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U.S. Army Aviation Epidemiology Data Register: Army Aviators With Diabetes Mellitus and Impaired Glucose Tolerance

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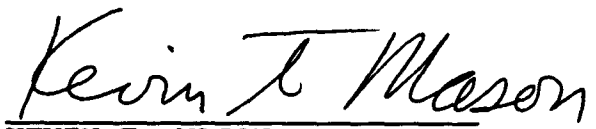

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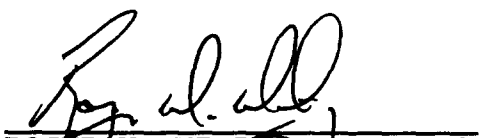

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The U.S. Army Aviation Epidemiology Data Register (AEDR) was queried for Army aviators with the finding of glycosuria, hyperglycemia, impaired glucose tolerance (IGT), diabetes mellitus (DM), use of oral hypoglycemic agents, or use of insulin for the period 1988 to 1992. The paper reviewed the literature pertaining to aircrew with diabetes, listed the aeromedical concerns related to flying duties and diabetes, and listed factors affecting the incidence and prevalence of diabetes mellitus in Army aviators.

The study tabulated the incidence and age-specific annual rates of diabetes mellitus and impaired glucose tolerance, and tabulated the distribution and reasons for aeromedical dispositions of aircrew with these conditions. U.S. Army aeromedical planners can expect about 21 new cases of DM and IGT each year. Aviators over 35 years of age were at the greatest risk. About 78.4 percent of the aviators with DM and about 10.9 percent of the aviators with IGT will not be fit for flying duties. This was primarily due to an inability to gain dietary control of their condition or the discovery of other significant medical conditions, such as coronary artery disease.

A cost-benefit and case-finding analysis of trained aviators stratified by age showed that screening for DM and IGT would be more effective if started at 35 years of age.

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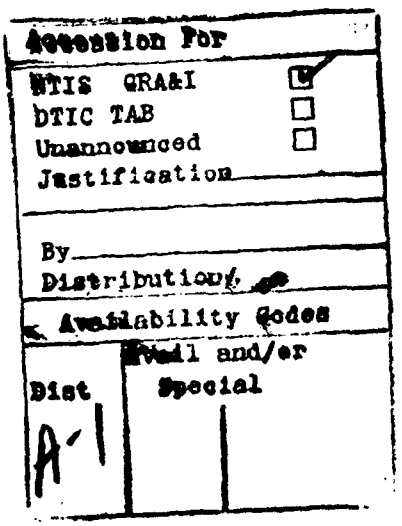
Table of contents

List of tables

List of tables (Continued).



Background

Introduction

Diabetes mellitus (DM) is a common metabolic disorder. In the United States, 11 million Americans have DM. Of these, five million are unaware they have the disorder. DM is the seventh leading cause of premature death in the United States contributing to 130,000 deaths each year. DM is associated with cardiovascular disease, blindness, renal failure, and peripheral neuropathy. The health care burden of DM is estimated to be $14 billion per year (U.S. Preventive Services Task Force, 1989).

DM is a cluster of syndromes, separated into four groups: Type I, type II, gestational diabetes, and secondary DM. Type I DM is caused by pancreatic beta cell degeneration resulting in insulin deficiency, hyperglycemia, and ketoacidosis. Type I DM has been called "insulin-dependent" or "juvenile-onset" diabetes. While the cause of type I DM is unknown, it may be associated with viral infections and other factors in genetically susceptible individuals. Type I DM may occur at any age, but usually occurs in childhood or early adulthood. About 10 percent of patients with DM have type I DM (Last and Wallace, 1992).

Type II DM is characterized by a gradual onset of resistance to insulin metabolism at the cellular level, despite normal serum insulin levels. This results in hyperglycemia without ketoacidosis. Type II DM occurs primarily in adulthood, especially after age 40. Type II DM also has been called "adult-onset diabetes" or "non-insulin-dependent diabetes," though some patients with Type II DM may be treated with insulin. Advancing age, obesity, family history, and a history of gestational diabetes are major risk factors associated with the onset of symptomatic disease. About 90 percent of patients with DM have type II DM (Nelson et al., 1988).

Gestational diabetes is a dysfunction of glucose metabolism that develops during three percent of pregnancies. The condition usually resolves spontaneously after delivery. Gestational diabetes is associated with an increased risk for premature delivery, macrosomia, perinatal morbidity and mortality, congenital malformation, and metabolic disorders (Willson, 1992).

Secondary DM is diagnosed by exclusion of the other three types of DM and assessment of other risk factors. Causes include pancreatic disease, hormonal imbalances, drug and chemical insult, insulin receptor abnormalities, and rare genetic syndromes (Last and Wallace, 1992).

Impaired glucose tolerance (IGT) is a metabolic state represented by hyperglycemia, but not of a degree to meet the

DTIC QUALITY INSPECTED 3

various criteria proposed for the diagnosis of DM. IGT has been called "prediabetes" or "glucose intolerance." In many patients, IGT is transient and spontaneously reverts to a normal state (Troxler, Trabal, and Lancaster, 1975). Other patients progress to the diabetic state over a variable period. Surgery, trauma, infection, obesity, pregnancy, and alcohol intoxication are risk factors associated with IGT (Last and Wallace, 1992).

Military relevance

The incidence and age-specific rates of diabetes mellitus and impaired glucose tolerance among U.S. Army aviators, and other aircrew, are not known. Among aircrew members with these conditions, the risk of medical termination from aviation service and cost-benefit of detection are unknown. We conducted a review of the literature and an analysis of the Aviation Epidemiology Data Register to answer these questions.

Diabetes mellitus in the general population

The prevalence of DM varies in the general population based on medical criteria for DM, geographic location, genetic history, population age distribution, and availability and quality of medical care. For example, in Zimbabwe and across the African rain belt, the prevalence ranges from one to two per 1,000 population. In developed, Western countries, the prevalence of DM varies from 10 to 40 per 1,000 population. Some populations in the Asian subcontinent have a prevalence of DM as high as 100 per 1,000 population (Renftle, 1973; Petersdorf et al., 1983; Manson-Bahr and Bell, 1987).

In the United States during the period 1980 to 1987, the age-standardized prevalence of DM increased significantly from 25.4 to 27.6 cases per 1,000 persons ($p=0.03$). This increase was due to a combination of factors, including an increase in the incidence of DM, a decrease in DM mortality, and an increase in the age of the population. Although the total mortality from DM declined during this period, there was a significant increase in the hospitalization rates for DM complicated by stroke, ketoacidosis, cardiovascular disease, lower extremity amputations, and end-stage renal disease (Centers for Disease Control, 1990; Wetterhall et al., 1992).

The age-stratified prevalence of DM in the United States increases by four-fold after age 44, and doubles again by age 65. Females have a higher prevalence than males, whatever their age and race (Hadden and Harris, 1987). African, Hispanic, and Native Americans are at higher risk for developing DM and its complications than Americans of European descent (Harris and

Hamman, 1985; Department of Health and Human Services, 1985; Harris, 1991; Gohdes, Kaufman, and Valway, 1993).

From birth until 19 years of age, the incidence of insulin-dependent DM is about 18 per 100,000 population. For the age group 20 to 24 years, the incidence drops to 5.2 per 100,000 population, rising to 10.7 per 100,000 population for the age group 40-49, and rising again to 15.2 per 100,000 population for the age group greater than 69 (Melton, Palumbo, and Chu, 1983a). These figures may be biased because some patients older than 20 with noninsulin dependent DM may be treated at some time with insulin, especially upon initial diagnosis. It is estimated that 7.9 percent of Americans with DM have insulin-dependent DM, but how many truly have type I DM is unknown (Melton et al., 1983b).

Similar to the age-specific prevalence in DM, the age-specific prevalence of IGT increases with age. There is nearly a four-fold increase after age 44, followed by a gradual increase into the seventh decade of life. In contrast to DM, the differences in the prevalence of IGT by gender and race are diminished (Harris et al. 1987).

Employees with diabetes mellitus

The prevalence of DM was 7.43 per 1,000 employees in a survey of 400,795 workers from a variety of major British companies. In the same study, the prevalence of insulin dependent DM was 2.77 per 1,000 employees (Waclawski, 1989).

Patients with DM have employment prospects similar to patients without DM. An exception is restriction from employment in certain occupations that might affect public or personal safety. Example occupations include aviation, racing, diving, military service, commercial and railway transportation, search and rescue, law enforcement and fire fighting, bridge and electrical line repair, heavy construction, scaffold work, mining, hazardous material handling, and remote petrochemical and construction operations (Waclawski, 1989).

The main basis for employment restriction is the possible public or personal hazard due to acute medical incapacitation caused by DM, especially insulin-dependent diabetes. The risk of incapacitation may be greater in occupations with irregular work hours, unpredictable meal and sleep times, unpredictable demand for physical activity, or exposure to physiologic stressors. Such circumstances are common in operational military aviation.

Another basis for restriction may be isolation of the work site from basic or emergency medical services. Insulin requires special handling and storage. Complications of DM may require

prompt or specialized medical attention. As many as 9 percent of patients with insulin-dependent DM may require emergency room care for hypoglycemic reactions each year (Potter et al., 1982).

Military service applicants with diabetes mellitus

During the period 1980 to 1990, 3886 officer candidate applicants to the Royal Army of Great Britain were examined. Three (0.08 percent) were disqualified due to DM (Dignan, 1992).

Among 5,858 male applicants to U.S. Army aviator training positions during 1989, one (0.017 percent) was disqualified for DM and two (0.034 percent) for IGT (Mason, 1990). None of 554 female applicants to U.S. Army aviator training positions were disqualified for DM or IGT from 1986 to 1988 (Mason, 1989).

All of these Army applicants were prescreened as military recruits, or Reserve Officer Training Corps or U.S. Military Academy cadet applicants. During prescreening testing, all with DM or IGT are disqualified from entering the service and cannot apply for aviator training positions. The number of cases found in these studies reflects the number of individuals who escaped detection or developed abnormal glucose chemistries between their recruitment physical and flight school application physical. The interval between examinations varies from 1 month to 5 years.

Aircrew members with diabetes mellitus

From 1969 to 1976, 90 of 1232 (73 per 1,000 over 8 years) Indian civil pilots were unfit for duties due to DM or glucose tolerance test abnormalities. The cases accounted for 38 percent of total medical disabilities in this pilot cohort (Mukerjee and Seth, 1978). Over 28 years, United Airlines reported an incidence of DM of 0.27 per 1,000 man-years of pilot employment, accounting for 9.7 percent of pilot groundings (Catlett and Kidera, 1966). As of 1986, Japan Airlines reported 92 of 2,071 (47.8 per 1,000) pilots were under care for non-insulin-dependent DM or IGT (Tajima et al., 1989). The subject age distribution and age-specific rates of DM were not stated in these studies.

Among Canadian military aircrew members followed for 10 years, 15 were referred for persistent glycosuria. Four cases (26.7 percent) were medically retired due to symptomatic DM requiring oral hypoglycemic agents or insulin for control. Six cases (40.0 percent) were diagnosed with DM, but returned to flying duties with a waiver after achieving dietary control of hyperglycemia. Four cases (26.7 percent) were returned to flying duties with the diagnosis of IGT. One patient was found to be normal and returned to flying duties (Stevenson, 1971).

A review of 7,778 U.S. Army aviator trainees from 1986 to 1990, found one trainee who was medically eliminated from the 1 year flight training program due to DM. Each trainee underwent a minimum of two screening examinations for DM consisting of fasting blood sugar and urine glucose measurements before beginning flight training (Mason, 1991).

Screening for diabetes mellitus

Consideration must be given to the cost-benefit of screening aircrew members for DM and IGT. Available tests include screening the urine glucose, fasting blood sugar (FBS), 1-hour and 2-hour postprandial blood glucose, and fasting glycosylated hemoglobin A1c (HgbA1c).

Used independently, the urine glucose and HgbA1c are poor screening tests for DM and IGT (National Diabetes Data Group, 1984; Ashby, 1985). Using both a FBS and HgbA1c obtains the best specificity and positive predictive value of screening test panel for DM and IGT (Cederholm, 1984). However, the FBS is the best single screening test, though the FBS may miss some patients with postprandial hyperglycemia (Modan, 1984).

Postprandial blood glucose tests are useful as diagnostic tests, differentiating DM from IGT when the screening FBS is abnormal. The 1-hour postprandial blood glucose is the more specific for differentiating IGT from normal glucose tolerance, while the 2-hour postprandial glucose is more specific for differentiating DM from normal glucose tolerance (Modan, 1984; Simon, 1985; Albutt, 1985; Lester, 1985).

A recent technique used to monitor blood glucose at home is the "finger-stick" capillary blood test. Patients prick their finger tip with a needle and place a drop of capillary blood on a special dipstick. After time exposure to the blood, the dipstick is rinsed with water and placed in a colorimeter to measure the approximate blood glucose (±15 percent), but the result is usually lower than the FBS. The predictive value of this method as a screening test for DM and IGT is still under investigation.

Aviation Epidemiology Data Register

The AEDR is a family of databases containing the medical history and physical parameters of Army aircrew members. One component stores the physical examination parameters, which are evaluated during the annual flying duty medical examination (FDME). A second component consolidates and stores the history information from each FDME. Another component is the waiver and suspense file (WSF). The WSF is an index of major diseases and

disabilities of Army aircrew that references an image archive (Microx and laser optic) of the medical documents about the case.

Methods

The AEDR consolidated history database (Standard Form 93), flight physical examination findings, and the Waiver and Suspense File were searched for ICD9-CM codes related to cases with the finding of glycosuria, hyperglycemia, impaired glucose tolerance, diabetes mellitus, use of oral hypoglycemic agents, or use of insulin for the period 1988 to 1992. The case summaries and consolidated histories of each case matching the search were reviewed. Selected data elements were cross tabulated on a spreadsheet for analysis. These elements included Social Security numbers (SSN), age at diagnosis, calendar year of diagnosis, the final aeromedical disposition, and other medical diagnoses.

Aviators with glycosuria or fasting blood sugar greater than 115 mg/dl underwent standard glucose tolerance testing with a 75 gram oral glucose load. The results of the fasting blood sugar, and 1-hour and 2-hour postprandial glucose, were applied to the criteria in Table 1, adopted from the National Diabetes Data Group of the National Institute of Health classification (National Diabetes Data Group, 1979). The aviator met the criteria for a given condition on two or more occasions before a final diagnosis was made (Department of the Army, 1989).

Table 1.

National Diabetes Data Group classification of diabetes.

Category	Glucose, mg/dl		
	Fasting	1 hour postprandial	2 hour postprandial
Normal	<115	<200	<140
Impaired glucose tolerance	115-140	140-200	>200
Diabetes mellitus	>140	>200	>200
Gestational diabetes	>105	>190	>165

An "aviator-year" was defined as an individual aviator undergoing a physical examination in 1 calendar year. The aviator was assumed to be in the followup cohort for that entire calendar year.

The costs of screening tests used to detect DM and IGT were determined by telephonic survey of area military and civilian hospital laboratories. The U.S. Army aviation training applicant cohort noted in the background discussion, and the trained aviator cohort from this study were used for the cost-benefit analysis.

Results

The incidence of DM and IGT per 1,000 Army aviator-years for each calendar year from 1988 through 1992 is shown in Table 2. There were about 10 new cases of DM per year and 11 new cases of IGT per year among U.S. Army aviators.

Table 2.

Incidence of diabetes mellitus and impaired glucose tolerance per 1,000 Army aviator-years.

Year	Aviator years	Diabetes mellitus		Impaired glucose tolerance	
		N	Incidence	N	Incidence
1988	22417	8	0.36	1	0.04
1989	22092	9	0.41	5	0.23
1990	21830	14	0.64	14	0.64
1991	21694	11	0.51	18	0.83
1992	19653	9	0.46	17	0.87
N		51		55	

Each calendar year was compared to the other calendar years using the binomial test with a one-tail test of significance (Conover, 1980; Gustafson, 1984). After controlling for the influence of multiple comparisons on the experimentalwise error rate (Snedecor and Cochran, 1980), the incidence of DM did not change significantly during the period 1988 through 1992.

By contrast, the incidence of IGT increased significantly between 1988 and 1989 ($p=0.0004$), and 1989 and 1990 ($p=0.0003$). After 1990, the incidence of IGT continued to increase, but not significantly compared to 1990.

Table 3 shows the annual rate of DM and IGT per 1,000 aviator-years stratified by age groups, divided into five year intervals, for the period 1988 to 1992. An aviator case was counted in an age group based on the age at initial diagnosis. The risk of developing DM and IGT increases with age, a pattern seen in the age-specific incidence in the general population.

Table 3.

Annual rate of diabetes mellitus and impaired glucose tolerance per 1,000 aviator-years stratified by age group.

Age Group	Mean annual aviator-years 1988 to 1992	Diabetes mellitus		Impaired glucose tolerance	
		N	Annual rate per 1,000 aviator-years	N	Annual rate per 1,000 aviator-years
20-24	1,571	0	0.00	0	0.00
25-29	4,740	2	0.42	0	0.00
30-34	4,104	1	0.24	1	0.04
35-39	3,821	6	0.34	8	0.45
40-44	4,196	15	3.57	15	0.64
45-49	1,644	8	4.90	13	1.29
50-54	421	10	23.75	11	4.08
55-59	149	7	46.98	5	5.24
60-70	30	4	20.73	1	5.18
Summary		53	2.64	55	0.51

Each 5-year age group interval was compared to the next using the binomial test with a one-tail test of significance (Conover, 1980; Gustafson, 1984). The age-specific rate of DM increased significantly for each 5-year interval from ages 25 through 54 ($p<0.01$). After age 55, although the rate of DM increased two-fold, and then three-fold, differences between each group had only borderline statistical significance ($p<0.06$). The borderline significance likely was due to the small number of aviators in the last two year-groups (N=191 and N=39) and the infrequent occurrence of DM in the total aviator population.

The age-specific rate of IGT increased significantly for each 5-year interval from ages 35 through 54 ($p<0.001$). After age 55, the age-specific rate of IGT gradually increased, but the difference between age groups was not statistical significant.

Table 4 shows the distribution of aeromedical disposition outcomes for DM and IGT by calendar year of diagnosis. Overall, 21.6 percent of aviators with DM were returned to flying duties with a waiver following nonpharmacologic control of their hyperglycemia. Among the aviators with IGT, 89.1 percent were returned to flying duties as qualified "for information only" following nonpharmacologic control of hyperglycemia.

Table 4.

Distribution of aeromedical disposition outcomes for Army aviators with diabetes mellitus or impaired glucose tolerance.

	Diabetes mellitus		Impaired glucose tolerance	
Year	N	Not flying	N	Not flying
1988	8	7 (87.5%)	1	0 (0.0%)
1989	9	5 (55.5%)	5	0 (0.0%)
1990	14	9 (64.3%)	14	2 (14.3%)
1991	11	10 (90.9%)	18	3 (16.7%)
1992	9	9 (100.0%)	17	1 (5.9%)
Totals	51	40 (78.4%)	55	6 (10.9%)

Table 5 shows the major reasons for medical termination from aviation service. Of the 55 aviators with IGT, six were not returned to flying duties. The diagnosis of IGT was not the cause of medical termination from aviation service. Each case had other medical conditions incompatible with flying duties.

Of the 51 aviators with DM, 40 were not returned to flying duties (Table 5). One-half required insulin or oral hypoglycemic medications for control. These medications generally are considered incompatible with piloting military aircraft (Stevenson, 1971; Renftle, 1973; DeHart, 1985; Ernsting and King, 1988; Department of the Army, 1989). Two aviators, who were under waiver for continued flying duties with diet-controlled DM, relapsed while in Saudi Arabia during Desert Shield/Storm Operations in 1991. They were evacuated to their home base, achieved control with oral hypoglycemic medication, and were medically terminated from aviation service. The remaining grounded aviators with DM either had cardiovascular disease, poor control of hyperglycemia by diet, or were lost to followup.

Table 5.

Primary reasons for medical termination from aviation service due to diabetes mellitus or impaired glucose tolerance.

Diagnosis	Total	Primary reason for not flying
Diabetes mellitus	12	Use of oral hypoglycemic medications
	9	Use of insulin
	8	Retired, followup evaluation incomplete
and	4	Coronary angiography indicated, but declined
	4	Poor control by diet at last followup
	3	Coronary or aortic atherosclerotic disease
Impaired glucose tolerance	2	Administrative elimination for obesity
	1	Mitral valve prolapse and abnormal GXT
with	1	Unresolved major affective disorder
	1	Significant coronary artery disease
	1	Retired, followup evaluation incomplete

A survey of venipuncture and processing costs of a FBS in area hospitals averaged $4 per test, and $1 per test when the FBS was measured in a panel of multiple tests. FBS testing is submitted with a flying duty medical examination usually as a panel of multiple blood tests. Home monitoring of the blood glucose costs about $1 per test.

Three of 6,412 U.S. Army aviator training applicants were disqualified for DM and IGT as noted in the backgound discussion. The theoretical cost of finding these three cases, $6,412, is overshadowed by over $750,000 potentially lost in basic flight training costs had they been trained and disqualified later.

The annual cost of screening the entire trained aviator population would be $21,530 (Table 6). Screening for DM and IGT beginning at age 35 would cost $11,241 annually, or an average of $551 per case of diabetes. Screening beginning at age 35 would identify 95 percent of the DM cases and 98 percent of the IGT cases. The intangible benefit would be treatment and return to flying duties of 57 percent of the aviators with DM and IGT, and restriction from flying duties of the 43 percent at high risk for acute incapacitation or deployment restriction. Screening before age 35 would cost 23-fold more dollars, while only finding 3.8 percent of the total cases.

Discussion

Aircrew members with diabetes cannot properly metabolize serum glucose due to either insulin deficiency, impaired insulin utilization, or both. This metabolic state results in hyperglycemia, which is accompanied by acute and chronic, multisystem complications. Patients with diabetes are at an increased risk for premature mortality. Exposure to the combat operational environment increases the risk for complications due to irregular meal/rest hours, fatigue, environmental physiologic stress, and pathogen exposure. Control of hyperglycemia may decrease the risk for complications, but does not cure the disease process. Table 7 shows some general aeromedical concerns related to flying and diabetes. Table 8 shows the factors affecting the incidence and prevalence of DM in Army aircrew members.

Table 6.

Summary of screening costs for identifying diabetes mellitus and impaired glucose tolerance among Army aviators 1988 to 1992.

Age	Total aviator-years	Total FBS cost	Cases of DM and IGT	Cost per case	Percent of total cases
20-24	5,050	$5,050	0	$5,050	
25-29	23,300	$23,300	2	$11,650	
30-34	23,095	$23,095	2	$11,548	
Summary	51,445	$51,445	4	$12,861*	3.8%
35-39	17,910	$17,910	14	$1,279	
40-44	23,595	$23,595	29	$814	
45-49	10,850	$10,850	21	$517	
50-54	2,700	$2,700	21	$129	
55-59	955	$955	12	$80	
60-70	195	$195	5	$39	
Summary	56,205	$56,205	102	$551*	96.2%

* Average cost per case identified in the year groups summary.

This study supports the utility of developing aeromedical databases such as the Aviation Epidemiology Data Register. The AEDR permitted characterization of the incidence, age-specific rates, and aeromedical outcomes of DM and IGT for the first time in Army aviation medicine history. Other studies of DM and IGT in aviators were cross-sectional designs, usually without including age distribution or cost-benefit analysis. Others have focused on the problems of making a diagnosis based on the finding of one abnormal blood glucose or glucose intolerance test. Our analysis fills the void left by these previous works and directly supports the Army aviation medicine mission.

Conclusions

DM and IGT are significant causes of morbidity and mortality in the United States. DM is associated with multiple risks for acute incapacitation and limitations to deployability. Screening for DM and IGT in aircrew members is warranted due to many aeromedical concerns expressed in this paper.

Based on the historical data in this study, U.S. Army aeromedical planners can expect about 21 new cases of DM and IGT each year. Aviators older than age 35 are at the greatest risk for developing these conditions. About 78.4 percent of the aviators with DM and about 10.9 percent of the aviators with IGT will not be fit for flying duties. This is primarily due to an inability to gain dietary control of their condition or the discovery of other significant medical conditions, such as coronary artery disease.

This study discusses the cost savings of screening for DM and IGT in aviator training candidates, despite the rarity of new cases found in this population (0.5 per 1,000 candidates). A cost-benefit and case-finding analysis of trained aviators stratified by age shows that screening for DM and IGT would be more effective if started at age 35 and not at age 40, as stated in the current policy.

Table 7.

Aeromedical concerns related to flying duties and diabetes.

General

1. Aircrew members with DM are at greater risk for morbidity and mortality given the same degree of exposure to trauma or infection when compared to normal aircrew members

Increased risk for acute incapacitation due to-

1. Insulin deficiency with ketoacidosis and coma; often precipitated by infection, dehydration, irregular meals, fatigue, and other psychosocial and environmental factors common in combat aviation operations
2. Hypoglycemia with acute incapacitation or coma
3. Fluctuating visual acuity caused by hyperglycemia
4. Sudden death caused by cardiovascular complications
5. Frequency of urination during flight as a distractor

Limitations of the operational setting due to-

1. Irregular availability of insulin and oral hypoglycemic medications in combat, and insulin storage problems
2. Demand for care exceeds the capabilities of front line medical facilities for management of DM and complications
3. Decreased hygiene and increased risk of pathogen exposure
4. Unpredictable work, sleep, and meal schedules
5. Risk of prolonged operations behind enemy lines or sustained operations scenarios
6. Risk of no medical care in escape and evasion, hostage, or POW settings
7. Evacuation to higher echelons of medical care creates an aviation unit loss, replacement may be delayed or not available

Increased risk for complications due to multisystem chronic degenerative diseases involving the-

1. Cardiovascular system with myocardial infarction, cerebrovascular accident, peripheral vascular disease, and other incapacitating cardiovascular events
2. Neurologic system with peripheral neuropathy accompanied by trench foot, frost bite, contusion, laceration, thermal injury, infection, ulceration, and/or gangrene of the extremities
3. Ophthalmologic system with retinal hemorrhage, retinal degeneration, and blindness
4. Renal system with chronic renal failure and renal infections

Table 8.

Factors affecting the incidence and prevalence of diabetes mellitus in Army aviators.

Preselection effect
1. Aviator candidates must be qualified to join the military and are excluded if they have DM or persistent glycosuria. 2. Before application, most candidates have been under medical observation in military service for months to years, increasing the chance for disease discovery. 3. During the application process, aviator candidates undergo a minimum of two additional physical examinations. Patients with DM, IGT, or persistent glycosuria are excluded.
Health and welfare effect
1. Most aviators flying for the Army are soldiers. Soldiers participate in mandated physical fitness and weight control programs. These programs may influence the onset of disease. 2. Army aviators are examined annually, resulting in the discovery and treatment of "prediabetic" metabolic conditions. 3. Army aviators are fully employed and covered by a comprehensive health care plan.
Race, gender, and age differences effect
1. Army aviators are predominately Caucasian males, a subpopulation of the general population at lower risk for developing DM or IGT (Harris, 1991). 2. Noncaucasian and female Americans are at increased risk for developing DM in the general population. Only 4.9 percent of Army aviators are nonCaucasian (Schrimsher and Shannon, 1993). Only 2.5 percent of Army aviators are female (Mason, 1993). 3. The age distribution of Army aviators is different from the general population. Thirty-one percent of the U.S. population exceeds 44 years old, compared to 23.3 percent of Army aviators (Mason, 1993; U.S. Department of Commerce, 1992).
Aeromedical disposition effect
1. Seventy-eight percent of Army aviators with DM are removed from flying duties and are no longer part of the aviator cohort. 2. The diagnosis of DM affects flying careers. Some aviators may conceal the condition and seek treatment at nonmilitary facilities, delay seeking evaluation of symptoms, unconsciously attribute symptoms to other conditions, such as aging (Borzewski, 1991), or retire from service before the diagnosis is known by the military health care system. 3. Changes in aeromedical policy may change the diagnostic criteria for making the diagnosis of DM or IGT or alter risk for return to flying duties after diagnosis.

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