Susceptibility to motion sickness in trainee pilots at the Portuguese Air Force: a cross-sectional study using the Motion Sickness Susceptibility Questionnaire – Short (MSSQ-Short)

Original Article

Authors

Beatriz Pereira
Universidade de Lisboa, Portugal

João Subtil
Força Aérea Portuguesa

Tatiana Santiago
Força Aérea Portuguesa

Correspondence:
Beatriz Pereira
beatrizpereira4@edu.ulisboa.pt

Article received on June 1, 2026.
Accepted for publication on July 31, 2026.

Abstract

This study aimed to evaluate susceptibility to motion sickness in pilot trainees at the Portuguese Air Force Academy and to identify individuals at risk for early intervention. This is a cross-sectional observational study with a retrospective analysis of Pilot Selection Stages between 2015 and 2025. A total of 95 student pilots were assessed using the MSSQ-Short, validated for the Portuguese population, and institutional records from 463 candidates were analysed. The majority presented low susceptibility (67.4%), while 32.6% showed moderate or high susceptibility and 28% reported motion sickness during the Pilot Selection Stages In the retrospective analysis, 46.6% were eliminated, with 22% of voluntary withdrawals and 15–16% of unfit candidates presenting symptoms compatible with motion sickness. Individuals with MSSQ≥5 showed a higher risk of motion sickness (OR=4.06; 95% CI: 1.58-10.43). The MSSQ-Short demonstrated usefulness as a screening and risk stratification tool in an aeronautical context.

Keywords: Motion sickness; MSSQ-Short; pilots; susceptibility.

Introduction

Motion sickness is a physiological phenomenon triggered by exposure to motion,[1] arising from sensory conflict among the visual, vestibular, and somatosensory systems. Although common, it is particularly relevant in aviation, where it can compromise pilot performance and operational safety. The symptoms of motion sickness include nausea, vomiting, vertigo, sweating, and cognitive changes that can impair operational performance [2]. In aviation settings, cognitive changes and performance impairment can manifest

as reduced navigation ability, altered time perception, and an impaired operational response [3]. During flight, pilots are exposed to multiple triggering stimuli, including sensory discrepancies between perceived and actual aircraft motion, changes in the gravito-inertial vector, and maneuvers involving G-forces [4]. Although habituation can make it adaptive over time, individual susceptibility varies significantly. Factors such as female sex, a history of migraine or vertigo, and genetic predisposition (estimated at 55%–70%) are associated with a higher risk.

Studies in military populations show that motion sickness is common in the early stages of training, with an estimated prevalence of 10%–31% among student pilots, decreasing with flight exposure [5]. However, interindividual variability can affect the habituation process, delaying progression through training and, in some cases, leading to interruptions in training. The Motion Sickness Susceptibility Questionnaire – Short Form (MSSQ-Short) is a widely used instrument for assessing susceptibility to motion sickness, based on previous episodes associated with different types of motion. Its recent validation for the Portuguese population makes it suitable for use in the Portuguese aeronautical context.

In military settings, habituation strategies are preferred because pharmacological therapy can compromise operational performance[6]. Despite the effectiveness of habituation programs, the time required for adaptation can interfere with progression through pilot training. In the Portuguese Air Force, initial flight exposure occurs during the Initial Flight Screening Program (Estágio de Seleção de Voo [ESV]), and subsequent flight exposure is limited until more advanced stages of training. The occurrence of motion sickness during these stages can disrupt training progression, leading to the need for intervention and possible discontinuation of training.

This study aims to use the MSSQ-Short to identify the individuals at risk of developing motion sickness during training at the Portuguese Air Force Academy (AFA). This will help stratify susceptibility and facilitate the early implementation of monitoring and intervention strategies, ultimately preventing incapacitating symptoms during advanced stages of training.

Materials and Methods

This was an observational, cross-sectional study conducted between August 2025 and March 2026. Data collection took place between December 2025 and January 2026. The participants received standardized instructions before completing the questionnaire. A total of 95 student pilots from the pilot-aviator (PILAV) program of the AFA were included. Individuals with previous vestibular disease or a history of participation in motion sickness desensitization programs at the Aeronautical Medicine Center of the Armed Forces Hospital were excluded. Motion sickness susceptibility was assessed using the validated Portuguese version of the MSSQ-Short [Questionário Sensibilidade ao Enjoo de Movimento – Versão Reduzida].[14] The MSSQ-Short evaluates the susceptibility to motion sickness based on previous experiences of motion-related sickness, yielding a total score ranging from 0 to 54. Susceptibility was classified according to the validated cutoff points: low (<5), moderate (5–15.8), and high (>15.8). The participants completed the questionnaire voluntarily and anonymously via an online form (*Google Forms*). Additionally, we performed a retrospective analysis of institutional data from Portuguese Air Force initial flight screening programs (2015–2025) by reviewing and independently compiling clinical and operational records provided by the Aeronautical Medicine Center and Air Force Recruitment Center. This analysis was purely descriptive, serving to contextualize the results of the main study, and was not included in the inferential analysis. The primary outcome was motion sickness susceptibility (MSSQ-Short score). Demographic variables (age, sex, and year of training) and the occurrence of motion sickness symptoms during the ESV (yes/no) were also analyzed. Data were analyzed using Google Sheets. Continuous va-

riables are described as mean ± standard deviation, and categorical variables are described as frequencies and percentages. Parametric or nonparametric tests were used depending on the distribution of the variables. The study was approved by the Ethics Committee of the Armed Forces Hospital and AFA. All data were anonymized, and participation was voluntary.

Results

A total of 95 student pilots from the AFA's PILAV program were included. The mean age was 20 ± 1.8 years (range, 18–28 years). The sample was predominantly male (n = 91; 96%), with 4 female participants (4%; Table 1).

The mean MSSQ-Short score was 4.1 ± 5.4. According to the recommended classification, 64 participants (67.4%) had low susceptibility, 27 participants (28.4%) had moderate susceptibility, and 4 participants (4.2%) had high susceptibility (Table 2).

No significant differences were observed in the MSSQ-Short scores between sexes (male: 4.1 ± 5.4; female: 4.5 ± 6.3; $p > 0.05$) or between years of training ($p > 0.05$; Table 3). Motion sickness episodes were reported by 27 participants (28%); 68 participants (72%) reported no symptoms (Table 4).

Among participants with symptoms during the ESV, 14 participants (51.8%) had an MSSQ-Short score ≥5. Motion sickness occurred significantly more frequently in individuals with an MSSQ-Short score ≥5 compared with those with an MSSQ-Short score <5 (48% vs. 19%; $\chi^2 = 8.99$; $p = 0.003$). Individuals with moderate or high susceptibility had a higher risk of motion sickness (OR = 4.06; 95% CI: 1.58–10.43). The MSSQ-Short showed a sensitivity of 55.6%, specificity of 76.5%, positive predictive value of 48.4%, and negative predictive value of 81.3%.

We performed a retrospective analysis of Portuguese Air Force initial flight screening programs between 2015 and 2025, including 463 candidates for the PILAV program. Of these, 215 candidates (46.6%) did not complete the course; this included 132 voluntary withdrawals and 83 disqualifications. Symptoms consistent with motion sickness

Table 1
Demographic characteristics of the sample

	Mean ± SD / n (%)
Age (years)	20 ± 1.8
Year 1	18 (19%)
Year 2	21 (22%)
Year 3	22 (23%)
Year 4	19 (20%)
Year 5	15 (16%)
Male	91 (96%)
Female	4 (4%)

Table 2
MSSQ-Short distribution and susceptibility categorization

	Mean (± SD) / n (%)
MSSQ-Short score	4.1 ± 5.4
Low susceptibility	64 (67.4%)
Moderate susceptibility	27 (28.4%)
High susceptibility	4 (4.2%)

Table 3
MSSQ-Short distribution by year of training and sex

	MSSQ-Short score
1st year	4.0 ± 4.1
2nd year	4.1 ± 3.6
3rd year	3.5 ± 4.6
4th year	4.8 ± 6.6
5th year	4.37 ± 8.1
Male	4.1 ± 5.4
Female	4.5 ± 6.3

Table 4
Occurrence of motion sickness episodes during the ESV

	n (% based on year of training)
1st year	8 (44%)
2nd year	2 (10%)
3rd year	8 (36%)
4th year	5 (26%)
5th year	4 (26%)
Male	26 (29%)
Female	1 (25%)
Total episodes	27 (28%)

were identified in 29 candidates of those who withdrew (22.0%) and in 13 disqualified candidates (15.7%). In 13 candidates of those who withdrew (9.8%), motion sickness was explicitly cited as the reason for withdrawal.

Discussion

Susceptibility was predominantly low in the study population, although a notable proportion of individuals had moderate to high susceptibility. Additionally, approximately 28% of candidates reported episodes of motion sickness during the ESV. These results are consistent with the international literature, which describes prevalence rates between 20% and 46% in military populations during the early stages of training [7], and rates of approximately 33% in simulator training settings [8]. Despite the high initial exposure, the literature suggests that a small proportion of individuals do not develop complete habituation even after continued exposure, which highlights the clinical and operational importance of this condition.

MSSQ-Short scores were significantly associated with the occurrence of motion sickness during the ESV, and individuals scoring ≥5 had a higher risk of symptoms (OR = 4.06; 95% CI: 1.58–10.43). These data support the usefulness of the tool for risk stratification. It has good overall discriminative ability, albeit with limitations in differentiating between homogeneous subgroups (sex and year of training), as reported in the literature [9,10].

The retrospective analysis of the ESV programs suggests that motion sickness may contribute substantially to attrition and failure in the selection process, although it is rarely recorded as a formal reason for elimination. This finding supports the possibility that the problem is underreported in institutional records and underscores the importance of

early identification. Most episodes of motion sickness occur in the early stages of flight exposure, consistent with the progressive habituation mechanisms described in the literature. However, a subpopulation exhibits greater susceptibility and lower adaptive capacity, and these individuals may benefit from early monitoring and intervention strategies. The MSSQ-Short proved useful as a screening and risk stratification tool. The early identification of more susceptible individuals may allow for the implementation of educational measures, psychological support, and desensitization programs, potentially reducing the impact of motion sickness on training progression.

The main limitations include the retrospective nature of the study, possible recall bias, and underreporting associated with social desirability bias. Additionally, the cross-sectional design does not allow for causal inference or longitudinal assessment of symptom evolution.

Conclusion

Motion sickness susceptibility was low overall among AFA student pilots, although approximately one-third had moderate or high susceptibility. MSSQ-Short scores were significantly associated with the occurrence of motion sickness during the ESV, confirming the tool's utility for screening and risk stratification for the early identification of individuals at higher risk of motion sickness and enable timely intervention.

Author Contributions

Beatriz Pereira was responsible for the study conception, data collection, statistical analysis, and initial drafting of the manuscript. João Subtil and Tatiana Santiago contributed to the scientific supervision of the work, interpretation of the results, and critical revision of the manuscript.

Acknowledgements

I would like to thank my supervisor and co-supervisor for their availability, guidance, and support throughout this work. I would also like to express my gratitude to my friends and family for their encouragement and understanding throughout this project.

Funding Sources

This work did not receive any contribution, funding or scholarship.

Availability of scientific data

There are no datasets available, publicly related to this work.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the author used ChatGPT as a tool to support scientific writing, namely to assist with linguistic reformulation of texts, improve clarity and sentence structure, support translation, and review stylistic consistency. After using this tool, the author critically reviewed, verified, and edited all content, ensuring scientific accuracy and taking full responsibility for the final content of the publication.

References

1.Cha YH, Golding JF, Keshavarz B, Furman J, Kim JS, Lopez-Escamez JA, et al. Motion sickness diagnostic criteria: consensus document of the Bárány Society. *J Vestib Res*. 2021;31(5):327-44. DOI:10.3233/VES-200005

2.Golding JF. Motion sickness. In: *Handbook of Clinical Neurology*. 2016;137:371–390. DOI: 10.1016/B978-0-444-63437-5.00027-3

3.Money KE. Motion sickness. *Physiol Rev*. 1970;50(1):1-39. DOI: 10.1152/physrev.1979.50.1.1

4.Bronstein AM, Golding JF, Gresty MA. Visual vertigo, motion sickness, and disorientation in vehicles. *Semin Neurol*. 2020;40(1):116-129. DOI: 10.1055/s-0040-1701653

5.Leung AKC, Hon KL. Motion sickness: an overview. *Drugs Context*. 2019;8:2019-9-4. DOI: 10.7573/dic.2019-9-4

6.Powell-Dunford N, Bushby A. Management of sea sickness in susceptible flight crews. *Mil Med*. 2017;182(11-12):e1846-e1850. DOI: 10.7205/MILMED-D-17-00029

7.Samuel O, Tal D. Airsickness: etiology, treatment, and clinical importance — a review. *Mil Med*. 2015;180(11):1135-1139. DOI: 10.7205/MILMED-D-14-00315

8.Qi Loi JE, Ling Lee ML, Chuan Tan BB, See B. Time course of simulator sickness in Asian military pilots. *Aerospace Med Hum Perform*. 2020;91(11):892–896. DOI: 10.3357/AMHP.5674.2020.

9.Shi L, Zhao J, Lu J, Cao C, Zhang Q, Qiu C, et al. Effects of two kinds of vestibular function training on reducing

motion sickness in college students. Front Neurol. 2025;16:1433065. DOI: 10.3389/fneur.2025.1433065.
10.Lamb S, Kwok KCS. MSSQ-Short norms may underestimate highly susceptible individuals: updating the MSSQ-Short norms. *Hum Factors*. 2015;57(4):622-633. DOI: 10.1177/0018720814555862
11.Golding JF. Motion sickness susceptibility. *Auton Neurosci*. 2006;129(1-2):67-76. DOI: 10.1016/j.autneu.2006.07.019
12.Lackner JR. Motion sickness: more than nausea and vomiting. *Exp Brain Res*. 2014;232(8):2493-2510. DOI: 10.1007/s00221-014-4008-8
13.Paillard AC, Quarck G, Paolino F, Denise P, Paolino M, Golding JF, Ghulyan-Bedikian V. Motion sickness susceptibility in healthy subjects and vestibular patients: effects of gender, age and trait-anxiety. *J Vestib Res*. 2013;23(4-5):203-209. DOI: 10.3233/VES-130501
14.Santos C, Costa T, Matos T, Saraiva J. Validação e adaptação do Questionário Sensibilidade ao Enjoo de Movimento – versão reduzida para a língua e população portuguesa de Portugal. *Rev Port Otorrinolaringol Cir Cabeça Pescoço*. 2025;63(1):517–522. DOI: 0.34631/sporl.2168.
15.Greco A, et al. Hormones and Biomarkers in Student Pilots Before and After Rehabilitation from Airsickness. Aerosp Med Hum Perform. 2025 Jun;96(6):461-468. DOI: 10.3357/AMHP.6811.2025.
16.Aerospace Medical Association Working Group. Mental health considerations in aviation personnel. 2016. https://www.asma.org
17.Hospital das Forças Armadas – Centro de Medicina Aeronáutica. Dados institucionais dos Estágios de Seleção de Voo (ESV), 2015–2025. Lisboa, Portugal. *(dados internos não publicados)*