Grounding of Pilots: Medical Reasons and Recommendations for Prevention

Ries Simons; René Maire; Alwin Van Drongelen; Pierre Valk

BACKGROUND: This article presents the results of an EASA-commissioned study aimed at analyzing the medical causes of grounding of a broad European pilot population and recommending measures to reduce the risk of in-flight incapacitation in commercial air transport pilots.

METHOD: European National Aviation Authorities (NAAs) were requested to provide data concerning the total number of pilots that were examined, their age and license category, number of unfit pilots, and the medical causes of each case of grounding. Diagnoses were classified according to the format and definitions laid down in Commission Regulation (EU) No. 1178/2011 Part Med.

RESULTS: Analyzed were 82,435 cases assessed by 6 NAAs. Of these cases, 2.1% were assessed as unfit to fly. Frequent causes for grounding a pilot were cardiovascular (19%), psychiatric (11%), neurological (10%), and psychological (9%). Cardiovascular conditions were the most frequent cause for grounding in the older age groups, with 21% in the age 51–60 cohort, 28% in the age 61–65 cohort, and 48% in those beyond 65 yr. Psychiatric and psychological diagnoses were most frequent in the age 20–40 cohort.

DISCUSSION: Cardiovascular conditions were the most frequent cause for grounding. Cardiovascular diseases (CVD) are associated with modifiable risk factors. Tackling these risk factors gives aeromedical examiners the opportunity to improve the health of pilots and reduce CVD-related flight safety risks by reducing the number of pilots at risk of in-flight incapacitation. The mandatory periodical medical examination of pilots provides an excellent framework for risk prevention and follow-up of preventive measures.

KEYWORDS: pilot health, cardiovascular diseases, incapacitation risk, stratified risk assessment, prevention.

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European commercial air transport (CAT) pilots have to undergo an annual (up to the age of 60) or semiannual (over 60) medical examination by an aeromedical examiner (AME) in order to assess their fitness to perform all flying tasks and their risk of acute in-flight incapacitation due to a medical event.[9] Current European rules mandate age limits of 60 yr for commercial single-pilot operations and of 65 yr for multipilot operations.[9] As life expectancy and socially acceptable retirement ages have increased in Europe, the European Aviation Safety Agency (EASA) is challenged to reconsider these mandatory age limits. In that context EASA commissioned a project to develop medical references related to the risk of pilot incapacitation in relation to the pilot's age and to determine whether the risk of incapacitation can be mitigated by appropriate health screening.[23]

Within the framework of this project a systematic literature study has been done in which it was found that in-flight incapacitation of pilots due to a medical cause is estimated to occur up to 0.45 times per 10^6 flight hours or 0.25% per annum.[7,11,23] Evidence was found for an increasing rate of

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in-flight incapacitations with increasing age.[23] Of in-flight incapacitations, 50 to 70% are caused by problems that cannot be predicted during the periodical medical screening and are barely preventable: acute gastroenteritis, laser strikes, headache, and ear/sinus conditions.[15,16] The remaining 30–50% of in-flight incapacitations are, to a great extent, caused by potentially preventable causes, such as sudden cardiac death, acute coronary syndrome, cardiac arrhythmias, pulmonary embolism, and stroke.[13,23] Because in-flight incapacitation is a rare event, data of the medical causes of incapacitation might not represent the full scope of medical conditions that need to be dealt with when trying to improve a pilot's fitness and reduce in-flight incapacitation risks. Grounding of pilots for medical reasons is based on the consideration that the medical condition concerned bears an unacceptable risk of inability to safely perform flying tasks or in-flight incapacitation. A study of the medical conditions related to grounding of pilots can, therefore, provide indicators of the health status of the pilot population and additional knowledge regarding the medical conditions that should be considered in the context of incapacitation risk. Quantitative data from the literature showed evidence that the most prevalent medical causes for grounding of pilots are cardiovascular, neurological, psychological/psychiatric conditions (including problematic use of substances), and musculoskeletal conditions.[2,11,14] While musculoskeletal conditions are common causes of unfitness to fly, they are not considered an important cause of acute in-flight incapacitation as these conditions prevent pilots from flying in most cases.

The above-mentioned scientific studies concerned national cohorts with relatively small numbers of grounded pilots. Disease patterns of national cohorts might be influenced by geo-epidemiological effects. For example, it is known that prevalence of ischemic heart disease may differ between Eastern, Western, Northern, and Southern European countries.[24] The present article presents the results of the EASA-commissioned study,[23] which aimed at analyzing the aeromedical fitness and medical causes of grounding of pilots representing a broad European pilot population, and to assess the main medical risk factors influenced by age. Based on the results of this study, the advisability of preventive measures to improve pilots' health and flight safety will be discussed.

METHODS

After approval of the study protocol by the Institutional Review Board of the Netherlands Organization for Applied Scientific Research and consultation with EASA, the available anonymized data of aeromedical examinations concerning CAT pilots were requested of 18 European National Aviation Authorities (NAAs). Requested data concerned total number of pilots screened, their age category, license category (EASA Class 1, Class 2), number of unfit pilots per subgroup, and the medical diagnoses of each case of unfitness to fly. The diagnoses were classified according to the format and definitions laid down in EASA Commission Regulation No. 1178/2011 Part Med.[9]

Data of the responding NAAs were pooled, after which the Class 1 (commercial pilots) and Class 2 (private pilots) medical examinations were analyzed. Associations between age category, license category, and unfitness were assessed. This was also done for the most frequent medical diagnoses that are generally considered to bear the highest incapacitation risks.[7,11,23] For each diagnostic category observed, frequencies for each age group were compared with expected frequencies in case of even distribution using Chi-squared statistics. Although there are some differences between the requirements of Class 1 and Class 2 medical certificates, it was decided to include data of both categories in our analyses, as it was considered that this would enable a more robust analysis of the 60–65 age group. The number of pilots older than 60 yr is low in the Class 1 cohort due to the existing age limit of 60 for single flying commercial pilots and a smaller number of airline pilots who are active up to the age of 65.

RESULTS

Six NAAs were able to submit all required data. NAAs that were not able to provide data attributed their inability to inaccessibility of their database for digital data retrieval and understaffing, preventing manual data retrieval. A total of 50,101 Class 1 examinations and 32,334 Class 2 examinations were included in the analysis. Data covered a time span from 2013 to 2017. Of the grand total of 82,435 examinations, 1724 cases (2.1%) were found in which a pilot was assessed as unfit to fly.

Table I shows that among the 1074 unfit cases of Class 1 pilots, the highest rate was found in 51–60 age category (4.4%), followed by the 61–65 and >65 age categories (3.0% both). Among the 652 unfit cases of Class 2 pilots, the highest rates were found in the 61–65 category (2.9%) and >65 category (3.1%).

Fig. 1 shows the relative contribution of the diagnostic categories that bear the highest incapacitation risks to the total number of unfit pilots. Cardiovascular conditions were the most frequent cause (19%) of unfitness, followed by psychiatric (11%), neurological (10%), and psychological conditions (9%).

Table I. Number of Examined and Unfit Pilots Per Age Category and License Category.

AGE	CLASS 1	UNFIT (%)	CLASS 2	UNFIT (%)	TOTAL	UNFIT (%)
20–40	24,149	358 (1.5%)	6.987	125 (1.8%)	31.136	483 (1.6%)
41–50	14,950	266 (1.8%)	7.569	112 (1.5%)	22.519	378 (1.7%)
51–60	8396	370 (4.4%)	8.893	147 (1.7%)	17.289	517 (3.0%)
61–65	1843	55 (3.0%)	3.347	96 (2.9%)	5.190	151 (2.9%)
>65	763	23 (3.0%)	5.538	172 (3.1%)	6.301	195 (3.1%)
Total	50,101	1072 (2.1%)	32,334	652 (2.0%)	82,435	1724 (2.1%)

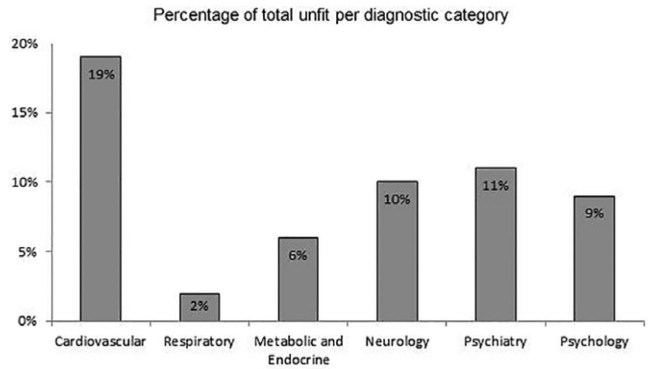

Fig. 1. Relative contribution of the diagnostic categories to the total number of unfit cases (N = 1724; pooled data of Class 1 and 2).

The differences between the different age groups in diagnostic categories causing unfitness are shown in **Table II**. Cardiovascular conditions are the most frequent reason for unfitness in the older age groups, with 21% (517 cases) in the 51–60 group, 28% (151 cases) in the 61–65 group, and 48% (195 cases) in those beyond 65 yr of age. It is noteworthy that in the 20–40 age group psychiatric and psychological reasons for grounding were most frequent. Frequencies of neurological causes of unfitness were evenly distributed between all age groups. For all other medical conditions, the frequencies of unfit cases per age group differed significantly from what was expected in case of even distribution ($\chi^2 P < 0.05$).

DISCUSSION

The geographical distribution of the six responding NAAs showed a fair balance between Eastern, Western, Northern, and Southern European states. The collected NAA data covered more than 80,000 aeromedical examinations and included more CAT pilots ages 61–65 (N = 1843) and >65 yr (N = 763) than comparable national studies.[2,11,14] Therefore, we consider the present data provide a good representation of the European pilot population and allow for a well-founded estimation of the aeromedical fitness of pilots and of older pilots in particular. A limitation of the study was that, due to understaffing and/or limited accessibility of their data systems, several European NAAs were not able to provide us with the requested data. A larger response would have led to an even more robust dataset.

Among those holding a commercial pilot license (Class 1), a clear effect of aging on the unfitness rate was found, with the highest rate in the 51–60 age cohort and, although slightly lower, in the >60 age cohorts. The slightly lower unfitness rate in the >60 age cohorts might be explained by a healthy worker effect caused by self-selection and medical screening, leaving the more physically and mentally fit older pilots in the workforce.[18]

The results of the analyses are in agreement with the outcomes of the national studies on the most frequent medical reasons for grounding pilots being cardiovascular, neurological, and psychological/psychiatric conditions.[2,11,14] The present study shows that 19% of all medical reasons for grounding of European pilots concerned a cardiovascular condition. This finding is in agreement with the studies of Årva and Wagstaff,[2] Evans and Radcliffe,[11] and Høva et al.[14] The results of our study show a significant increase in unfitness cases of pilots due to cardiovascular conditions with increasing age, which is in conformity with the findings of national studies of Zeeb et al.[25] and Linnersjö et al.[18]

The fact that the present study found cardiovascular conditions to be the most frequent reason for grounding and loss of license of pilots underlines the importance of prevention. Cardiovascular diseases (CVD) are associated with modifiable risk factors, such as smoking, high blood pressure, dyslipidemia, diabetes mellitus, large waist circumference and high BMI, unhealthy nutrition, low physical activity level, and excessive alcohol intake. Tackling these risk factors gives aeromedical examiners the opportunity to improve the health of pilots and reduce flight safety risks. Early prevention of cardiovascular disease is considered to reduce the number of pilots at risk of acute in-flight incapacitation and thereby improve flight safety.[10] This is important because the sensitivity to identify coronary risk equivalents in midlife is imperfect and it is assumed that 25% of cases may remain undetected.[21] Therefore, prevention by means of individually tailored counseling should be an important part of each aeromedical examination. In accordance with the recommendations of the International Civil Aviation Organization,[15] we recommend screening CAT pilots on modifiable and nonmodifiable cardiovascular risk factors and advising the individual pilot how to reduce these risks. The mandatory annual examination of CAT pilots provides an excellent framework for risk prevention and follow-up of the preventive measures that were advised to the pilot in question. For safety risk screening in combination with pilot's health prevention, it is recommended to use a stratified cardiovascular risk assessment approach.[13,22]

Stratified cardiovascular risk assessment includes a full clinical history and physical examination, blood lipids and glucose, and estimation of the 5–10 yr nonfatal and fatal CVD risk using a CVD risk calculator appropriate for the pilot's gender and

Table II. The Relative Contribution of the Most Frequent Diagnostic Categories Causing Unfitness to the Total Number of Unfitness Cases Per Age Group.

AGE (YR)	CARDIOVASCULAR	RESPIRATORY	METABOLIC ENDOCRINE	NEUROLOGY	PSYCHIATRY	PSYCHOLOGY
20–40	8%	3%	4%	7%	15%	20%
41–50	13%	1%	4%	11%	14%	8%
51–60	21%	2%	6%	10%	10%	4%
61–65	28%	2%	13%	11%	8%	2%
>65	48%	0%	6%	13%	2%	1%

ethnicity.[23] Risk calculators use an equation with regression coefficients for factors such as age, gender, LDL- and HDL-cholesterol and triglycerides, systolic blood pressure, smoking, diabetes mellitus, and a family history. A statistical analysis of epidemiological data derived from a defined population cohort is used to provide a crude risk estimate. Frequently used CVD risk calculators, such as the Framingham risk score[6] and the Prospective Cardiovascular Munster Study (PROCAM),[3] consider a 10-yr risk of <10% as low, 10–20% as intermediate, and >20% as high, while the Pooled Cohort Equations[12] and the Reynolds Risk Score,[20] respectively, consider ≥7.5% and ≥10% as high risk scores. Although the Systematic Coronary Risk Evaluation (SCORE) risk charts[5] are easy to use tools adapted to suit different European populations, they are considered less suitable for risk assessment in CAT pilots because Systematic Coronary Risk Evaluation does not estimate nonfatal CVD risk, and a nonfatal cardiac event might be the cause of in-flight incapacitation.

Modifiable and nonmodifiable risk factors should be considered in making a clinical judgement about the individual's total CVD risk. Related conditions that could contribute to CVD risk, such as diabetes, chronic kidney disease, familial hypercholesterolemia, and the presence of atrial fibrillation should also be considered. A 12-lead resting ECG is recommended to identify abnormal conduction or other arrhythmogenic patterns that could increase the risk of cardiovascular incapacitation in aircrew. For pilots with a low 10-yr CVD risk score preventive lifestyle counseling with emphasis on healthy diet and exercise measures is recommended. An intermediate 10-yr CVD risk score may be reclassified to a lower or higher level using additional laboratory tests such as high sensitivity C reactive protein (hs-CRP), or apolipoprotein B. A hs-CRP level of ≥2.0 $mg \cdot L^{-1}$ or apolipoprotein B ≥130 $mg \cdot dL^{-1}$ can be considered a risk-enhancing factor that may lead to a higher risk classification.[4,12] In the future genetic exploration using artificial intelligence might play an important role in the evaluation of cardiovascular risk.

Pilots with an intermediate or high CVD risk should be referred for enhanced cardiological risk assessment using

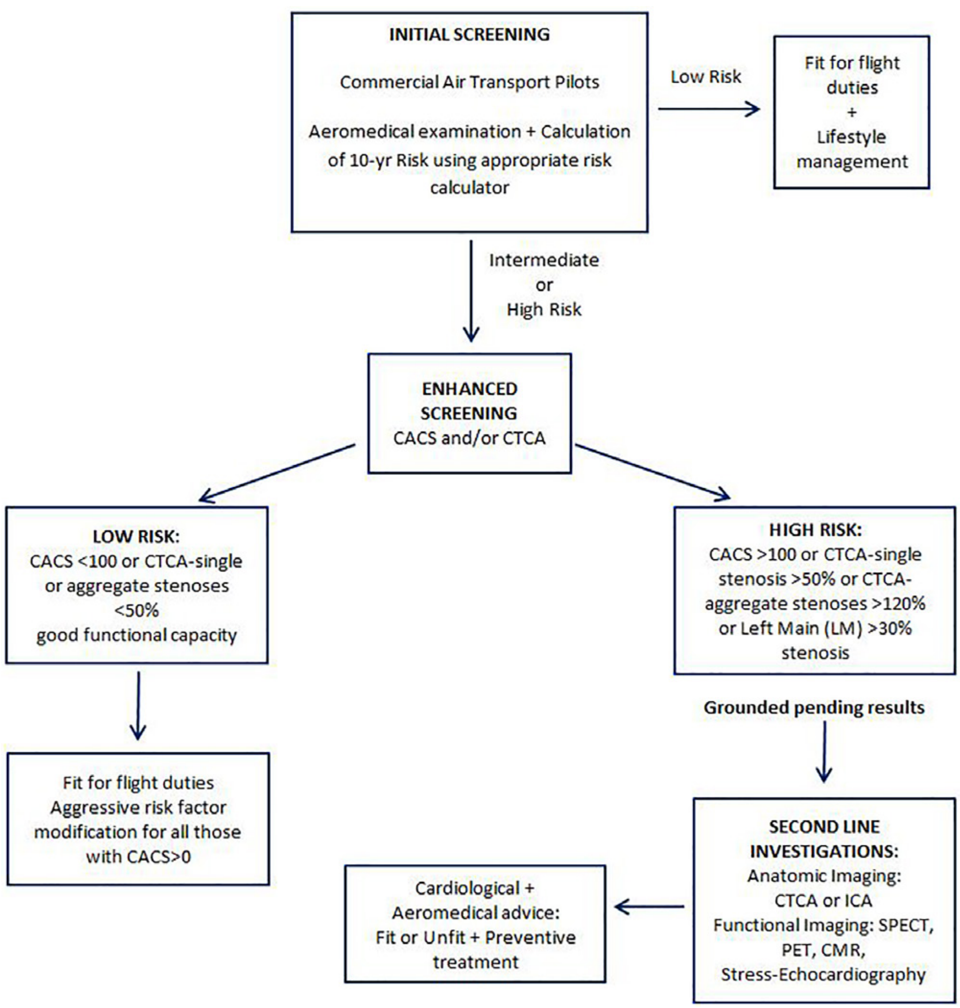

Fig. 2. Flow chart with algorithm adapted from Gray et al.[13] This algorithm is aimed at supporting AMEs and medical assessors. The classification of low, intermediate, or high risk is given by the cardiovascular score being used. The enhanced screening investigations are in the realm of the consultant cardiologist. CACS = coronary artery calcium score; CTCA = computed tomography coronary angiography; SPECT = single-positron emission tomography; PET = positron emission tomography; CMR = cardiac magnetic resonance; ICA = invasive coronary angiography.

state-of-the-art cardiological techniques. Depending on the nature of the individual case, the cardiologist can decide to use coronary artery calcium score, computed tomography coronary angiography, single-positron emission tomography, positron emission tomography, cardiac magnetic resonance, or invasive coronary angiography. Computed tomography coronary angiography is currently recommended as the preferred method for the analysis of the coronary anatomy.[8,17]

It is considered useful to start CVD risk estimation and preventive counseling in the beginning of a pilot's career because it is known that atherosclerosis progresses during adolescence and young adulthood[19] and there is evidence that elevated non-high-density lipoprotein cholesterol in adolescence is strongly associated with coronary atherosclerosis in midadulthood.[1] The flow chart in **Fig. 2**, adapted from Gray et al.,[13] is aimed to support the AME and medical assessors in the process of deciding a pilot's fitness to fly. It shows the decision criteria for each step of the stratified risk assessment and it allows an in-depth CVD risk estimation by anatomical and, if necessary, functional methods.

As the present study shows in-flight incapacitations are to an important extent caused by potentially preventable cardiovascular causes, it is recommended to intensify CVD prevention in pilots in order to reduce the number of pilots at risk. Therefore, aircrew should be periodically screened using a stratified CVD risk assessment as described in Fig. 2 or using a similar approach. The emphasis should be on tailor-made prevention of modifiable risk factors by a healthy lifestyle, diet, and exercise measures. The serial character of the annual medical screening of CAT pilots enables the identification of individual trends in CVD risk and the timely intensification of preventive measures if necessary.

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