness.

Air sickness desensitization therapy (ASDT), a specialized protocol designed to mitigate air sickness susceptibility among aviation professionals, particularly air force cadets in Indian context, plays a pivotal role in this narrative.[10] This protocol aims to desensitize individuals to the sensory triggers associated with air sickness, enhancing their physiological resilience during flight. It integrates psychological interventions, including relaxation therapy and CBT, tailored to individual needs. The observed reduction in air sickness symptoms reflects an improved ability to manage psychological stress and physiological responses during flight.

While the literature provides valuable insights into the factors underlying motion sickness susceptibility, a significant gap persists in understanding its implications within the context of air force cadet training. This study seeks to bridge this gap by exploring the intricate psychometric aspects and predictive factors associated with successful outcomes within the ASDT protocol among air force aviators. The Institute of Aerospace Medicine (IAM) ASDT protocol employs a comprehensive evaluation by specialists in Aviation Medicine, Ophthalmology, ENT and Aviation Psychology. After evaluation, the case is exposed to gradually increasing provocative motion stimuli in a simulator by inducing Coriolis cross-coupling. Cases are considered successful when the set criteria are achieved. They are deemed unsuccessful if they fail to adapt to the provocative motion in the simulator, leading to termination before meeting the criteria.[10] This research paper aims to identify key psychological predictors of air sickness vulnerability and evaluate the effectiveness of ASDT by comparing successful and unsuccessful cases to enhance diagnostic accuracy and advocate targeted intervention strategies for aviators.

MATERIAL AND METHODS

Research design

This study employs a retrospective cross-sectional analysis of psychological characteristics and treatment outcomes among aviators who underwent air sickness desensitization and investigated the predictive factors associated with the effectiveness of the ASDT protocol.

Sample

The study sample comprises 35 cases, experiencing symptoms of air sickness during flight, referred for ASDT at the IAM over a 5-year period (2019–2023). Of the total cases, 13 achieved successful outcomes through the ASDT protocol, while the remaining 22 cases did not show significant improvement. Among the cases who did not achieve success, 13 were randomly selected to create two equal groups for statistical analyses.

Measures

MSAQ

The MSAQ, a validated instrument,[11] assesses susceptibility to motion sickness and related symptoms. It consists of items scored on a 7-point Likert scale, ranging from 1 (no discomfort) to 7 (severe discomfort). It measures motion sickness symptoms classified into four distinct facets:

- Gastrointestinal (G) discomfort: Symptoms related to gastrointestinal distress such as nausea and vomiting.
- Central nervous system (CNS) involvement: Symptoms indicating central nervous system disturbances, such as dizziness and disorientation.
- Sopite (S)-related symptoms: Symptoms associated with sopite syndrome, such as fatigue and drowsiness.
- Peripheral (P) physiological responses: Symptoms related to peripheral physiological changes, such as sweating.

Work need assessment inventory (WNAI)

The WNAI assesses motivational factors, including achievement, affiliation, and power.[12] These factors were categorized into desirability (1) and undesirability (2). The inventory's subscales are scored on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

Neuroticism-extraversion-openness personality inventory-revised (NEO PI-R)

The NEO PI-R measures the Big Five personality traits, including neuroticism, extraversion, openness, agreeableness, and conscientiousness.[13] The inventory comprises 240 items, scored on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

Study procedure

Cases underwent a comprehensive psychological assessment encompassing the measures such as MSAQ, WNAI, NEO PI-R, and clinical interview. Subsequently, ASDT was administered, involving relaxation therapy and CBT tailored to individual "caseness." The success rate of ASDT was measured based on the reduction of air sickness symptoms while experiencing the provocative motion stimuli in the simulator. Further to understand the effectiveness, MSAQ was administered post therapy on successful candidates. Ethical guidelines were followed throughout the study, ensuring case confidentiality and data security.

Statistical analysis

Data analysis was carried out using IBM Statistical Package for the Social Sciences 26. Descriptive statistics were computed to provide an overview of the distribution and characteristics of the study variables. Analyses included -

Mean comparisons: Differences in variables between cadet groups (successful vs. unsuccessful outcomes) were assessed using non-parametric significance tests.

Regression analysis: Predictor variables associated with treatment outcomes were identified using logistic regression analysis.

Paired samples *t*-test: Mean differences of pre-post MSAQ scores in the successful cases were calculated.

RESULTS

Sample characteristics

The sample consisted of 26 participants, including Flight Cadets (61.5%), Flying Officers (11.5%), Sub Lieutenants (11.5%), Assistant Commandants (3.8%), Deputy Commandants (7.7%), and Captains (3.8%). Most participants were male (92.3%) and single (92.3%). The mean age of participants was 24.3 ± 2.1 years.

Mean differences in treatment outcomes using Kruskal–Wallis test

To investigate potential mean differences in various variables between successful (Pass) and unsuccessful (Fail) cases, a Kruskal–Wallis test was conducted. The analysis included the assessment of age, MSAQ overall score with facets, configuration of needs, as well as personality traits measured by NEO PI-R administered before the treatment.

Noteworthy distinctions emerged within various demographic factors when comparing the "Pass" and "Fail" treatment outcomes [Table 1]. Notably, P-values for age ($P = 0.049$), MSAQ overall score ($P = 0.007$), as well as its facets' gastrointestinal score ($P = 0.039$), CNS score ($P = 0.009$), and sopite-related score ($P = 0.013$), demonstrated statistical significance. Furthermore, the personality facets modesty ($P = 0.003$) and activity ($P = 0.012$) exhibited significant differences between the two treatment outcomes. This suggests that these variables may play a role in distinguishing between successful and unsuccessful cases.

Table 2 shows the significant mean rank differences. Results indicate that successful cases had a significantly lower mean age as compared to unsuccessful cases. This implies that flight cadets undergoing training are more inclined to positively respond to therapy compared to trained aviators. In terms of MSAQ scores before the therapy, successful cases demonstrated a significantly lower mean rank in MSAQ score in comparison to unsuccessful cases. The nuances of the MSAQ were further illuminated through the facet analyses. Notably, the cases when compared for gastrointestinal, CNS, and sopite scores, results showed that successful cases had lower mean rank compared to their counterparts who experienced less favorable outcomes. Moving beyond the MSAQ, NEO PI-R facets also played a significant role. Modesty emerged as a distinguishing factor, with cases who achieved successful outcomes holding a significantly higher mean rank in this facet, whereas the personality facet activity also contributed to differentiation, as those who succeeded in the treatment had a significantly higher mean rank.

Table 1: Kruskal–Wallis test results [degrees of freedom (df)=1].

Variable	Chi-square	*P*
Age	3.87	0.049*
MSAQ		
MSAQ score	7.41	0.007*
Gastrointestinal score	4.24	0.039*
CNS score	6.77	0.009*
Sopite-related score	6.21	0.013*
NEO PI-R Facets		
Modesty	8.98	0.003*
Activity	6.36	0.012*

*$P<0.05$. MSAQ: Motion sickness assessment questionnaire, CNS: Central nervous system, NEO PI-R: Neuroticism-extraversion-openness personality inventory-revised

Table 2: Significant mean rank differences in treatment outcomes using Kruskal–Wallis test.

Variable	Treatment outcome	
	Mean rank of successful cases (*n*=13)	Mean rank of unsuccessful cases (*n*=13)
Age	10.62	16.38
MSAQ score	9.42	17.58
Gastrointestinal score	10.42	16.58
CNS score	9.62	17.38
Sopite-related score	9.77	17.23
Modesty	17.96	9.04
Activity	17.27	9.73

MSAQ: Motion sickness assessment questionnaire, CNS: Central nervous system

Logistic regression analysis of treatment outcome

The logistic regression analysis was conducted to examine the association between various factors and treatment outcomes. Analyses indicated that among the variables considered, only MSAQ scores demonstrated a significant association with treatment outcomes. None of the other factors, including age, MSAQ facets, WNAI factors, or NEO-PI-R factors, showed a significant relationship with treatment outcomes.

Table 3 shows logistic regression analysis conducted to examine the relationship between the MSAQ score and the treatment outcome. The coefficient for the MSAQ score was found to be 0.061 ($P = 0.017$), indicating that for each one-unit increase in the MSAQ score, the log odds of failing the treatment increased by 0.061. The odds ratio was 1.063, signifying that the odds of failing the treatment increased by a factor of 1.063 for each one-unit increase in the MSAQ Score. The constant term, −4.107 ($P = 0.020$), represents the baseline log odds of treatment failure when the MSAQ score is zero. These findings suggest that the MSAQ score is a significant predictor of treatment outcome, with higher MSAQ scores associated with an elevated likelihood of treatment failure.

Table 3: Logistic regression between the MSAQ score and the treatment outcome.

	B	*SE*	Wald	*P*	Exponential B
MSAQ score	0.06	0.03	5.71	0.02*	1.06
Constant	−4.11	1.77	5.39	0.02*	0.02

*$P<0.05$. MSAQ: Motion sickness assessment questionnaire, SE: Standard error

Changes in MSAQ scores for successful treatment outcome group

Paired samples statistics were analyzed to assess changes in MSAQ scores before and after treatment for the cases who successfully achieved required criteria in the simulator run. For the unsuccessful cases, therapy was terminated as they could not complete the simulator run. Hence, post-evaluation of MSAQ was not conducted as the symptom did not mitigate.

Paired samples *t*-test [Table 4] indicated a significant difference between pre-treatment and post-treatment MSAQ scores (mean difference = 31.58, standard deviation = 23.62, standard error mean = 6.82, 95% confidence interval = 16.58–46.59), with $t(11) = 4.632$, $P = 0.001$. These findings suggest a notable reduction in MSAQ scores following successful treatment, indicating a positive impact on cases' air sickness symptoms.

DISCUSSION

This paper aimed to explore the psychological predictors of the efficacy of ASDT in aviators. Certain findings of the study challenge conventional psychological assumptions and shed light on the multifaceted nature of air sickness.

The overall statistical analysis results defy prevailing beliefs held by psychologists and psychiatrists regarding personality traits as predictors of air sickness treatment outcomes. The finding of this study delves into the efficacy of personality traits as predictors for air sickness susceptibility, as mentioned in prior researches.[2,14] Personality profiling emerges as a tool for positive prognosis, considering the substantial influence of external factors on predictive markers. This underscores the intricate interplay of various factors in inducing air sickness and suggests that state and external factors could exert a more substantial influence than inherent traits. Variables such as motion exposure, environmental conditions, and individual physiological responses may collectively contribute to the susceptibility.[4,5,15] Consequently,

Table 4: Paired samples *t*-score for MSAQ changes pre-post ASDT on successful cases.

	Paired differences		*t*	*P* (2-tailed)
	Mean	Std. deviation		
Pre ASDT - MSAQ Post ASDT - MSAQ	31.58	23.62	4.63	0.001

MSAQ: Motion sickness assessment questionnaire, ASDT: Air sickness desensitization therapy

a comprehensive understanding of the broader context, including psychological, physiological, and situational aspects, is essential to devising tailored interventions for air sickness management.[7,12]

This study employed a diverse range of statistical analyses to provide a comprehensive view of the data. The Kruskal–Wallis test uncovered significant differences in age and specific facets of the MSAQ and the NEO PI-R. This detailed examination allowed us to uncover nuanced patterns and relationships that may have otherwise gone unnoticed.

When compared to previous research involving flying crew members, our study reveals both consistencies and disparities. While some previous studies found links between specific personality traits and susceptibility to air sickness, our findings indicate that there is no specific relation. Discrepancies across studies may arise due to variations in sample characteristics, research methodologies, or contextual factors, emphasizing the importance of clinical judgment of psychologist and holistic view when interpreting findings.[16,17] While modesty and activity did not function as significant predictors of treatment outcomes in logistic regression analysis, their notable differences between successful and unsuccessful cases highlight their potential relevance in future studies. These findings suggest a nuanced role for these personality traits in influencing air sickness management outcomes, warranting further exploration in tailored intervention strategies.

The study reinforces the significance of individualized intervention strategies, that is, “caseness” for addressing air sickness challenges.[18] The significant differences found in age, MSAQ scores, and certain personality traits between successful and unsuccessful cases bring out the need for customized ASDT modules. These findings underscore the necessity of considering both internal psychological attributes and external conditions when designing effective interventions. A thorough understanding of each case’s unique context is vital for enhancing the success of interventions and improving the well-being and performance of aviation professionals.[4,19]

It is interesting to note that scores on MSAQ do influence the outcome of the therapy. The higher MSAQ indicate that a customized intervention with an eclectic approach needs to be designed to target vulnerability of mind and specific physiological systems. Such an eclectic system includes Jacobson’s modified progressive muscular relaxation, visual imagery, cognitive behavior therapy and mindfulness based on “caseness” and involves a intense collaborative effort from the therapist and the crew. Since it is highly subjective, a longitudinal study may be undertaken in a larger sample size with objectives to examine if high scores beyond a cutoff on MSAQ can serve as a predictive mechanism for success or failure of MSDT and the tailored interventions that would be effective in alleviating the motion sickness symptoms.

It is crucial to distinguish between operational protocols[8] and clinical treatment strategies for addressing air sickness challenges, particularly when it is associated with neurotic spectrum symptoms of anxiety and stress. Treating air sickness within this spectrum demands a more comprehensive and time-intensive approach involving gradual relaxation and desensitization techniques over an extended period. Given the constraints of a high-pressure training environment and limited time at the disposal of air warriors, the implementation of this approach may sometimes be limited in scope. By integrating clinical therapeutic strategies into ASDT modules, effective-tailored interventions will ensure high receptivity promoting a successful treatment outcome and effectively target the individual needs of aviators.

CONCLUSION

Our investigation significantly enhances the understanding of ASDT in aviation. While the absence of direct personality predictors underscores the complexity of air sickness, our findings emphasize the need for a multifaceted approach. Significant differences in age and MSAQ scores between successful and unsuccessful cases indicate that tailored interventions are essential. We advocate for a comprehensive strategy that integrates psychological, physiological, and environmental factors to optimize intervention outcomes. This tailored approach not only aims to improve the adaptability, retentivity, and receptivity to the motion stimuli but also supports the overall well-being and operational efficiency of aviation professionals. The successful return of even a single aircrew member to flying duties following treatment highlights the critical impact of our research in advancing aviation safety and performance standards.

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