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COMPARISON OF STATUS VARIABLES AMONG ACCIDENT AND NON-ACCIDENT AIRMEN FROM THE ACTIVE AIRMAN POPULATION

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I. Introduction

The investigation of human factors has commanded considerable attention in the search for information applicable to accident prevention [1-3]. A recent analysis has shown that 85–90% of fatal general aviation accidents were attributed to human factor causes[4]. Annually, the number of pilots involved in aircraft accidents approximates one per cent of the active airman population (those airmen medically certified within the past twenty-five months)[5]. However, the growth rate of the active airman population is such that the increasing number of accidents represented by a one per cent incidence remains a forceful mandate for continued effort towards accident prevention.

During recent years, substantial effort has been devoted to the analysis of age-related factors in aviation accidents. The rationale for this focus on the age/accident relationship seems to be straightforward: (1) aging is usually associated with a deterioration of several performance functions likely to be involved in aircraft operation, and (2) age is a readily obtained status variable. These numerous studies on various segments of the aviation population were accomplished for a variety of purposes [6-13].

It is the purpose of this report to examine whether any of the status variables, age, height or weight, bears a relationship to the accident statistics of the civilian aviation population. This effort represents an initial attempt to extract some common denominator from the population of accident-involved airmen in order to narrow the focus for further study within the broad spectrum of human factor causes.

From the measures of height and weight obtained from airman medical records, it was also possible to examine the weight variable more critically. Several rationales exist which suggest that excessive body weight should be explored as a pertinent item within the category of human factors associated with aviation accidents. However, weight alone cannot be used as an index of overweight, unless some measure of stature is included.

Two indices relating stature and body weight were examined in this study. The first was a "ponderal index (PI)," a ratio widely used in anthropology to evaluate bodily configuration[14]. This index is defined as the ratio of height (inches) to the cube root of weight (pounds). The second weight index examined is related to the metabolic base of surface area (M^2) computed according to the expression of DuBois, et al.[15] from height (centimeters) and weight (kilograms). The ratio of body weight to body surface area (BW/BSA) is also an expression of bodily configuration but is inversely related to PI.

Given these considerations, the hypothesis was tested that the frequency distributions of age, height or weight in accident-involved airmen was not different from the distribution in airmen not involved in accidents over the same period of consideration. The frequency distribution of PI and BW/BSA were also examined according to similar hypotheses.

General aviation accident-involved airmen of 1966 and 1967 inclusively provided the study frame. Data from existing FAA medical records were obtained and statistically analyzed.

II. Methods and Source Material

During 1966 and 1967, the number of persons involved in accidents as pilot in command (PIC) of a general aviation aircraft totaled 12,119 for 12,026 recorded accidents (some accidents involved two aircraft)[5]. The Accident Investigation Branch of the Aeromedical Applications Division, Office of Aviation Medicine, routinely requests medical data on all airmen involved in general aviation accidents. Using the airman listing previously compiled in connection with this effort, magnetic tape medical history files maintained by the Aeromedical Certification Branch in Oklahoma City were searched for the most recent record of medical certification which immediately preceded the date of the accident. In this manner, status data were obtained from the medical records of 9,639 airmen. Of this number, 382 were involved in multiple accidents (360—2 accidents; 21—3 accidents; 1—4 accidents) and only the medical information immediately prior to the most recent accident was obtained. Therefore, 10,044 (83%) of the total 12,119 PICs were accounted for by this data search. Data were not available for the remaining 2,075 PICs due to insufficient or inaccurate identification data or because the individual was not medically certified, i.e., mechanics involved in accidents, individuals operating aircraft in violation of regulations, international pilots, etc.

The data for these 9,639 PICs (most recent data only for multiple-accident airmen) were proportionately extrapolated to the total 12,119 accident-involved airmen for the years 1966 and 1967. This extrapolation was made so that the calculated rates (accidents/10,000) would not be biased by the exclusion of unavailable data from the 2,075 cases cited earlier. The distributions of the five selected status variables (age, height, weight, BW/BSA and PI) for the accident airman population were then compared to those of the mid-period (December 1966)[1] non-accident airman population via conventional chi-square techniques.

The five status variables used in this study are based on three elements of data (age, height, and weight) which were obtained from each airman medical record.

The date of birth, as indicated by the airman on the application for medical certification, provided the means for determining age at last birthday for accident-involved airmen at the time of the accident. The age distribution of the non-accident population was based on computation of age at last birthday as of December 31, 1966. Date of birth, as provided by the airman, is a particularly reliable datum since a match between the list of accident airmen and the computer tape file would not have occurred in the absence of identical data in both files. Date of birth was an element of identification data.

Height, as recorded on the airman's application, is also felt to be reliable. Computer input processing rounds fractional data to the nearest inch. However, further use of these data is conservatively consistent with this rounding procedure.

Stated weight, as reported by the airman, is subject to a recognized error[16]. However, the computations of BW/BSA and PI and the comparisons with accepted tables of desirable weights[17] are all based on stated weight and are thereby consistent with respect to the recognized error.

Regarding preliminary statistical analyses, it should be mentioned that the accident-involved airmen were separated into two categories based on "ground accidents" versus "in-flight accidents" and compared by chi-square analyses for differences in the proportions of ground accidents and in-flight accidents with respect to the five status variables. In all cases, the chi-square analyses indicated no significant differences in these proportions. Therefore, subsequent analyses did not treat ground accidents and in-flight accidents separately.

It was recognized from the beginning of this study that exposure would be an important consideration affecting general aviation accident rates. Although medical records do contain "total flight time" and "last six month's flight time" as possible indices of exposure, such data are considered to be generally unreliable from a statistical viewpoint[18]. How the exposure factor affects the distributions we have examined will remain an unknown until such time as accurate data are available.

III. Results

The distributions as well as the total and interval rates for the five status variables in the accident, non-accident, and total airman populations are presented in Tables I–V. The distributions of these five variables in the accident versus non-accident airman populations were significantly different in all instances.

AGE

The age distributions of accident and non-accident airmen are presented in Table I. The

[1] The 1967 Aeromedical Certification Statistical Handbook data less accident-involved airmen for the class interval. These data represent the most recent status information for active airmen as of December 31, 1966, with no duplication of data.

TABLE I.—COMPARISON OF AGE GROUPS—TOTAL ACCIDENT VERSUS NON-ACCIDENT AIRMAN POPULATION

Age	Accident Airmen	Non-Accident Airmen	Total	Percent of Total	Annual Rate*	Expected Accidents	0−E	$\frac{(0-E)^2}{E}$	Expected Non-Accident	0−E	$\frac{(0-E)^2}{E}$
<20	332	27,573	27,905	5	59.5	588	−256	111.34	27,317	+256	2.40
20–29	3,196	170,816	174,012	30	91.8	3,666	−470	60.18	170,346	+470	1.30
30–39	3,914	167,988	171,902	30	113.8	3,621	+293	23.67	168,281	−293	0.51
40–49	3,050	143,759	146,809	25	103.9	3,093	− 43	0.59	143,716	+ 43	0.01
50–59	1,349	44,561	45,910	8	146.9	967	+382	150.79	44,943	−382	3.24
≥60	278	8,477	8,755	2	158.8	184	+ 94	47.48	8,571	− 94	1.02
Total	12,119	563,174	575,293		105.3			394.05			8.48

RESULTS:

$x^2 = 402.53$
d.f. = 5
$P < 0.001$

INFERENCE: Significant difference between age distribution of accident involved airmen and non-accident involved airmen.

Source: Civil Aeromedical Institute, Aeromedical Certification Branch, Medical Statistical Section; 1966 and 1967 accident airmen on medical tape file. Active airman population as of December 31, 1966.

*Per 10,000 active airmen

TABLE II.—COMPARISON OF HEIGHT—TOTAL ACCIDENT VERSUS NON-ACCIDENT AIRMAN POPULATION*

Height	Accident Airmen	Non-Accident Airmen	Total	Percent of Total	Annual Rate*	Expected Accidents	0−E	$\frac{(0-E)^2}{E}$	Expected Non-Accident	0−E	$\frac{(0-E)^2}{E}$
≤61	89	6,017	6,106	1	72.9	129	−40	12.20	5,977	+40	0.26
62	48	3,162	3,210	1	74.8	68	−20	5.69	3,142	+20	0.12
63	50	3,993	4,043	1	61.8	85	−35	14.52	3,958	+35	0.31
64	98	7,253	7,351	1	66.7	155	−57	20.87	7,196	+57	0.45
65	191	11,139	11,330	2	84.3	239	−48	9.52	11,091	+48	0.20
66	503	23,339	23,842	4	105.5	502	+ 1	0.00	23,340	− 1	0.00
67	786	37,222	38,008	7	103.3	801	−15	0.27	37,207	+15	0.01
68	1,391	61,484	62,875	11	110.6	1,325	+66	3.34	61,550	−66	0.07
69	1,497	64,882	66,379	11	112.8	1,39	+99	6.96	64,981	−99	0.15
70	1,924	88,116	90,040	16	106.8	1,897	+27	0.39	88,143	−27	0.01
71	1,717	79,525	81,242	14	105.7	1,711	+ 6	0.02	79,531	− 6	0.00
72	1,819	83,060	84,879	15	107.2	1,788	+31	0.54	83,091	−31	0.01
73	905	42,551	43,456	7	104.1	915	−10	0.12	42,541	+10	0.00
74	612	29,154	29,766	5	102.8	627	−15	0.36	29,139	+15	0.01
75	248	12,584	12,832	2	96.6	270	−22	1.84	12,562	+22	0.04
>75	241	9,693	9,934	2	121.3	209	+32	4.81	9,725	−32	0.10
Total	12,119	563,174	575,293		105.3			81.45			1.74

RESULTS:

$x^2 = 83.19$
d.f. = 15
$P < 0.001$

INFERENCE: Significant difference between height distribution of accident involved airmen and non-accident involved airmen.

Source: Civil Aeromedical Institute, Aeromedical Certification Branch, Medical Statistical Section; 1966 and 1967 accident airmen on medical tape file. Active airman population as of December 31, 1966.

*Per 10,000 active airmen

TABLE III.—COMPARISON OF WEIGHT—TOTAL ACCIDENT VERSUS NON-ACCIDENT AIRMAN POPULATION

Weight	Accident Airmen	Non-Accident Airmen	Total	Percent of Total	Annual Rate*	Expected Accidents	0−E	$(0-E)^2$/E	Expected Non-Accident	0−E	$(0-E)^2$/E
<110	33	2,940	2,973	1	55.5	63	− 30	14.01	2,910	+ 30	0.30
110–119	77	6,122	6,199	1	62.1	131	− 54	21.99	6,068	+ 54	0.47
120–129	144	12,053	12,197	2	59.0	257	−113	49.64	11,940	+113	1.07
130–139	401	23,651	24,052	4	83.4	507	−106	22.04	23,545	+106	0.47
140–149	810	43,537	44,347	8	91.3	934	−124	16.51	43,413	+124	0.36
150–159	1,460	71,526	72,986	13	100.0	1,538	− 78	3.91	71,448	+ 78	0.08
160–169	1,980	93,508	95,488	16	103.7	2,012	− 32	0.49	93,476	+ 32	0.01
170–179	2,108	96,590	98,698	17	106.8	2,079	+ 29	0.40	96,619	− 29	0.01
180–189	1,875	83,485	85,360	15	109.8	1,798	+ 77	3.28	83,562	− 77	0.07
190–199	1,318	56,419	57,737	10	114.1	1,216	+102	8.51	56,521	−102	0.18
200–209	798	32,662	33,460	6	119.2	705	+ 93	12.31	32,755	− 93	0.26
210–219	499	19,177	19,676	3	126.8	414	+ 85	17.23	19,262	− 85	0.37
220–229	327	10,282	10,609	2	154.1	223	+104	47.94	10,386	−104	1.03
230–239	134	5,368	5,502	1	121.8	116	+ 18	2.83	5,386	− 18	0.06
> 239	155	5,854	6,009	1	129.0	127	+ 28	6.38	5,882	− 28	0.14
Total	12,119	563,174	575,293					227.47			4.88

RESULTS:

$x^2 = 232.35$
d.f. = 14
$P < 0.001$

INFERENCE: Significant difference between weight distribution of accident involved airmen and non-accident involved airmen.

Source: Civil Aeromedical Institute, Aeromedical Certification Branch, Medical Statistical Section; 1966 and 1967 accident airmen on medical tape file. Active airman population as of December 31, 1966.

*Per 10,000 active airmen

TABLE IV.—COMPARISON OF WEIGHT/UNIT OF BODY SURFACE AREA—TOTAL ACCIDENT VERSUS NON-ACCIDENT AIRMAN POPULATION

Kg/M^2	Accident Airmen	Non-Accident Airmen	Total	Percent of Total	Annual Rate*	Expected Accidents	0−E	$(0-E)^2$/E	Expected Non-Accident	0−E	$(0-E)^2$/E
<35	254	19,508	19,762	3	64.3	416	−162	63.27	19,346	+162	1.36
35–39	4,929	251,818	256,747	45	96.0	5,409	−480	42.52	251,338	+480	0.92
40–44	6,158	263,660	269,818	47	114.1	5,684	+474	39.54	264,134	−474	0.85
> 44	778	28,188	28,966	5	134.3	610	+168	46.16	28,356	−168	0.99
Total	12,119	563,174	575,293		105.3			191.49			4.12

RESULTS:

$x^2 = 195.61$
d.f. = 3
$P < 0.001$

INFERENCE: Significant difference between weight/unit of body surface area distribution of accident involved airmen and non-accident involved airmen.

Source: Civil Aeromedical Institute, Aeromedical Certification Branch, Medical Statistical Section; 1966 and 1967 accident airmen on medical tape file. Active airman population as of December 31, 1966.

*Per 10,000 active airmen

TABLE V.—COMPARISON OF PONDERAL INDEX—TOTAL ACCIDENT VERSUS NON-ACCIDENT AIRMAN POPULATION

Ponderal Index	Acci-dent Airmen	Non-Accident Airmen	Total	Percent of Total	Annual Rate*	Expected Acci-dents	0−E	$\frac{(0-E)^2}{E}$	Expected Non-Accident	0−E	$\frac{(0-E)^2}{E}$
<12.0	1,466	54,187	55,653	9	131.7	1,173	+293	73.19	54,480	−293	1.58
12.0–12.4	3,617	151,000	154,617	27	117.0	3,257	+360	39.79	151,360	−360	0.86
12.5–12.9	4,374	211,440	215,814	38	101.3	4,546	−172	6.53	211,268	+172	0.14
13.0–13.4	2,131	112,196	114,327	20	93.2	2,408	−277	31.95	111,919	+277	0.68
>13.4	531	34,351	34,882	6	76.1	735	−204	56.62	34,147	+204	1.22
Total	12,119	563,174	575,293					208.08			4.48

RESULTS:

$x^2 = 212.56$
d.f. = 4
$P < 0.001$

INFERENCE: Significant difference between the ponderal index distribution of accident involved airmen and non-accident involved airmen.

Source: Civil Aeromedical Institute, Aeromedical Certification Branch, Medical Statistical Section; 1966 and 1967 accident airmen on medical tape file. Active airman population as of December 31, 1966.

*Per 10,000 active airmen

chi-square value of 402.53 with 5 degrees of freedom indicates that it is extremely unlikely that this great a difference between these two distributions could be due to chance alone ($P<0.001$). The alternate hypothesis suggests that age is associated with differences in the proportions of accident-involved airmen. Further, Table I indicates that the accident-involved airmen in the first two age intervals (<20 and 20–29) experienced less accidents than would have been expected based on the total airman population distribution by age. With the exception of the 40–49 age interval, accident-involved airmen above age 29 exceeded expected values with the large contributions to the total chi-square coming from age intervals 30–39, 50–59, and ≥60. A graphic plot of both distributions is presented in Figure 1.1.

As shown in Figure 1.2, with the exception of the 40–49 age interval, the accident rate (per 10,000 airmen) increases with age from a value of 59.5 for the <20 age interval to a value of 158.8 for the ≥60 age interval.

HEIGHT

The height distributions of accident and non-accident airmen are presented in Table II. The chi-square value of 83.19 with 15 degrees of freedom indicates a significant difference between these two distributions with a probability of <0.001 that this large a difference could occur due to chance alone. The alternate hypothesis would suggest that height is associated with the difference between these two distributions.

Expected accidents based on the total airman population distribution exceeded observed accidents in the height intervals up to 66 inches with the largest contributions to the total chi-square coming from these lower intervals. At heights of 66 inches or greater, the relationship of expected versus observed accidents appears to vary randomly throughout the remainder of the distribution comparison with four sign changes occurring in eleven class intervals. Practically speaking, no conclusion is apparent from the chi-square analysis or accident rates as applied to the variable "height" even though the chi-square value infers significant statistical difference between the distributions.

As shown in Figure 2, the accident rates for heights of 66 through 74 inches are not greatly different. The highest rate in this height range was 112.8 and the lowest was 102.8. The rates for heights below 66 inches varied from 61.8 for the 63 inch height to 84.3 for the 65 inch height. The tallest group, >75 inches, had a rate of 121.3.

WEIGHT

The weight distributions of accident and non-accident airmen are presented in Table III. The chi-square value of 232.35 with 14 degrees of

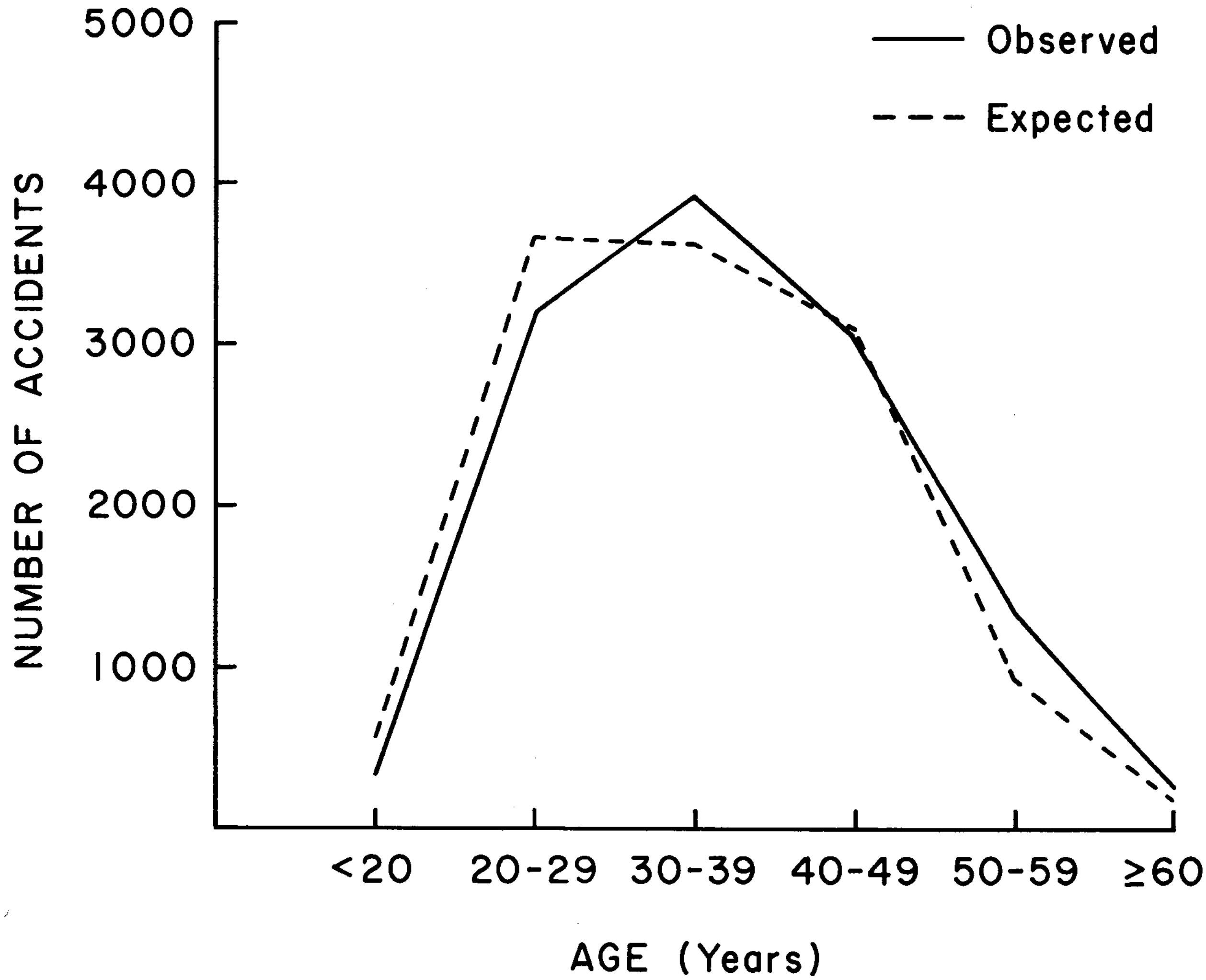

FIGURE 1.1. Observed Versus Expected General Aviation Accidents by Age.

freedom infers a significant difference between these two distributions. The probability is <0.001 that this great a difference would have occurred due to chance alone. The alternate hypothesis suggests that weight is a factor other than chance associated with this great a difference between these two distributions.

Expected accidents exceeded observed accidents in the weight intervals of <110 through 160–169. The largest contributions to the total chi-square came from these lower weight intervals. Observed accidents exceeded expected accidents in all class intervals above 170–179. The largest contribution to the total chi-square in these upper weight intervals came from the 200–229 class intervals.

As shown in Figure 3, the accident rates for each weight interval show an apparent trend of increasing rates with increasing weight. The only exceptions were in the 120–129 and the 230–239 weight intervals.

WEIGHT PER UNIT OF BODY SURFACE AREA

The BW/BSA distributions of accident and non-accident airmen are presented in Table IV. The chi-square value of 195.61 with 3 degrees of freedom infers a significant difference between these two distributions. The chance occurrence of this great a difference has a probability of <0.001. The alternate hypothesis suggests that BW/BSA is associated with the difference between these two distributions.

Expected accidents exceeded observed accidents in the class intervals <35 through 39 kg/m². Above 39 kg/m², observed accidents exceeded expected accidents with large contributions to the total chi-square coming from these higher class intervals. A graphic plot of both distributions is presented in Figure 4.1.

As shown in Figure 4.2, the greater the BW/BSA, the greater the accident rate. A BW/BSA value of 40 kg/m² or greater is considered to be an indication of an overweight condition for any height and weight combination[17].

PONDERAL INDEX

The PI distributions of accident and non-accident airmen are presented in Table V. The chi-square value of 212.56 with 4 degrees of freedom indicates a significant difference between these two distributions. The probability is <0.001 that this great a difference could have occurred by chance alone.

The opposite relationship observed in this table is in keeping with the conclusion reached with respect to "weight per unit of body surface area," since the variables exert an inverse influence in the formulas for determination of weight per unit of body surface area and ponderal index.

Observed accidents exceeded expected accidents in the PI class intervals of <12.0 and 12.0–12.4. Expected accidents exceeded observed

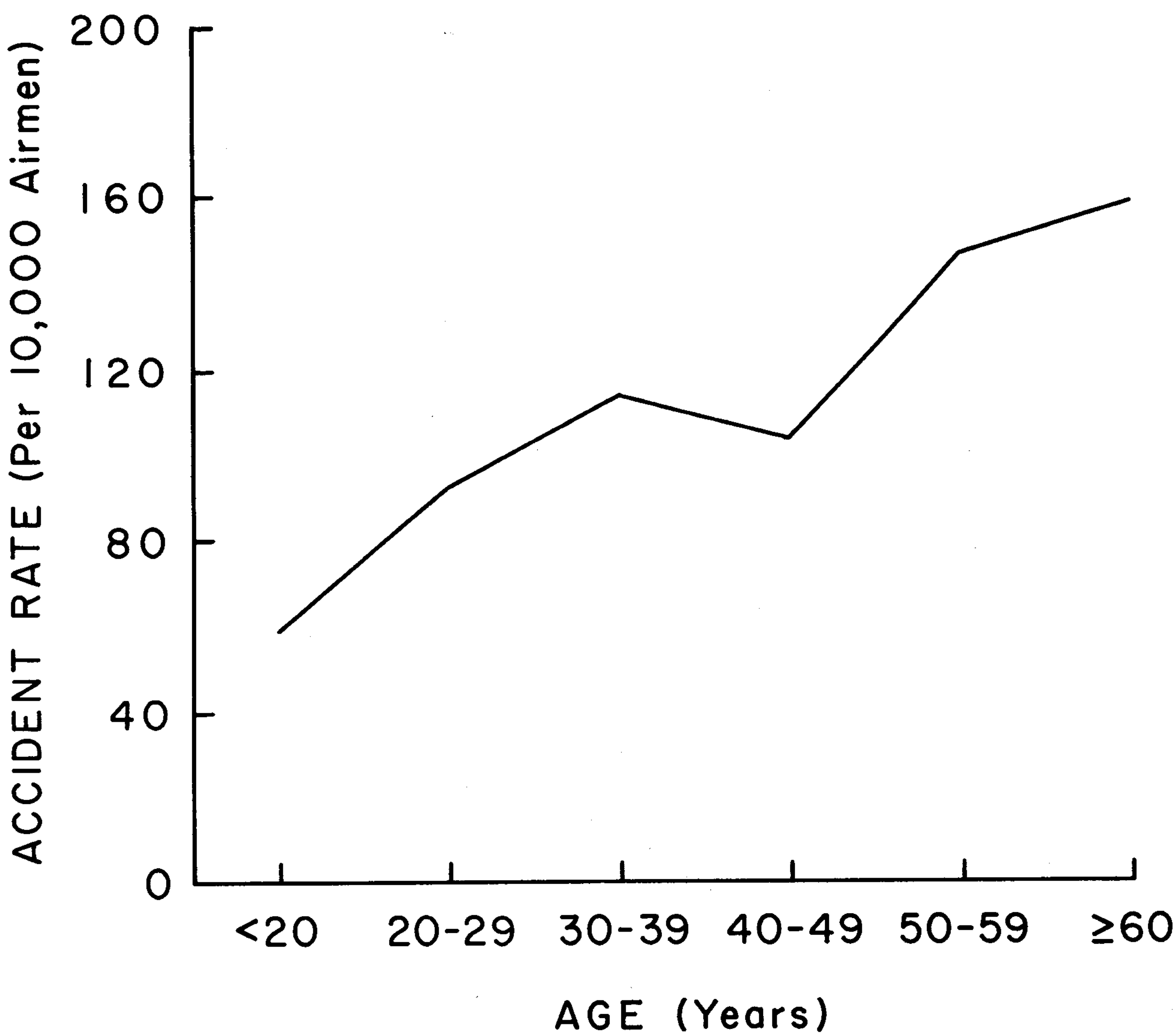

FIGURE 1.2. General Aviation Accident Rate by Age.

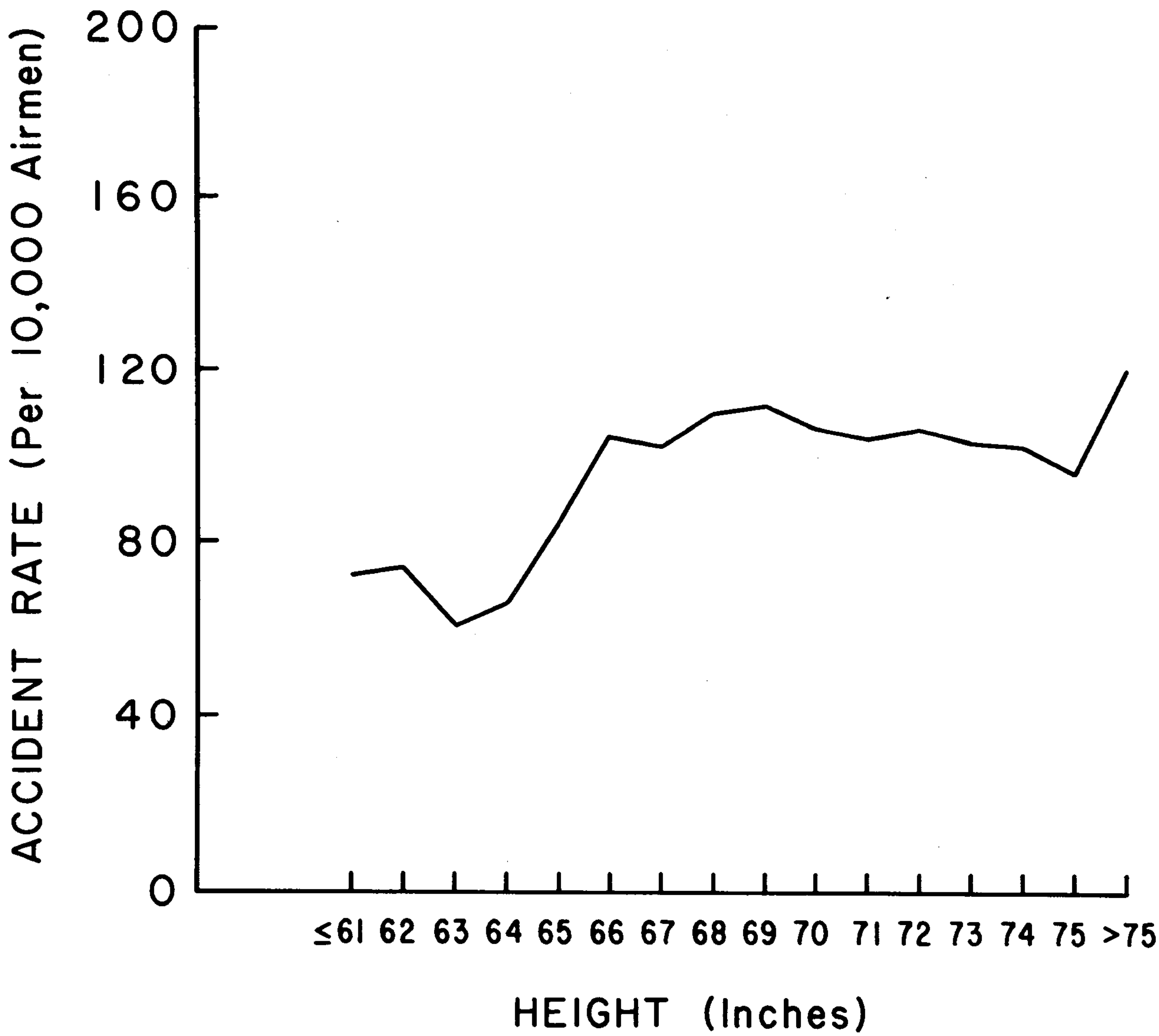

FIGURE 2. General Aviation Accident Rate by Height.

accidents in the remaining class intervals. A graphic plot of both distributions is shown in Figure 5.1.

A graphical plot of accident rates versus PI class intervals is presented in Figure 5.2. The accident rate decreases in successive PI class intervals. The maximum rate at PI class interval <12.0 is 131.7. The rate then falls successively to the value of 76.1 at PI class interval >13.4.

IV. Discussion and Summary

In this retrospective study, five status variables have been analyzed in an attempt to narrow the focus of where, within the active airman population, to look for some of the remaining undetected human factors associated with accidents. As mentioned earlier, exposure is a critical factor in any consideration of aircraft accidents. Several other factors of equal importance come to mind readily, i.e., phase of flight, weather conditions, experience in make and model, currency of experience, etc. Although certainly not all encompassing, this report has served to make the scope of subsequent analysis more manageable. Extensive additional efforts will be required before a final "profile" of the accident involved airman can be proposed, if indeed a common denominator is attainable at all.

The identification of age as a significant variable differentiating the accident and non-accident distribution deserves some comparative comment.

An earlier FAA report[12] based on accident data in 1965 concluded that age and accidents were not significantly related, particularly with respect to older airman age groups. The authors' approach was to analyze accident experience and age by chi-square technique for the various airman ratings.

If one compares the previous findings with this report, several similarities are obvious even though different population data were utilized, i.e., 1964–1965 *airman rating data* versus 1966–1967 *airman medical record data* in this report. In Table II of the earlier report, it may be seen that total accident rate is lowest for age interval 16–29 (106 accidents per 10,000); highest for age interval 30–44 (121 accidents per 10,000); tapers off to 109 accidents per 10,000 for age interval 45–59; and goes up slightly for ages 60 and over (110 accidents per 10,000). Age intervals are different in our report, however, for in the two-year period we also observe the accident rate to be lowest for ages less than 29; to increase in the age interval 30–39; to decrease in the age interval 40–49; and in contrast to the previous findings to increase quite rapidly above age 50 and reach

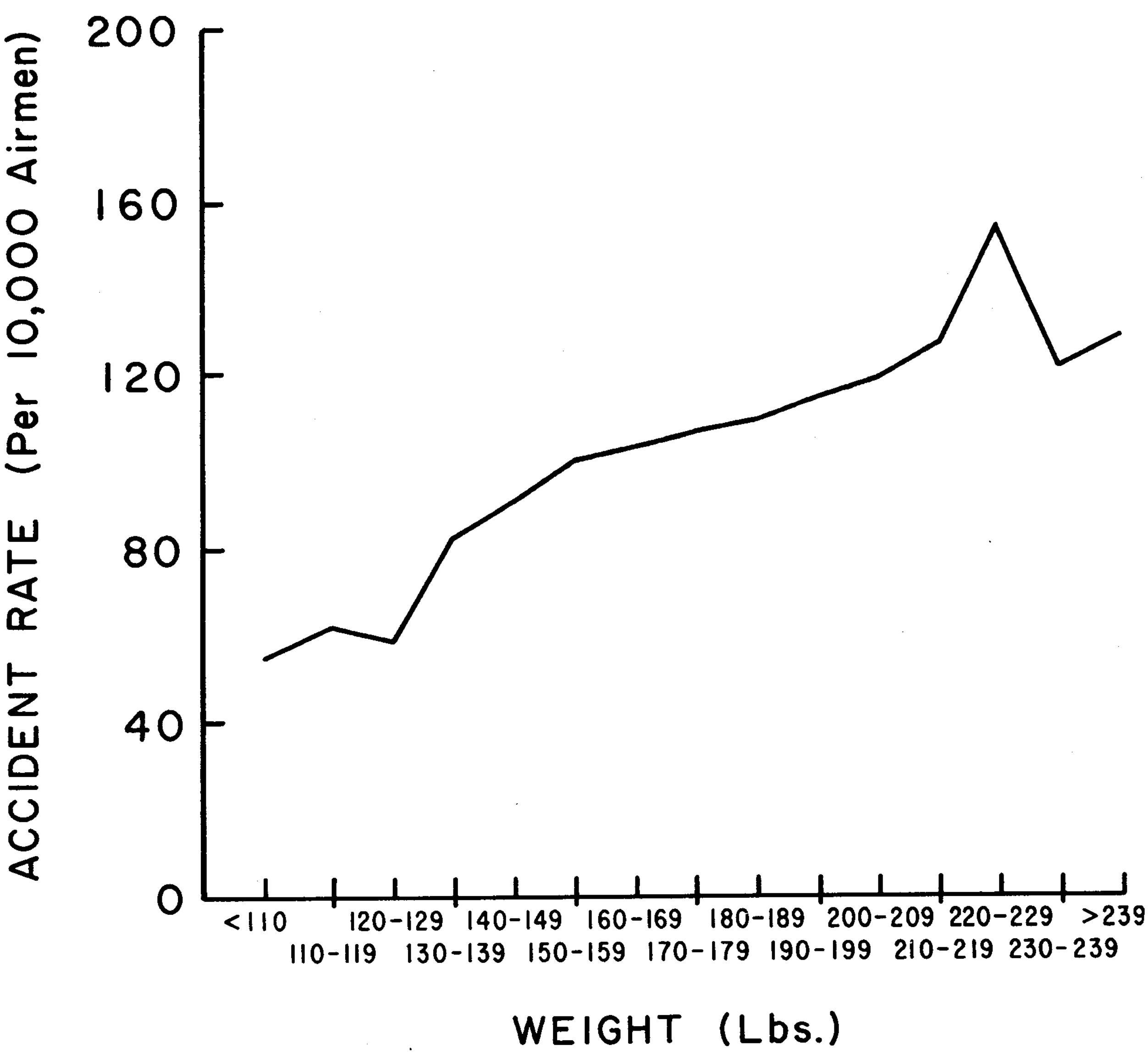

FIGURE 3. General Aviation Accident Rate by Weight.

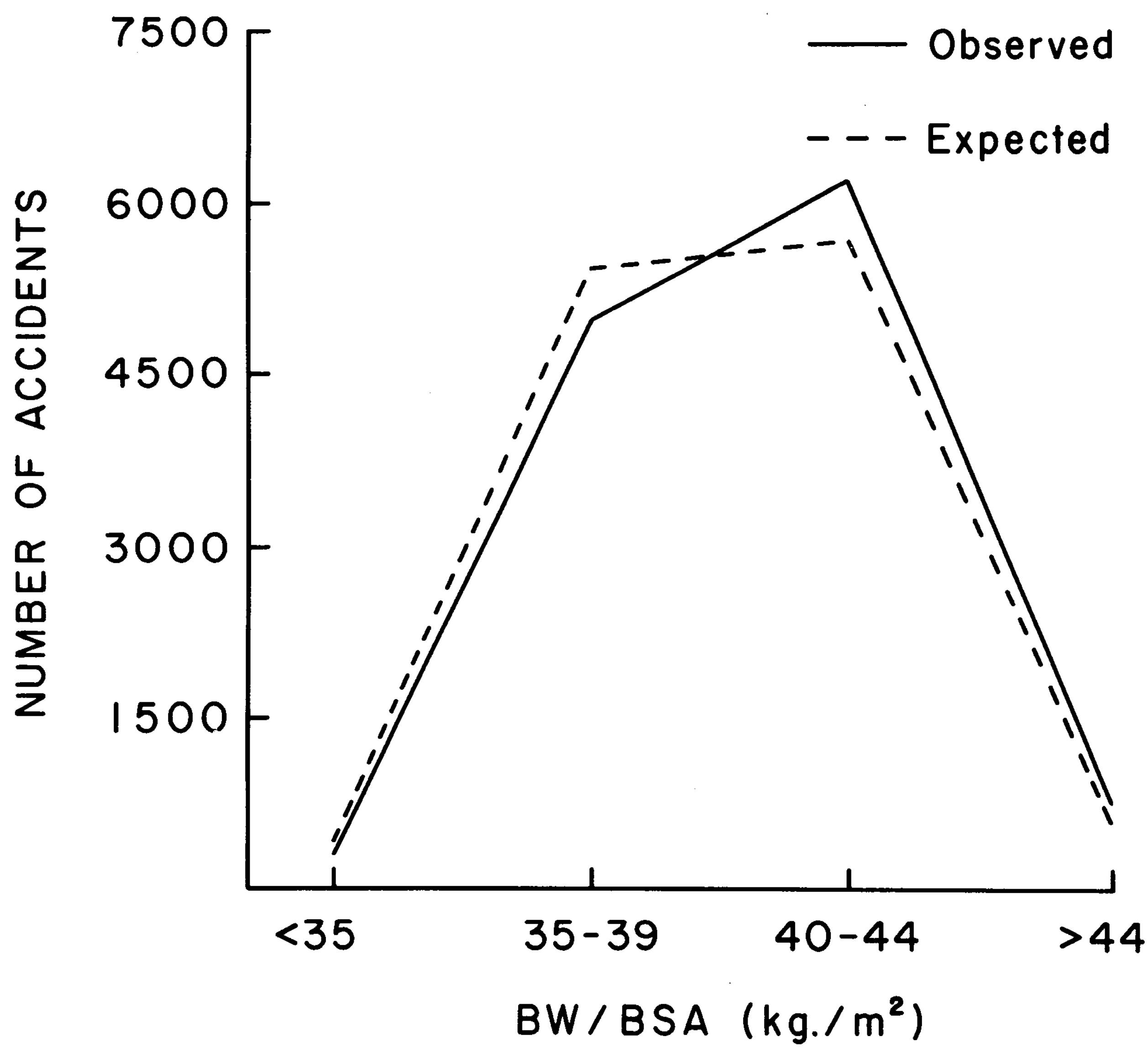

FIGURE 4.1. Observed Versus Expected General Aviation Accidents by Weight Per Unit of Body Surface Area (BW/BSA).

its highest rate for ages 60 and above. (See Figure 1.2 and Table 1.)

Population and accident data were different in the two reports and different age intervals were chosen for purposes of analysis. One would expect similar findings if age were truly important with respect to accident rates. Findings with respect to older airmen differ appreciably in the two reports and some additional comments are appropriate if we are to appreciate these differences.

The previous findings result from utilizing airman rating data contained in the 1966 edition of the FAA Statistical Handbook and the resultant findings with respect to older airmen precipitate from the fact that this population definition contains more airmen in the older age intervals than does the population based on medical records. Data contained in the FAA Statistical Handbook are based on a records match between airman records file and medical files. All airmen who possess an airman rating and a valid medical certificate issued within the preceding 30 calendar months are considered active airmen. Additionally, if records do not match but the airman has a valid medical certificate within 30 months or an airman rating issued within 30 months, the airman is also considered active. From a regulatory standpoint, an airman must possess medical certification commensurate with airman rating usage, but in no event can the medical certificate be older than 24 calendar months for private pilot purposes. This latter definition applies to the population data utilized in our analysis.

The extent to which the six month grace period inherent in the FAA Statistical Handbook data affects the older age intervals can only be surmised. Attrition from an active airman status can occur the day after medical certification and/or airman rating and is recognized in both definitions of the population. However, to define the active population six months beyond regulatory limitations would obviously inflate population data.

Additionally, if one follows the data contained in the FAA Statistical Handbook over the years 1964 through 1968, the frequency of airmen in

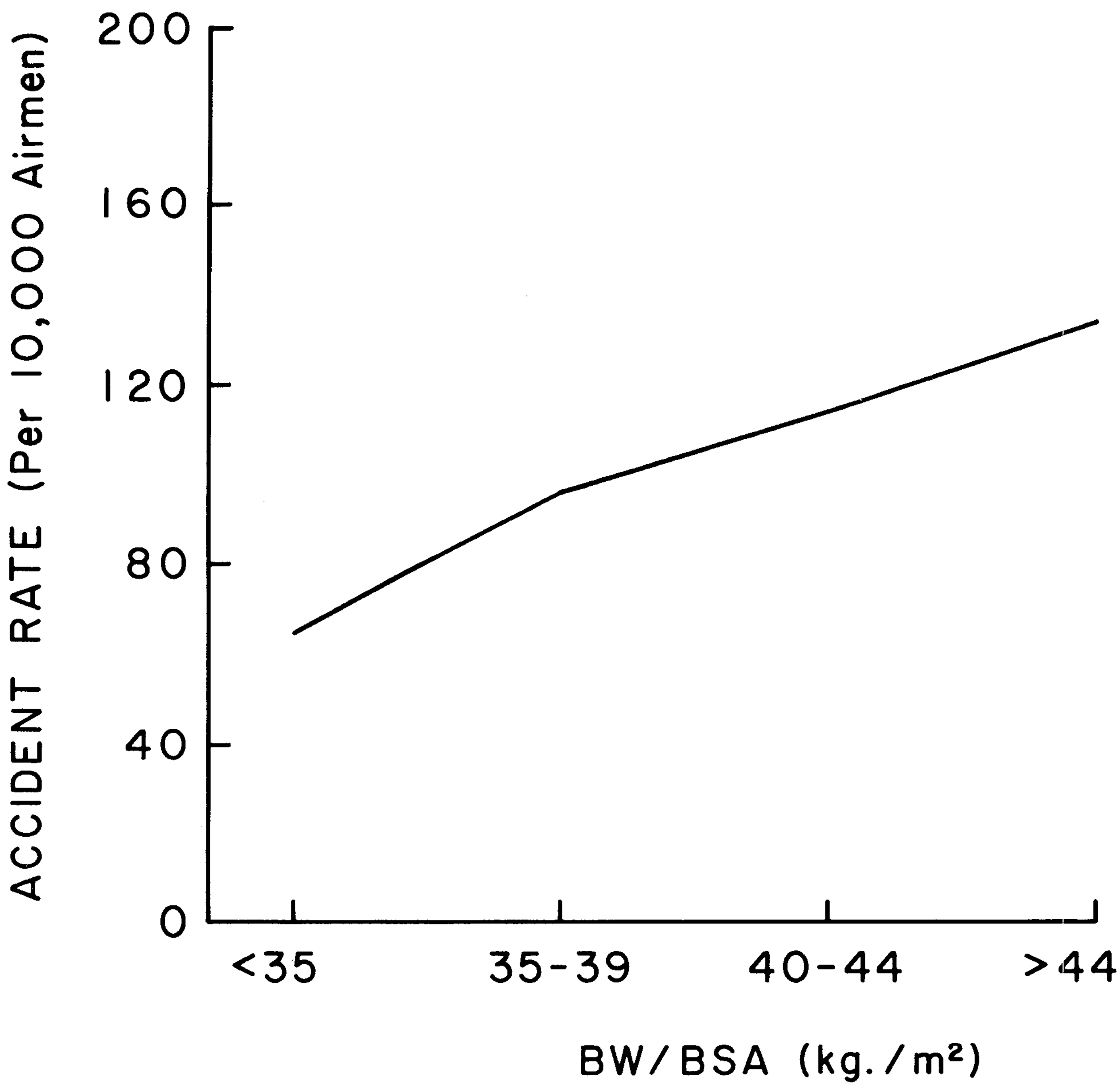

FIGURE 4.2. General Aviation Accident Rate by Weight Per Unit of Body Surface Area (BW/BSA).

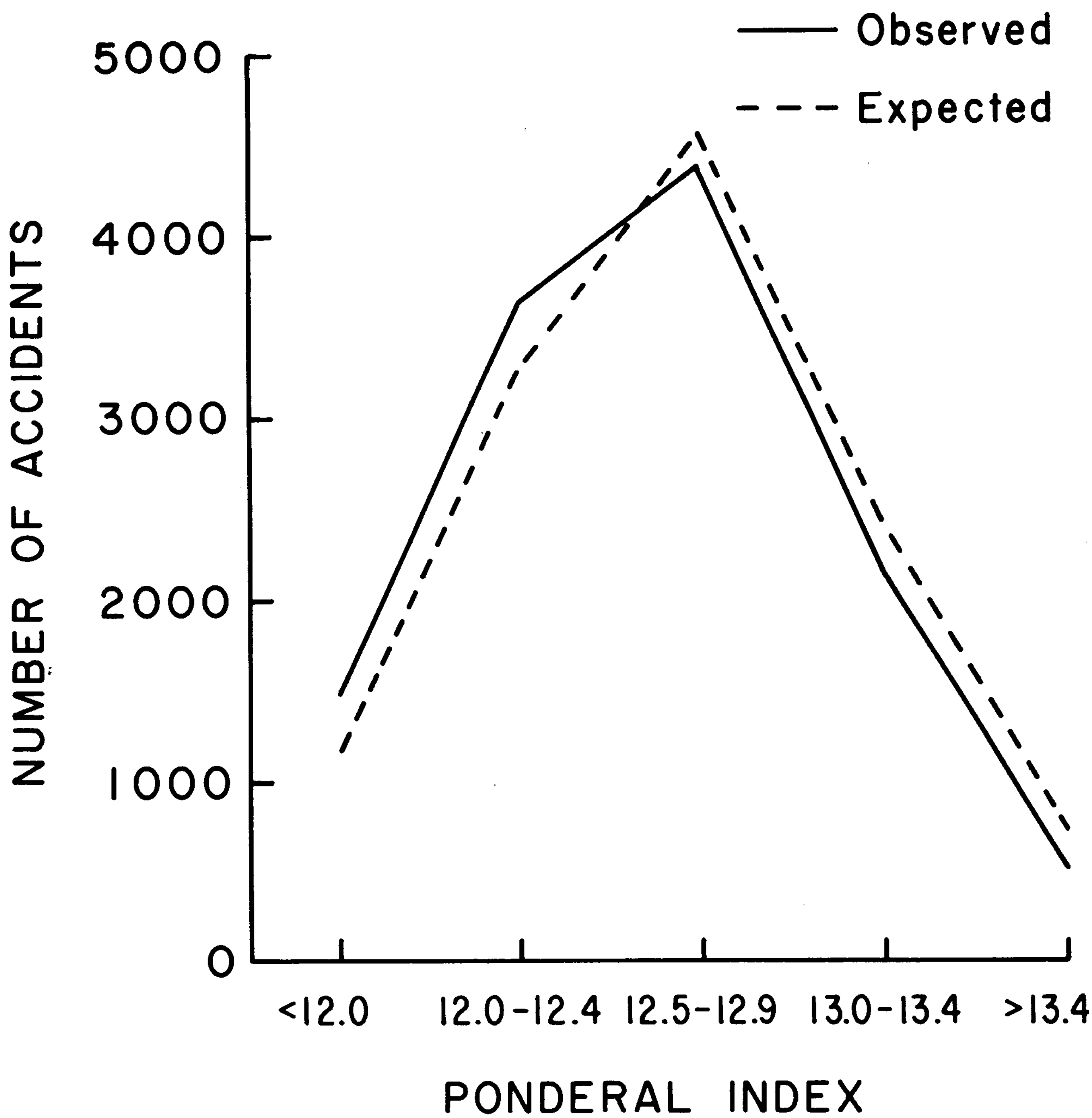

FIGURE 5.1. Observed Versus Expected General Aviation Accidents by Ponderal Index.

the older age interval suggests a possible change in programming criteria or possibly a records change, i.e., for year ending 1964, active pilots 60 and over were reported as 8,513; for 1965, active pilots 60 and over were 11,317; for 1966, active pilots 60 and over were 17,362; for 1967, active pilots 60 and over were 10,844; a drop of some 6,500 airmen in the age interval 60 and over from 1966 to 1967, while medical summaries indicate a gradual increase during the same time period. This latter total of 10,844 compares favorably with medical record summaries based on the 24 month criteria for the year ending 1967, i.e., 10,844 versus 9,884 from medical summaries. The 960 difference is probably due to the six month grace period inherent in the FAA Statistical Handbook data.

There are problems with the medical definition of the active airman population also. The problem of attrition during the 24 month period, which is common to both population definitions, has been discussed. Additionally, the medical population contains some air traffic controllers who are not pilots and who do not intend to become pilots.

In the opinion of the authors, the 24 month medical definition offers a better definition of the active airman population recognizing the limitations of both. It should be noted that criteria have recently been changed to the 24 month definition in the FAA Statistical Handbook data by rating.

The statistically significant differences in the frequency distributions of accident and non-accident airman populations on the basis of the status variables age, weight, BW/BSA, and PI suggest that factors associated with these variables should be given closer attention in the

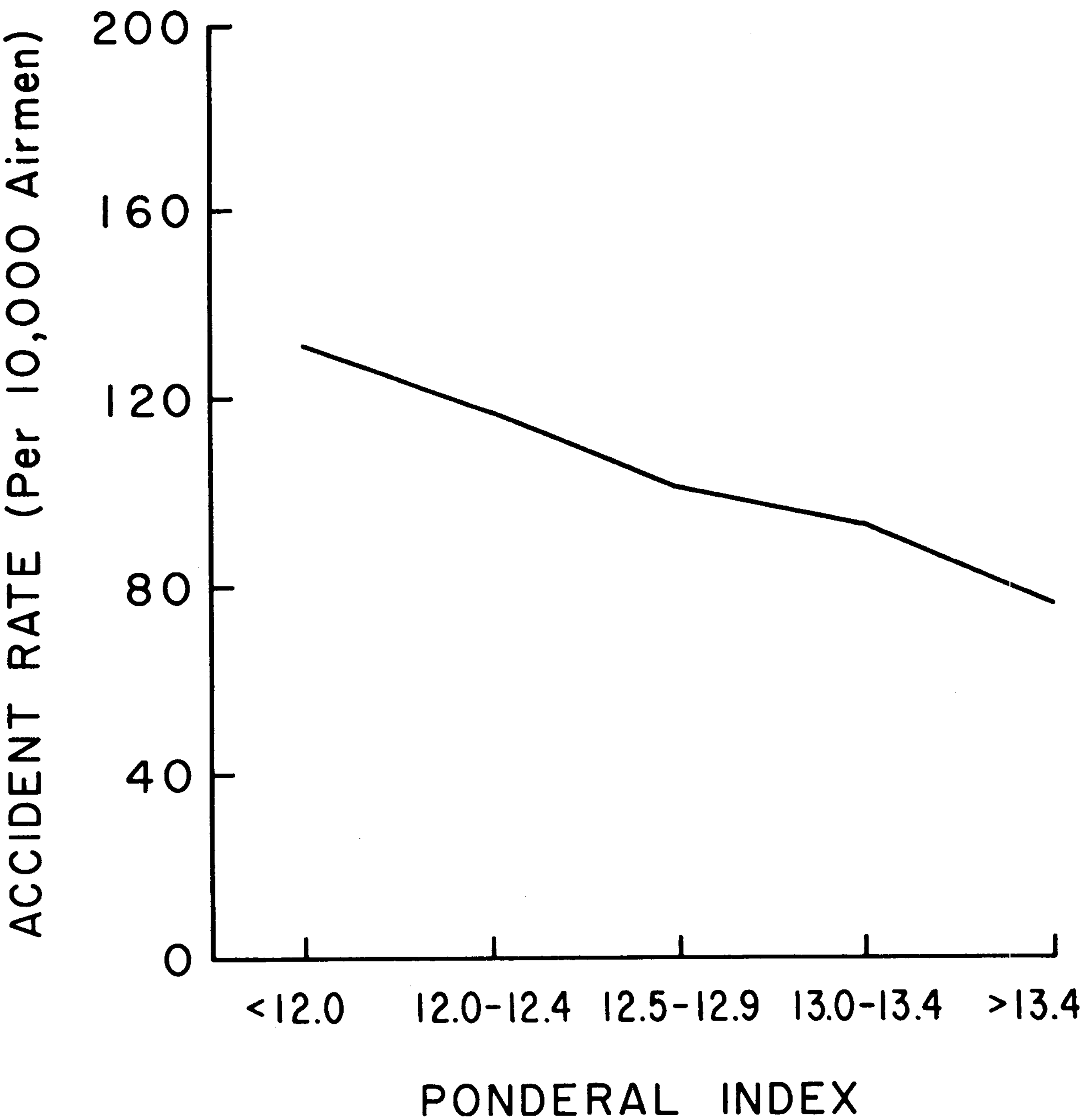

FIGURE 5.2. General Aviation Accident Rate by Ponderal Index.

analysis of the causes of general aviation accidents. The manner in which the body weight factors (body weight, BW/BSA, and PI) may operate is as yet unknown. Whether the fundamental problems are psychological, biological, or simply reflect a discrepancy at the man-machine interface can only be speculated at present.

Several lesser points uncovered in this study deserve some specific comment, although adequate explanations are not immediately apparent. In general, the accident rate increases with increasing age (Figure 1.2). However, the decade 40–49 years appears to deviate from a smooth trend line suggesting that the accident rate in this decade is less than that of the decade immediately preceding (30–39 years) or immediately following (50–59 years). The characteristics peculiar to this decade which might be responsible for the lower than expected accident rate are not known. However, one might speculate from observing Table 1 that this age interval is a "staging area" for attrition from an active status.

The observation that the "short" (<63″) and "tall" (>75″) class intervals have a slightly higher accident rate than adjacent intervals (Figure 2) also suggests that unidentified factors are operating within these classes. While this finding offers an interesting point for further study of man-machine interface, an attempt to explain it at present is beyond the scope and limitations of this report.

Identification of age as a significant variable differentiating the accident and non-accident distributions deserves some additional comment as related to the weight factors. It is generally recognized that as age increases in American men, body weight on the average also increases[19]. This fact poses the additional problem of deciding whether weight or age is the more significant variable affecting the frequency distributions reported here. The present analysis of accident data does not permit a further discussion on this point, but the question is a fundamental one and deserves further attention, particularly because the combination of advanced age and obesity are known to be partially implicated in the susceptibility of American men to coronary heart disease[20 21]. It may be possible that age and weight are additive in their effects on the distributions. This could explain why age has not been found to be an important accident factor in populations which are highly selective in terms of physical fitness (military pilots and commercial air transport pilots)[10]. The involvement of age and age-associated variables (physical defects) in general aviation accidents has been analyzed recently by Dougherty and Harper[13]. However, the age/weight relationship was not considered.

The observations that weight and variables derived from weight have a relationship to general aviation accident frequencies is interpreted here as only a first approximation to the problem. It seems reasonable that further exploration into this area should be considered from both a statistical and biological viewpoint in order to better characterize the mechanism(s) through which the gross variable operates.

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