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THE 1980 AND 1981 ACCIDENT EXPERIENCE OF CIVIL AIRMEN WITH SELECTED VISUAL PATHOLOGY

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16. Abstract

In studies of the 1974-76 accident experience of U.S. general aviation pilots with static physical defects, all the significantly increased rates and ratios were for visual defect categories--blindness or absence of either eye, deficient distant vision, deficient color vision with no operational limitations, and contact lenses. A 1979 study was limited to accident airmen with 19 visual deficiencies. The 1,140 pilots with aphakia and 173 with artificial lens implants had significantly higher rates, but the monocular pilots and contact lens users did not. The present study examined the 1980-81 accident experience of 4,169 monocular pilots, 1,299 with amblyopia, 969 with aphakia, 285 with lens implants, 118 with a history of diplopia, 1,269 with a tropia, 2,601 with hyperphoria >1 diopter, and 2,711 with esophoria or exophoria >6 diopters by class of medical certificate held.

Numbers were too small for statistical treatment, but first and second class medical certificate holders, who often have more accidents per 1,000 airmen, consistently had progressively lower accident rates per 100,000 hours. They fly more. Monocular, aphakic, lens implant, and amblyopic accident airmen had higher accident rates than did the total airman population.

Bases were found to question the value and adequacy of phoria and field of vision testing.

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THE 1980 AND 1981 ACCIDENT EXPERIENCE OF CIVIL AIRMEN WITH SELECTED VISUAL PATHOLOGY

INTRODUCTION

In studies of the 1974-76 accident experience of U.S. general aviation pilots with static physical defects (1,2,3), all the significantly increased rates and ratios were for visual defect categories--blindness or absence of either eye, deficient distant vision, deficient color vision with no operational limitations, and contact lenses. The blindness or absence of an eye group included administratively monocular pilots who had a best corrected acuity of 20/200 or worse in one eye. The deficient distant vision group included applicants for first and second class medical certificates who had poorer than 20/100 distant vision in one or both eyes before correction or applicants who failed to correct to the standards for any class of certificate. The defective color vision group had taken and passed a color signal light gun test, and limitations on flight at night or by color signal control had been removed. Neither the deficient distant vision group nor the defective color vision group had a higher accident rate when their rates were calculated on the basis of recent flight time (self-reported flying time during the 6 months before their last physical examinations).

A 1979 study (4) was limited to accident airmen with 19 visual deficiencies. The 1,140 pilots with aphakia and 173 with artificial lens implants had significantly higher accident rates, but the monocular pilots and contact lens wearers did not. Aphakia, lens implant, and monocular categories were deemed worthy of further study. Since some airmen who had accidents had uncorrectable distant visual acuities better than 20/200 in one eye and no organic lesions, and others had an entry of "no fusion" on their reports of examination, the amblyopia and tropia categories were also scheduled for reevaluation even though their 1979 accident rates were not significantly higher than expected.

A recent case report (5) raised questions about the detection of diplopia proneness, phoria values for which a specialist evaluation is indicated, and the need for phoria testing, which may be relevant to the upcoming FAA review of all airman medical standards. Therefore, airmen with a history of diplopia were chosen for reexamination, although this small group had no accidents in 1979, and a special effort was made to identify for study those pilots with more than 1 prism diopter of hyperphoria, 6 prism diopters of esophoria, or 6 prism diopters of exophoria.

METHOD

There were 718,186 active airmen with pilot certificates on January 1, 1982. This was the best base available for this study. According to our records, they were involved in 8,844 accidents during 1980 and 1981.

The frequencies of the 10 selected eye pathologies (diplopia, tropia, aphakia, lens implants, blindness or absence of an eye, amblyopia, right hyperphoria >1 diopter, left hyperphoria >1 diopter, esophoria >6 diopters, and exophoria >6 diopters) were determined in the active airman population. For each category, (i) the total self-reported flying time for the 6-month period before each airman's last physical examination, (ii) extrapolated total flying time for

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2 years, (iii) accident frequency, (iv) a pathology specific accident rate for each 1,000 airmen per year, and (v) a pathology specific accident rate per 100,000 hours of flight time per year were determined. Significance was determined by critical ratio rate testing, where possible.

Medical and accident files for each case were reviewed to determine the accuracy and currency of assigned pathology codes; ascribed causal roles in the accidents; details of accidents to include type of operation, phase of flight, visibility, and the likelihood of eye pathology being a factor; the presence of unilateral or bilateral aphakia and lens implants; field of vision reported for monocular pilots; and classes of medical certificates held for calculation of class specific accident rates for each pathology category.

RESULTS AND DISCUSSION

The airman frequencies for nine selected pathology and airman categories on January 1, 1982, by class of medical certificate held, are shown in Table 1. The active airman population is about 110,000 less than the January 1, 1980, total used in our last analysis; only the lens implant and tropia conditions were more frequent for this study. Phoria measurements are required only for first and second class medical certificates.

TABLE 1. AIRMAN FREQUENCIES FOR SELECTED PATHOLOGY CATEGORIES BY CLASS OF MEDICAL CERTIFICATE HELD, JANUARY 1, 1982

	Population Frequency			
Category	Class I	ClassII	Class III	Total
Monocular vision	153	865	3,151	4,169
Amblyopia	54	271	974	1,299
Aphakia	92	277	600	969
Lens implant	36	85	164	285
Diplopia	18	52	48	118
Tropia	125	505	639	1,269
Hyperphoria >1 diopter	467	2,004	130*	2,601
Esophoria or exophoria >6 diopters	531	2,073	107*	2,711
Total airman population	103,045	225,603	389 538	718,186

*Test not required for third class medical certificate.

The sums of self-reported flight times, for the 6 months preceding the most recent physical examination, are given for each category and class in Table 2. Each figure has been multiplied by four in order to estimate the flight times for 1980 and 1981.

TABLE 2. RECENT SELF-REPORTED AND ESTIMATED FLIGHT TIME BY CLASS OF MEDICAL CERTIFICATE FOR SELECTED PATHOLOGY CATEGORIES AND TOTAL ACTIVE AIRMAN POPULATION, 1980-81

Category	Hours of Recent Flight Time by Population			
	Class I	Class II	Class III	Total
Monocular vision	36,633 (146,532)	60,319 (241,276)	65,533 (262,132)	162,485 (649,940)
Amblyopia	11,772 (47,088)	16,545 (66,180)	17,953 (71,812)	46,270 (185,080)
Aphakia	22,331 (89,324)	18,889 (75,556)	12,859 (51,436)	54,079 (216,316)
Lens implant	7,714 (30,856)	7,412 (29,648)	3,716 (14,864)	18,842 (75,368)
Diplopia	3,357 (13,428)	3,944 (15,776)	937 (3,748)	8,238 (32,952)
Tropia	29,387 (117,548)	34,405 (137,620)	10,690 (42,760)	74,482 (297,928)
Hyperphoria >1 diopter	91,219 (364,876)	108,746 (434,984)	3,223 (12,892)	203,188 (812,752)
Esophoria or exophoria >6 diopters	66,242 (264,968)	114,224 (456,896)	2,131 (8,524)	229,258 (917,032)
Total airman population (1/1/82)	22,663,314 (90,653,256)	12,808,165 (51,232,660)	6,104,589 (24,418,356)	41,576,068 (166,304,272)

Estimated 2-year totals ( )

The medical and accident records of 141 airmen with one or more of the selected pathologies, and an aircraft accident during 1980 or 1981, were reviewed. No accident was attributed to a medical problem in the FAA report. (The National Transportation Safety Board makes the official determination of cause(s) in each accident, and these reports were not readily available for this study.)

Of the 31 accidents involving airmen originally identified as having more than 1 prism diopter of hyperphoria, 16 were deleted for the analysis after review of the medical records. Five had been reported with the same amount of both left and right hyperphoria (probably double entry of the answer to "what stair does the line cross?"), seven were felt to have measurement errors since the hyperphorias on only one exam differed considerably from the normal findings on all prior and at least one subsequent exams, and four were clerical (heart rates had been typed on the wrong line on one, 0.5 became 5 on another, and two were miscoded by our staff).

When the records were checked for 38 accident airmen listed as having more than 6 diopters of esophoria or exophoria, all but 16 were deleted because of reported esophoria and exophoria (6 cases) and clerical errors.

It should be noted that the errors reported in this study were detected during a special screening of nearly 1,000,000 reports of airman physical examinations to specifically look for these mistakes.

Accident frequencies by class of medical certificate held for the selected pathology categories and for the active airman population are shown in Table 3.

TABLE 3. ACCIDENT FREQUENCIES BY CLASS OF MEDICAL CERTIFICATE HELD FOR SELECTED PATHOLOGY CATEGORIES AND ACTIVE AIRMAN POPULATION, 1980-81

	Accident Frequency by Class			
Category	Class I	Class II	Class III	Total
Monocular vision	2	17	24	43
Amblyopia	0	4	7	11
Aphakia	2	5	6	13
Lens implant	0	1	5	6
Diplopia	0	0	1	1
Tropia	0	7	4	11
Hyperphoria >1 diopter	0	14	1	15
Esophoria or exophoria >6 diopters	3	13	0	16
Total airman population (1/1/82)	1,291	3,901	3,652	8,844

One monocular pilot (of 43) landed on rough ground at the edge of the runway and another veered off a road to his right (blind) side after a precautionary landing. Eight others had landing accidents. This is a near-normal percentage of landing accidents and no definite associations with the pathology can be made.

Nine accident airmen with amblyopia had best distant visual acuities in one eye of 20/40 to 20/100. These nine had four landing accidents. Two with amblyopia and visual acuities of 20/200 or poorer were also coded as monocular.

A 75-year-old pilot with aphakia and a lens implant in the left eye drifted left and struck a pile of dirt to the left of a farm strip; he blamed a "whirlwind." Thirteen pilots with aphakia had one accident while taxiing, three on landing, and two during spray runs.

The one accident involving a pilot with a history of diplopia was due to loss of control on landing.

One pilot with a tropia, who was reported on a specialist's examination to disregard his right visual field, landed on plowed ground between the runway and taxiway. Three of the other 10 accident airmen with tropias had their accidents on landing.

Our uncertainty about any association between these visual defects and the accidents cited above illustrates our ignorance of operational vision requirements and of practical measurement techniques for essential functions.

Thirty pilots who had been screened out with moderate phorias, and who had accidents, reported no diplopia and had no increased percentage of accidents during the approach and landing phases. Three (two fatal) accidents occurred when agricultural aviation pilots struck wires and trees during spray runs on clear days. The relationships between heterophoria, fatigue, dim light, a break in fusion, decreased depth perception, diplopia, and accidents are unknown. We remain unconvinced that routine phoria measurements for first and second class medical certificates are worth the cost for predicting flying ability and recommend consideration of this question during the forthcoming review of vision standards.

Accident rates per 1,000 airmen per year, by class of medical certificate held, for pathology, phorias, and total active airmen categories are shown in Table 4. The effects of differences in flight time by class are not apparent in this treatment, and the numbers are too small to provide discrimination power for determination of statistical significance.

Table 5 shows accident rates per 100,000 hours of extrapolated self-reported flight time, by class of medical certificate held, for the selected pathology, phorias, and total active airmen categories. While the numbers are too small for statistical treatment in other than the total airman population category, an interesting association of accident rates with class of medical certificate is noted as are higher rates than the total population rate for monocular, aphakic, lens implant, and amblyopic accident airmen. A longer term study will be necessary if we are to determine statistically significant accident rates for these medical conditions by class of medical certificate.

TABLE 4. ACCIDENT RATES PER 1,000 AIRMEN PER YEAR BY CLASS OF MEDICAL CERTIFICATE FOR SELECTED PATHOLOGY CATEGORIES AND TOTAL ACTIVE AIRMAN POPULATION, 1980-81

Category	Pathology-Class Specific Rate/1,000 Airmen/Year			
	Class I	Class II	Class III	Total
Monocular vision	6.5	9.8	3.8	5.2
Amblyopia	-	7.4	3.6	4.2
Aphakia	10.9	9.0	5.0	6.7
Lens implant	-	5.9	15.2	10.5
Diplopia	-	-	10.4	4.2
Tropia	-	6.9	3.1	4.3
Hyperphoria >1 diopter	-	3.5	3.8	2.9
Esophoria or exophoria >6 diopters	2.8	3.1	-	3.0
Total airman population (1/1/82)	6.3	8.6	4.7	6.2

TABLE 5. ACCIDENT RATES PER 100,000 HOURS OF RECENT FLIGHT TIME BY CLASS OF MEDICAL CERTIFICATE FOR SELECTED PATHOLOGY CATEGORIES AND TOTAL ACTIVE AIRMAN POPULATION, 1980-81

	Pathology-Class Specific Rate/100,000 Hours/Year			
Category	*Class I*	*Class II*	*Class III*	*Total*
Monocular vision	1.4	7.0	9.2	6.6
Amblyopia	-	6.0	9.7	5.9
Aphakia	2.2	6.6	11.7	6.0
Lens implant	-	3.4	33.6	8.0
Diplopia	-	-	26.7	3.0
Tropia	-	5.1	9.4	3.7
Hyperphoria >1 diopter	-	3.2	7.8	1.8
Esophoria or exophoria >6 diopters	1.1	2.8	-	1.7
Total airman population (1/1/82)	1.4*	7.6*	15.0*	5.3

*Significant at 0.01

One monocular accident airman had 20/800 uncorrected distant vision recorded as 20/20 on one exam; three with uncorrectable 20/200, 20/200, and 20/400 distant visual acuity in one eye had corrections to 20/15, 20/20, and 20/20, respectively, on one of their exams; and two had the eye with defective vision reversed on one exam. While these errors are relatively rare, aviation medical examiners must be regularly reminded of the need for maximum accuracy.

Normal field of vision in each eye is commonly reported for monocular pilots. Many with an uncorrectable distant visual acuity of 20/200 will have useful peripheral vision in that eye. Of 43 pilots with monocular vision in this study, the reported normal field of vision is suspect in 7 with no useful vision in one eye and in 13 where other aviation medical examiners had reported defects. From the cases reviewed here, one must question whether the test is done in many cases, performed correctly with a perimeter or tangent screen, and worth the cost of proper testing on each exam. This requirement, too, is recommended for further evaluation.

The present certification policy for monocular pilots is as follows. If an eye has been enucleated or if an initial applicant (or an applicant for first or second class certification with less than 250 hours of flight time) has an eye that does not correct to at least 20/200, distant vision, there must be no pathology in the better or remaining eye, its distant visual acuity must be no worse than 20/200 corrected to 20/20, and the required correction must be no more than plus or minus 3.5 diopters spherical equivalent for a "waiver." The refractive error and uncorrected distant vision policy is not applied when the poorer eye of a third class certificate applicant, or of a first or second class certificate applicant with 250 hours, corrects to 20/200 or better. Applicants whose best distant vision correction in their worst eye is no better than 20/200 are still considered monocular and are issued medical certificates with the limitation "Valid for Student Pilot Purposes Only" until they have successfully completed a medical flight test.

In summary, we feel that this study has generated some interesting, albeit inconclusive, data. Research to determine operational vision requirements, consideration of revision of required tests, increased emphasis on aviation medical examiner examination procedures, and continued emphasis on accuracy are suggested.

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