A PRELIMINARY STUDY OF PHYSICAL STANDARDS IN RELATION TO SUCCESS IN FLIGHT TRAINING

Prepared

by

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and

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This is a report of a study conducted by the National Research Council Committee on Selection and Training of Aircraft Pilots through the cooperation of the RAF Delegation and the British Flying Training Schools, with funds provided by the Civil Aeronautics Administration.

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Committee on Selection and Training of Aircraft Pilots

Executive Subcommittee

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LETTER OF TRANSMITTAL

NATIONAL RESEARCH COUNCIL

2101 Constitution Avenue, Washington, D. C.
Division of Anthropology and Psychology

Committee on Selection and Training of Aircraft Pilots

February 17, 1944

Dr. Dean R. Brimhall
Director of Research
Civil Aeronautics Administration
Washington 25, D. C.

Dear Dr. Brimhall:

Attached is a report entitled A Preliminary Study of Physical Standards in Relation to Success in Flight Training, prepared by Dean R. Brimhall and Raymond Franzen, with the assistance of H. M. Johnson, R. C. Rogers, W. E. Vinacke, M. S. Viteles, and R. Y. Walker. The report is submitted by the Committee on Selection and Training of Aircraft Pilots with the recommendation that it be included in the series of technical reports of the Division of Research, Civil Aeronautics Administration.

The report embodies the results of a unique exploratory analysis of findings of the medical examination in relation to success in flight training. Particular significance is derived from the fact that the subjects of the investigation, RAF student pilots receiving training in this country, included men who would not have been acceptable for training under American medical standards. The report will therefore be of special interest to those concerned with the establishment and review of medical standards for the selection of personnel for flight training.

Plans are being made for a repetition of this study on a second group of RAF student pilots. This repeat study will be so designed as to avoid the difficulties in interpretation arising out of the loss of early eliminations in the study described in the attached report.

Cordially yours,

Morris S. Viteles, Chairman
Committee on Selection and
Training of Aircraft Pilots
National Research Council

RCR:ts

ACKNOWLEDGMENTS

The study described in this report was undertaken at the specific suggestion of Dean R. Brimhall, Director of Research, Civil Aeronautics Administration. It was made possible only through the cooperation of the office of the Surgeon General of the Royal Air Force and of the RAF delegation in this country--particularly that of Wing Commander P. A. Lee.

D. R. Brimhall, Raymond Franzen, H. M. Johnson, and M. S. Viteles collaborated in preparing the design of the experimental investigation. R. Y. Walker directed the collection and microfilming of the original data used in this study. Statistical analyses were carried out by Raymond Franzen and W. E. Vinacke, and the report prepared initially by Raymond Franzen. The report has benefited from considerable editorial revision by R. C. Rogers, and from review by J. G. Jenkins, Lt. Cdr., U.S.N.R., and the members of the staff of the Psychological Section of the Bureau of Medicine and Surgery, U. S. Navy. Acknowledgments are also due to the Commanding Officers of the British Flying Training Schools at which this study was conducted for most helpful cooperation in the collection of data.

EDITORIAL FOREWORD

One of the most pertinent problems in the selection and training of aircraft pilots is concerned with the efficacy of medical standards of acceptance for flight training. Studies in this field have been hampered by the fact that there has never been any real opportunity to test the validity of existing medical standards, since applicants for training who did not meet the standards are not allowed to try their hand at flying. Consequently it cannot be said definitely that they would or would not have made just as good pilots as those who did meet the standards and were accepted for flight training.

An opportunity to test the validity of American standards came with the training of the RAF cadets in this country. Many of the RAF medical standards of acceptance were lower than those used by the American Air Forces. It was therefore possible to compare a group of pilots who could not meet American standards and a group who could meet these standards in relation to their progress in flight training. This report embodies the results of this investigation.

The results of this study are of interest in two connections:

(1) in licensing of private pilots;

(2) in the selection of commercial and of military pilots.

In licensing pilots the problem is unequivocally that of determining the lowest standards compatible with required skill and safety in flying. The objective is to give every applicant with an interest in flying and who is competent to fly an opportunity to learn to fly and to enjoy the benefits of flying a plane. This report definitely calls into question the validity of present medical standards and their usefulness to a central agency entrusted with the task of qualifying applicants for flight training and of licensing them as private pilots.

The problem of selecting pilots, particularly military pilots, is more complex than that of licensing. The contention here is that fitness for military activities other than flying must be considered along with fitness for flying itself. The situation is confused, too, by the responsibilities for medical care and upkeep for flight casualties assumed by the Government (and also by commercial carriers) in accepting applicants for flight training. Under these circumstances, it is said that selection standards (cutting scores) should be set primarily with regard to the supply of applicants and that only if the demand for more flyers exceeds the reserve of applicants should the standards be lowered. The potential success of those applicants who are rejected, it is contended, becomes an important practical problem only when the reserve supply of applicants

is low. This problem apparently has not as yet confronted the American Air Forces. To the extent that this situation persists, the results of this study have more immediate implications for a licensing agency (such as the Civil Aeronautics Administration) than for the Armed Services. To the extent that there is a need and impetus for setting standards principally on the basis of the demands of the flying task itself, the findings are also of immediate significance to the Armed Forces.

Apart from the problems discussed above, there is another question which must be considered in connection with the results of this study. This is concerned with the criteria of flight competence. The criteria employed are all "in-training" criteria, i.e., they are all measures of the performance of the cadet under the watchful eye of an instructor at some comparatively safe training center. The performance of the pilot may be a great deal different when he attempts to fly under combat conditions. The stresses and strains of battle make new and greater demands on him. It is possible therefore that even though physical defect is not significantly related to a cadet's progress during flight training and his skill in the specific task of flying, it may nevertheless have a high degree of association with his performance under combat conditions. It is conceivable that a pilot with physical handicaps may break down sooner under battle conditions than the more physically perfect individual. No experimental data are available at this time bearing on this problem.

CONTENTS

SUMMARY

Many times, particularly since the entry of America into the war, those concerned with the examination of applicants for flight training have called into question the stringency of American medical standards of acceptance. It has been continually pointed out that the standards now in field use were arbitrary; that there had never been any real test of their appropriateness or validity; that there were wide variations in the rigidity with which they were adhered to; that due to strict adherence to these standards a large amount of perfectly acceptable pilot material was being wasted.

Stories have drifted back from the various fighting fronts, from the various air forces, to the effect that some apparently very successful combat fliers are physically handicapped to a great extent yet continue to fly. In civilian flying, many examples are found of pilots who are successful, yet would not be able to meet the standards set up by the American Air Forces. The argument has always been that once the pilot has learned to fly and has a great deal of flying experience, the physical qualifications could be relaxed somewhat and not interfere with his success as a pilot. It has been argued further, however, that relaxing the standards for cadets just beginning their flight training would result in a greater incidence of failure during these early stages of training or that the time necessary to train would be markedly increased, or that the accident rates, etc., would be greatly increased.

Evidence with respect to these situations is available in the experience of the Royal Air Force. British standards of acceptance for flight training are somewhat lower than the American. Since the outbreak of the war the British and Canadians have trained scores of pilots who would have been rejected from flight training had they been forced to meet American standards. As a matter of actual fact, many of these applicants for flight training who were rejected by the American Air Forces early in the war went directly to Canada and were accepted. Although no data are available on these men it is suspected that no greater percentage of them failed in their training than did those who would have met current standards in the American Air Forces.

Since many RAF cadets are being trained in this country it has become possible to begin a scientific investigation of the standards of acceptance in both countries. We know that, according to American standards, many of the RAF students would not have been accepted for flight training. If, then, the incidence of failure in training is no greater among those men who could not have met American standards than those who could have met them, we might do well to lower the standards. Further, if there is no increase in training time, in the number of accidents, in the degree of skill the men develop as pilots, further reason will be provided for a change of standards.

The study presented in this report represents one of the first in a series of investigations aimed at accurately testing the efficiency of American medical standards of acceptance for flight training. This study, although providing only a partial answer to questions concerning physical standards, definitely points the way for further investigations and indicates the trend the results are taking.

In this study the standards of acceptance for measures of pulse, systolic and diastolic pressure, and visual acuity in the worst eye were investigated with respect to success in flight training. It was found that there was little, if any, association between the approximate levels of acceptance now employed by the American Air Forces and the incidence of failure in flight training. It was also demonstrated that certain other factors (height, weight, chest circumference, body build, elasticity of arterial walls, the amount the cadet smokes or drinks, etc.) would not distinguish the cadets who passed flight training from those who were failed. Further, these same factors do not differentiate the cadets with respect to the degree of success in flight training.

The results suggest that the medical standards of acceptance might well be lowered, provided that subsequent analyses of the same factors again demonstrate the lack of relationship between such medical factors and success and failure in flight training.

It must be pointed out that these conclusions hold only for those factors analyzed in this study. Also, approximately two-thirds of the group of failures in flight training consisted of men who had failed after completing their primary training. It is possible then, that when other medical factors are investigated or that when data on these same factors are available for men who washout of flight training (fail) during the early stages, some association may be found between the standards of acceptance and success in flight training. It is possible that comparison of the medical factors with performance under combat condition will yield quite different results, e.g., a pilot with physical defect, while able to perform perfectly well while in training, may break down much more readily under the stress and strain of combat conditions.

A PRELIMINARY STUDY OF PHYSICAL STANDARDS IN RELATION TO SUCCESS IN FLIGHT TRAINING

INTRODUCTION

One of the vexatious problems in the field of selection of candidates for training in military aviation is the stringency of standards of acceptance. Although it is not difficult to eliminate obviously unfit individuals, it is much harder to determine the limits of disability within which it is safe to give training. It is reasonable to inquire whether perfectly acceptable pilot material is being eliminated by the medical standards now in use. The essence of this question, of course, lies in the relationship between the factors of physical status and success or failure in learning to fly.

Although medical examiners agree that physical disability is a handicap to flight training, they have never determined experimentally the degree of the disability which limits success. The level at which a variable (e.g., blood pressure) becomes a "disability" has not been investigated. The relationships of the physical measurements set up as standards and various criteria of flight competence have not been analyzed.

Should the pool of applicants for flight training become smaller, the problem of the validity of the selection and elimination standards will become more and more acute. This is particularly true of physical standards established arbitrarily without analysis of their relation to flight success or failure.

That such an analysis has not previously been made of the physical standards currently employed may, at first thought, seem puzzling. It is obvious, however, on closer examination of the situation, that when standards are employed to effect elimination as these have been, the data necessary for a study of their validity are not available. Individuals who are eliminated by these standards are never given a chance to prove their worth as pilots. Thus, adequate evidence to prove that these eliminees are weak candidates is not available.

Arbitrary levels of acceptance and rejection are set up and put into field operation, and all applicants thereafter are selected on the basis of them. Obviously, then, all who are accepted and who are finally successful as pilots have met these standards and probably have maintained them. Conversely, it is assumed that those who were eliminated (that is, did not originally meet the standards) would never have learned to fly, or if they had, would be dangerous, unsafe pilots. The errors involved in such a method of establishing selection standards and in the reasoning behind their use are obvious.

THE PROBLEM

An opportunity to investigate the validity of current medical standards of acceptance was afforded by the circumstance that records of British Royal Air Force cadets who were receiving their flight instruction in this country were available for study. The physical standards, particularly visual and cardiovascular, used in the original selection of these men, were somewhat less strict than those employed by the American Air Forces.

It is possible, therefore, to analyze the relevant physical and flight data on two groups of RAF trainees: (1) a group composed of those pilots who passed or failed flight training who would have been accepted for training even if the American physical standards had been employed in their selection, i.e., a group of retained and eliminated trainees acceptable to both the British and American standards, and (2) a group made up of those who passed and failed flight training who would not have been accepted for training had the American physical standards been employed in their selection, i.e., a group of retained and eliminated trainees acceptable for flight training according to the British physical standards, but not according to the American.

It should be noted that both of those groups contain eliminated cadets (washouts). The reasoning is that if there is no difference between the two groups with respect to their flying progress, it may be inferred that the American standards are somewhat too rigid. Conversely, if there is a greater incidence of failure among those who would be regarded as having a disability according to American standards, the desirability of having medical examiners adhere to present stringent standards will be confirmed.

The attention of the present study is directed toward the solution of the following major questions:

A. Is there any significant association between progress in learning to fly and the physical status (particularly in visual and cardiovascular factors) of Royal Air Force trainees in this country?

B. Can the eliminated cadets be differentiated from the successful cadets on the basis of their medical records or is this differentiation possible only by means of their grades (or other criteria of flight competence) assigned by the flight instructors?

C. From the RAF evidence is it reasonable to conclude that the standards for elimination used by the American Air Force could be less stringent without increasing the instruction time or decreasing the efficiency of instruction?

THE SUBJECTS

The subjects of the study were Royal Air Force student pilots stationed for training at five British Flying Training Schools in the United States, located in Ponca City, Oklahoma; Miami, Oklahoma; Terrell, Texas; Mesa, Arizona; and Lancaster, California. Of these, all cadets from the Mesa school were dropped from the analysis because there was an insufficient number of washouts (those cadets eliminated from the training course as a result of failure as judged at the field) for our purpose. This left a total of 750 cadets, of whom 246 were used twice in all tables which include analysis of the medical records. The washouts fall into two groups. In the first group were all those eliminated prior to the collection of the records used in this study (i.e., in the earlier stages of training). No medical records were obtainable on these since they had been referred to another branch of the service and their medical records had accompanied them. In the second group were those who had been eliminated subsequent to the beginning of the present study, and for whom medical records were available. Approximately two-thirds of this group were cases eliminated after primary training was successfully completed and one-third during the later

stages of primary. There were 147 in the first group and 72 in the second (70 plus two subjects with double records). In those tables concerned with the criteria of flying progress (e.g., Table 2) the number of this latter group is 70, whereas in those tables concerned with analysis of medical records the number of washouts is 72.

THE MATERIALS

All available relevant data were photographed on microfilm. The data were then assembled directly from the films. The records contained on these films were of three basic sorts, as follows:

A. Medical Examination Records.[1] These records were standard blanks filled out in England before the candidate was accepted for flight training and contain the results of the medical examination. Inasmuch as the emphasis in this study is on those physical factors for which standards are more lenient in the RAF than in the American Air Forces, primary attention will be given to the visual and cardiovascular data. However, a complete analysis of other data (anthropometric, smoking and drinking habits, etc.) is presented in Appendix A. Listed below are those categories for which data were transcribed:[2]

1. Pulse rate sitting
2. Pulse rate after exercise
3. Pulse rate standing (change of position)
4. Pulse rate standing
5. Time of pulse rate return to normal
6. Blood pressure - systolic
7. Blood pressure - diastolic
8. Visual acuity - right and left
9. Visual acuity corrected - right and left
10. Color vision
11. Red-green test
12. Maddox rod test
13. Accommodation
14. Diaphragm and convergence
15. Hearing acuity - right and left
16. Anthropometric data, smoking and drinking habits, and others[3]

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[1]These records are reported on various forms by the British. Form 826 gives the results of the first medical examination, and Forms 39 and 522 contain information relating to any further medical attention or examination after the pilot has started training. Most of the data required for the present study were derived from Form 826, one of which is available for each pilot, with the use of the other forms only when supplementary information was needed for clarification of the measures reported on Form 826. The other forms were made out with full knowledge of any forms which had previously been filled out on the pilot, hence do not constitute confirmation.

[2]The categories actually employed in the analysis were visual acuity (right and left), pulse, systolic and diastolic blood pressure. The data for the other visual factors (accommodation, convergence, and maddox rod) were either too scant, or too uniform for all pilots, to be used. Hearing also proved to be fruitless for the purposes of this study because all cases were tested as 20/20.

[3]A complete analysis of these variables is presented in Appendix A of this report.

B. Flight Records. These records are blanks which were filled out for each training flight made by the student pilot. They contained the grades assigned by the instructor to each maneuver[4] practiced and whatever comments or recommendations he saw fit to make concerning the day's performance. Since the grading system differed from school to school, it was necessary to devise a method for making the records comparable. Toward this end the grades were classified into "satisfactory" and "unsatisfactory," a dichotomy which was available for all materials. On the microfilm, the flight slips were grouped into these categories. Check flights occurring in varying frequency were also a part of the photographic record. The total number of flights for any course at the several schools differed, depending upon the stage to which the class had advanced at the time of photographing the records.

C. Dispatcher's Flight Logs. Every flight was listed on the time dispatcher's records, both as to the duration (cadet's time in the air) of the flight and the type of flying (cross-country, formation, etc.). Dual time at first solo flight was used as one of the criteria of progress. The time of other types of flying, such as cross-country and instrument, were not used in the final analysis, but the grades for these types of flying were included in the flight records.[5]

CRITERIA OF PROGRESS IN FLYING

The real problem in the statistical analysis was the choice of an adequate criterion of flying progress, i.e., one that would truly differentiate between the washouts and retained cadets, as well as allow an assignment of degrees of success to all trainees. Because many of the washouts did not have medical records it was essential to have an objective basis for comparing the worst retained cadets with the better ones. A means was needed to assess the degree of progress achieved during flight training.

Three possibilities were apparent: (1) the ratio of unsatisfactory to satisfactory flights, (2) the ratio of unsatisfactory to satisfactory grades in maneuvers practiced, and (3) the ratio of check flights to all other flights (on the assumption that poor students would require more frequent checking than good ones). A fourth, time to solo, was added because of its frequent use in selection experiments.

Ratios were employed in the first three measures because the courses were in different stages of completion in the four schools at the time the records were collected. These ratios adequately summarize the behavior of the cadets during their training period as reflected in the judgments of the training staff.

The validity of the use of these criteria was measured by the extent to which they differentiate between retained cadets and washouts. Even if medical

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[4] A separate study, The Emphasis of Ratings of Various Maneuvers when Judged by their Effectiveness in Eliminating RAF Candidates from Training, was made with these data. This study will be presented in a later report.

[5] In preparation for the statistical analysis of these data, a record card was made for each cadet, and pertinent material transcribed onto it from the film. On one side were the flying and time records; on the other were the medical findings. A sample of this record card is presented in Appendix C of this report.

records were available for all washouts, it would facilitate the analysis to be able to assign degrees of success to all cadets, thus making possible a more refined statement of the association between flying progress and medical status than would be possible were the analysis restricted solely to passing and failing. Aside from proof that these ratios distinguish outright failure from success, it is reasonable to conclude that, within limits, the best retained pilot ranks higher with respect to instructor's grades than the next best, etc. It is, however, impossible in the present instance to validate the criteria in any way other than by determining how well the washouts as a group are distinguished from the retained cases as a group. Hence further use of the criteria must depend upon such validation. As the result of the analysis of these criteria, the ratio of unsatisfactory to satisfactory flights was chosen for use in the analysis of the medical records. The details of the analysis of these criteria is presented in Appendix B.

PROGRESS IN FLYING IN RELATION TO MEDICAL RECORDS

The ratio of unsatisfactory to satisfactory flights was shown to be most highly correlated with success and failure in the course (see Appendix B). Consequently, being low in a group which has been retained means being near the point of failure. It is, then, possible to study the total group in respect to the relation of this quality to medical records. (It will be recalled that this group does not include those cadets eliminated during the early stages of primary flight training.)

If having a heart rate 84 or over, a systolic blood pressure at or above 135, a diastolic blood pressure at or above 90, or visual acuity in one eye which is 20/30, 20/50, 20/60 prejudices a cadet's success, then cadets having a record of such "defect" will have lower grades in the criterion ratio than those who are more normal in these respects.

Since the materials offer continuous records, it is possible to use limits which are at or near the point of elimination by standards in use in this country and at the same time include or exclude natural modal points in the distribution.[6] It is not always possible to investigate exact points used as "standard." It might be desirable, for instance, to examine the importance of disqualification of heart rates over 100 (cited in AR 40-105, 38-40) but heart rates as high as this are extremely rare. There are no such cases in these materials. To complicate matters still further there is a marked mode at 84 in these records which is due to the method of examination. It then becomes necessary to investigate 84 and above, instead of 100 and above. Classification such as this may still have significance since a resting pulse of 84 and above does mark out a group that is very likely to be distinguished by the Schneider routine (cited in AR 40-110, 20).

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[6] Army Regulations AR 40-105 and AR 40-110 were used as reference to determine standards of elimination. These regulations are not definite about the lower limits of blood pressure stating that they will disqualify for "arterial hypotension when the systolic pressure is persistently less than 100 mm. in the sitting or standing position." Only three such cases appeared in this study. They also state that "a low diastolic pressure will suggest the presence of aortic insufficiency" but they do not state the qualifications of "a low diastolic pressure." They further state that "a heart rate of 100 or over" and "a heart rate of 50 or under" both call for further medical examination. Such cases are also rare in this investigation.

Upper points of investigation for systolic blood pressure were 135 (AR 40-110, 20: "In the case of applicants for flying training, a persistent systolic blood pressure of 135 millimeters or more, or a persistent diastolic blood pressure of 90 millimeters or more, or an unstable blood pressure disqualifies")[7] and 140 for aviation cadet training. Upper limits for diastolic blood pressure were 85 (to include a strict standard) and 90 (see quotation above).

With the exception of the pulse measures, the Army Regulations do not specify the acceptable "lower limits" of the medical factors. Thus, for purposes of this study, practical arbitrary cut-off points were selected at the lower levels of the distributions of the measures. In all cases, more than one cut-off point was analyzed at these lower levels. The distributions used to determine these cut-offs are presented in Table 1.

It is also apparent from examination of the distributions (Table 1) that it is not always feasible to analyze the data using the exact elimination points given in the Army Regulations. Particularly is this true when there are too few cases above the Army cut-off to warrant statistical treatment, or where the actual modal points in the distribution fall at a different level. Insofar as possible the exact Army cut-offs were analyzed. When this was not possible the cut-off was taken either at a point very closely approximating that given by the Army Regulations or at the modal point in the distribution. In all cases, two cut-offs were analyzed for each medical factor. The exact cut-off points treated in this study are presented below:[8]

Pulse . . . . . At or above 84 and at or above 78.
(there were no cases at or above 100 and a mode of 84)

Pulse . . . . . At or below 60 and at or below 66.
(there were only 2 cases at or below 50 and a mode of 60)

Systolic blood pressure . . . At or above 135 and at or above 140.

Systolic blood pressure . . . At or below 124 and at or below 119.
(there were only 3 cases under 100)

Diastolic blood pressure. . . At or above 85 and at or above 90.
(there were only 18 cases above 90)

Diastolic blood pressure. . . At or below 74 and at or below 68.

Visual Acuity worst eye . . . 6/9, 6/12, 6/18.
(using 6/12 or 6/18 separately)

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[7] It may be of interest to note that the phrase "or an unstable blood pressure" has the effect of negating the "persistent" since having a "high" blood pressure once but not the next time may easily count as "unstable."

[8] Editor's Note: Conferences with Commander W. E. Kellum, Aviation Medicine Division, Bureau of Medicine and Surgery, indicate that pulse rates above 84 and below 66, respectively, are considered significant contra-indications by the U. S. Navy. Systolic blood pressure above 135 is considered undesirable, but candidates with systolic blood pressures up to 140 will be accepted. Lower limits for systolic blood pressures are not indicated. Diastolic blood pressures above 90 are considered to be of significance. There are no official limitations with respect to minimum blood pressures. The Navy requires 20/20 vision for candidates training as pilots.

RESULTS OF THE ANALYSIS OF PROGRESS IN FLYING IN RELATION TO MEDICAL RECORDS

Presented in Table 1 are the distributions studied to determine the experimental cut-offs employed throughout this study. As indicated earlier in the paper, the washout group in this table and in subsequent analyses is composed of students washed out after successful completion of primary training (approximately two-thirds) and during the later stages of primary (one-third).

TABLE 1

DISTRIBUTION OF RETAINED AND WASHOUT CASES FOR EACH MEDICAL FACTOR

Pulse			Systolic B. P.			Diastolic B. P.			Acuity Worst Eye		
Rate	Ret.	Elim.	Reading	Ret.	Elim.	Reading	Ret.	Elim.	Score	Ret.	Elim.
95-98	17	1	181-185	1		95-98	6		6/6	317	43
92-94	4	-	176-180	-		91-94	11	1	6/5	136	28
87-90	10	2	171-175	3		87-90	43	4	6/4	1	-
83-86	151	23	166-170	-		83-86	53	4	6/9	38	7
79-82	24	3	161-165	3		79-82	113	18	6/12	17	2
75-78	26	5	156-160	17	3	75-78	93	13	6/18	4	2
71-74	187	21	151-155	8	2	71-74	37	9			
67-70	7	3	146-150	42	5	67-70	98	15			
63-66	10	3	141-145	30	2	63-66	26	5			
59-62	53	9	136-140	83	11	59-62	13	3			
55-58	1	1	131-135	51	5	55-58	1				
51-54	2	1	126-130	114	15						
47-50	2		121-125	43	5						
			116-120	67	15						
			111-115	11	5						
			106-110	17	4						
			101-105	1							
			96-100	1							
			91-95	1							
			86-90	1							
Total	494	72		494	72		494	72		493	72
No record	2	0		2	0		2	0		3	0

All cadets (retained plus eliminated cases) were then combined into contingency tables with the criterion of progress in flight training (the ratio of unsatisfactory to satisfactory flights) as one variable and each of the medical factors in turn as the other. Chi-squared was then computed for these medical standards.[9] The results of these analyses are presented in Table 2 (for the stringent standards) and in Table 2-a (for the more lenient standards).

TABLE 2

THE ASSOCIATION BETWEEN UNSATISFACTORY/SATISFACTORY FLIGHTS AND SELECTED MEDICAL FACTORS[10]
(on cases eliminated in the later stages of flight training)

Medical Factor	School	N	X^2	Degrees of Freedom	P
Pulse	Ponca City	128	5.93	8	.65
78 and above	Miami	142	3.08	4	.55
66 and below	Terrell	147	3.56	6	.73
	Lancaster	149	8.55	4	.07
Systolic B. P.	Ponca City	128	11.65	8	.17
135 and above	Miami	142	7.03	4	.13
124 and below	Terrell	147	4.46	6	.62
	Lancaster	149	6.71	4	.15
Diastolic B. P.	Ponca City	128	11.88	8	.16
85 and above	Miami	142	5.74	4	.22
74 and below	Terrell	147	8.24	6	.22
	Lancaster	149	10.02	4	-.04
Worst Eye	Ponca City	127	7.37	8	.50
6/9, 6/12 and	Miami	142	.50	2	-
6/18	Terrell	147	2.37	3	.51
	Lancaster	149	6.84	2	.03

[9] A sample computation of chi-squared as used in deriving the data presented in Tables 2-6 is presented in the Appendix D, Table D-1.

[10] The P-value in this table indicates the probability that groups classified in terms of the criterion belong to the same population with respect to their medical records. The theoretical frequencies are obtained from the coordinate distribution of the criterion and each medical record evaluated. Two levels of significance are usually employed in evaluating a given P-value: The 5% level ($P \leq .05$) meaning that 5 times out of 100 the difference will occur by chance, or the more rigid level of 1% ($P \leq .01$).

It should be noted that the direction of the P-value (-.04) on diastolic blood pressure for the Lancaster group is negative. Also, one case in the Ponca City group (N = 127) had no record of Visual Acuity for the worst eye.

TABLE 2-a

THE ASSOCIATION BETWEEN UNSATISFACTORY/SATISFACTORY FLIGHTS AND SELECTED MEDICAL FACTORS
(using more lenient standards including 140 systolic and 90 diastolic)

Medical Factor	School	N	X^2	Degrees of Freedom	P
Pulse	Ponca City	128	8.03	8	.43
84 and above	Miami	142	1.73	4	.78
60 and below	Terrell	147	3.61	6	.73
	Lancaster	149	3.88	4	.42
Systolic B.P.	Ponca City	128	1.73	8	.47
140 and above	Miami	142	3.44	4	.49
119 and below	Terrell	147	7.95	6	.24
	Lancaster	149	.93	4	.90+
Diastolic B.P.	Ponca City	128	8.03	8	.43
90 and above	Miami	142	10.08	4	.04
68 and below	Terrell	147	5.26	6	.51
	Lancaster	149	2.52	4	.65

Examination of Tables 2 and 2-a reveals that there is little if any relation between the degree of flying success as measured by the ratio of unsatisfactory to satisfactory flights and the visual and cardiovascular factors studied in this analysis.

The statistical details of these relations are presented in Tables 3 - 6 . In each of these tables the association between the cut-offs established for the medical factor under consideration and the ratio of unsatisfactory to satisfactory flights is analyzed. The P-values in this case then express the probability that the registered coordinate distribution would be as it is if there were no association between the criterion distribution (the ratio of unsatisfactory to satisfactory flights) and the medical factor being analyzed.

TABLE 3

THE ASSOCIATION BETWEEN RATIO OF UNSATISFACTORY TO SATISFACTORY TRAINING FLIGHTS AND RECORDED PULSE
(using 66 and 78 as cut-off points)

Ratio of Unsatisfactory to Satisfactory Flights (in 100ths)	Pulse Below 66		Pulse 67-77		Pulse Above 78		
	o	e	o	e	o	e	
Ponca City							
0-9	9	7.13	15	20.25	24	20.63	
10-19	4	5.64	20	16.03	14	16.33	
20-29	2	1.78	4	5.06	6	5.16	
30-39	1	1.93	7	5.48	5	5.59	
40 and over	3	2.52	8	7.17	6	7.31	
Total	19		54		55		128
P = .65							
Miami							
0-9	14	16.06	48	45.76	52	52.18	
10-19	4	1.97	4	5.62	6	6.41	
20 and over	2	1.97	5	5.62	7	6.41	
Total	20		57		65		142
P = .55							
Terrell							
0-9	7	9.18	29	27.05	35	34.78	
10-19	6	5.04	16	14.86	17	19.10	
20-29	4	3.23	6	9.52	15	12.24	
30 and over	2	1.55	5	4.57	5	5.88	
Total	19		56		72		147
P = .73							
Lancaster							
0-39	9	12.72	36	33.93	34	32.34	
40-69	2	4.19	12	11.17	12	10.64	
70 and over	13	7.09	16	18.90	15	18.01	
Total	24		64		61		149
P = .07							

TABLE 3-a

THE ASSOCIATION BETWEEN RATIO OF UNSATISFACTORY TO SATISFACTORY TRAINING FLIGHTS AND RECORDED PULSE (using 60 and 84 as cut-off points)

Ratio of Unsatisfactory to Satisfactory Flights (in 100ths)	Pulse Below 60		Pulse 61-83		Pulse Above 84		
	o	e	o	e	o	e	
Ponca City							
0-9	8	5.63	20	25.50	20	16.88	
10-19	3	4.45	23	20.18	12	13.36	
20-29	1	1.41	7	6.38	4	4.22	
30-39	0	1.52	10	6.91	3	4.57	
40 and over	3	1.99	8	9.03	6	5.98	
Total	15		68		45		128
	P = .43						
Miami							
0-9	12	12.85	61	58.61	41	42.55	
10-19	2	1.58	7	7.20	5	5.23	
20 and over	2	1.58	5	7.20	7	5.23	
Total	16		73		53		142
	P = .78						
Terrell							
0-9	7	7.24	39	35.74	25	28.01	
10-19	3	3.98	20	19.63	16	15.39	
20-29	3	2.55	9	12.59	13	9.86	
30 and over	2	1.22	6	6.04	4	4.73	
Total	15		74		58		147
	P = .42						
Lancaster							
0-39	8	11.13	46	44.01	25	23.86	
40-69	3	3.66	15	14.48	8	7.85	
70 and over	10	6.20	22	24.51	12	13.29	
Total	21		83		45		149
	P = .42						

TABLE 4

THE ASSOCIATION BETWEEN RATIO OF UNSATISFACTORY TO SATISFACTORY TRAINING FLIGHTS AND RECORDED SYSTOLIC BLOOD PRESSURE

Ratio of Unsatisfactory to Satisfactory Flights (in 100ths)	Systolic B.P. Below 124		Systolic B.P. 125-134		Systolic B.P. Above 135		
	o	e	o	e	o	e	
Ponca City							
0-9	7	13.88	20	16.13	24	18.00	
10-19	12	10.98	14	12.77	32	14.25	
20-29	4	3.47	2	4.03	5	4.50	
30-39	5	3.76	3	4.37	5	4.88	
40 and over	9	4.91	4	5.71	5	6.38	
Total	37		43		48		128
	P = .17						
Miami							
0-9	28	26.49	43	38.54	43	48.97	
10-19	2	3.25	3	4.73	9	6.01	
20 and over	3	3.25	2	4.73	9	6.01	
Total	33		48		61		142
	P = .13						
Terrell							
0-9	20	19.80	25	23.67	26	27.53	
10-19	12	10.88	13	13.00	14	15.12	
20-29	5	6.97	6	8.33	14	9.69	
30 and over	4	3.35	5	4.00	3	4.65	
Total	41		49		57		147
	P = .62						
Lancaster							
0-39	26	22.27	16	23.33	35	33.40	
40-69	3	7.33	11	7.68	12	10.99	
70 and over	11	12.40	15	12.99	16	18.60	
Total	42		44		63		149
	P = .15						

TABLE 4-a

THE ASSOCIATION BETWEEN RATIO OF UNSATISFACTORY TO SATISFACTORY TRAINING FLIGHTS AND RECORDED SYSTOLIC BLOOD PRESSURE (using 119 as the lower limit and 140, the Army standard, as the upper limit)

Ratio of Unsatisfactory to Satisfactory Flights (in 100ths)	Systolic B.P. Below 119		Systolic B.P. 120-139		Systolic B.P. Above 140		
	o	e	o	e	o	e	
Ponca City							
0-9	3	6.00	30	29.25	15	12.75	
10-19	6	4.75	22	23.16	10	10.09	
20-29	1	1.50	7	7.31	4	3.19	
30-39	4	1.63	7	7.92	2	3.45	
40 and over	2	2.13	12	10.36	3	4.52	
Total	16		78		34		128
	P = .47						
Miami							
0-9	8	7.23	68	65.03	38	41.75	
10-19	1	.89	6	7.99	7	5.13	
20 and over	0	.89	7	7.99	7	5.13	
Total	9		81		52		142
	P = .49						
Terrell							
0-9	9	7.75	44	42.50	18	20.77	
10-19	4	4.24	36	23.35	9	11.41	
20-29	3	2.72	10	14.91	13	7.31	
30 and over	1	1.31	8	7.18	3	3.51	
Total	17		88		43		147
	P = .24						
Lancaster							
0-39	7	1.95	46	45.07	26	25.98	
40-69	2	2.62	15	14.83	9	8.55	
70 and over	6	1.43	24	25.10	14	14.47	
Total	15		85		49		149

TABLE 5

THE ASSOCIATION BETWEEN RATIO OF UNSATISFACTORY TO SATISFACTORY TRAINING FLIGHTS AND RECORDED DIASTOLIC BLOOD PRESSURE

Ratio of Unsatisfactory to Satisfactory Flights (in 100ths)	Diastolic B.P. Below 74		Diastolic B.P. 75-84		Diastolic B.P. Above 85		
	o	e	o	e	o	e	
Ponca City							
0-19	14	17.63	20	21.00	14	9.38	
10-19	18	13.95	13	16.63	7	7.42	
20-29	6	4.41	6	5.25	0	2.34	
30-39	4	4.77	6	5.69	3	2.54	
40 and over	5	6.24	11	7.44	1	3.32	
Total	47		56		25		128
	P = .16						
Miami							
0-9	52	48.17	42	45.76	20	20.07	
10-19	4	5.92	6	5.62	4	2.46	
20 and over	4	5.92	6	5.62	1	2.46	
Total	60		57		25		142
	P = .22						
Terrell							
0-9	24	26.08	37	31.39	10	13.52	
10-19	15	14.33	14	17.24	10	7.43	
20-29	12	9.18	7	11.05	6	4.76	
30 and over	3	4.41	7	5.31	2	2.29	
Total	54		65		28		147
	P = .22						
Lancaster							
0-39	30	24.39	34	42.42	15	12.19	
40-69	8	8.03	14	13.96	4	4.01	
70 and over	8	13.58	32	23.62	4	6.79	
Total	46		80		23		149
	P = .04						

TABLE 5-a

THE ASSOCIATION BETWEEN RATIO OF UNSATISFACTORY TO SATISFACTORY TRAINING FLIGHTS AND RECORDED DIASTOLIC BLOOD PRESSURE
(using 68 as the lower limit and 90, the Army standard, as the upper limit)

Ratio of Unsatisfactory to Satisfactory Flights (in 100ths)	Diastolic B.P. Below 68		Diastolic E.P. 60-89		Diastolic B.P. Above 90		
	o	e	o	e	o	e	
Ponca City							
0-9	4	5.25	39	38.63	5	4.13	
10-19	7	4.16	27	30.58	4	3.27	
20-29	1	1.31	11	9.66	0	1.03	
30-39	0	1.42	11	10.46	2	1.12	
40 and over	2	1.86	15	13.68	0	1.46	
Total	14		103		11		128
	P = .43						
Miami							
0-9	21	19.27	87	85.90	6	8.83	
10-19	1	2.37	9	10.55	4	1.08	
20 and over	2	2.37	11	10.55	1	1.08	
Total	24		107		11		142
	P = .04						
Terrell							
0-9	8	9.18	59	56.03	4	5.80	
10-19	6	5.04	28	30.78	5	3.18	
20-29	5	3.23	18	19.73	2	2.04	
30 and over	0	1.55	11	9.47	1	.98	
Total	19		116		12		147
	P = .51						
Lancaster							
0-39	12	9.54	60	63.62	7	5.83	
40-69	2	3.14	22	20.94	2	1.92	
70 and over	4	5.32	38	35.44	2	3.25	
Total	18		120		11		149
	P = .65						

TABLE 6

THE ASSOCIATION BETWEEN RATIO OF UNSATISFACTORY TO SATISFACTORY TRAINING FLIGHTS AND SNELLEN RECORD OF WORST EYE [11]

Ratio of Unsatisfactory to Satisfactory Flights (in 100ths)	Worst Eye 6/6, 6/5, or 6/4		Worst Eye 6/9, 6/12, or 6/18		
	o	e	o	e	
Ponca City					
0-9	45	42.71	3	5.29	
10-19	33	33.81	5	4.19	
20-29	12	10.68	0	1.32	
30-39	10	11.57	3	1.43	
40 and over	13	14.24	3	1.76	
Total	113		14		127
	P = .23				
Miami					
0-9	96	94.73	18	19.27	
10-19	11	11.63	3	2.37	
20 and over	11	11.63	3	2.37	
Total	118		24		142
	P = .99				
Terrell					
0-9	62	59.89	9	11.11	
10-19	30	32.90	9	6.10	
20-29	22	21.09	3	3.91	
30 and over	10	10.12	2	1.88	
Total	124		23		147
	P = .51				
Lancaster					
0-39	76	74.23	3	4.77	
40-69	26	24.43	0	1.58	
70 and over	38	41.34	6	2.66	
Total	140		9		149
	P = .03				

[11] One case in the Ponca City group had no record of visual acuity for the Worst eye. The N in this case is therefore 127 for the analysis of this factor.

Inspection of Tables 2-6 reveals that such relations as do appear between flying success and the medical factors are very inconsistent. For instance, diastolic blood pressure (Table 5) and vision defect (Table 6) seem to be related to success in Lancaster but not in the other schools, whereas low systolic blood pressure (Table 4) seems to be related to failure at Ponca City. If judgments were made on the basis of the Lancaster group alone (see Table 5) it might be concluded that having a diastolic pressure under 75 or over 85 predisposes the pilot to success in flight training. This anomalous conclusion is not confirmed by the other schools however. Having a visual acuity in the worst eye of 6/9 or less predisposes to failure in Lancaster (see Table 6). The cases which make the bad record are 6/9, and not 6/12 or 6/18. In the other schools the relations are too small to accredit.

When systolic blood pressure is examined at 140 and diastolic at 90 (to conform to Army Regulations) it is found that those cases exceeding these limits have succeeded as well in flight training as those who are well below them (see Tables 4-a and 5-a).

The materials contain 70 cases of visual defect of 6/9 or worse. Twenty-five of these are 6/12 or worse. Comparing records made by school, these extreme defects show slightly better performance than the 6/9 cases and about as good performance as normal vision cases do. This may be illustrated by the following figures (Table 7).

TABLE 7

Ratio of Unsatisfactory to Satisfactory Flights. (in 100ths)	Visual Acuity Worst Eye 6/9	Visual Acuity Worst Eye 6/12 or 6/18
0-9	19	14
10-29	14	6
30-39	3	2
40-49	9	3
Total	45	25

Examination of these tables has shown that there is no relation between degree of flying success and the possession of a disability as defined by the cut-offs. It will be noted that all but two of the P-values in Table 2, and all but one of those in Table 2-a, fail to attain even the 5% level of significance. Of the two which do approach this level (both pertaining to the Lancaster group) one of them is in the "wrong" direction, i.e., it indicates that cases with high or low diastolic blood pressure actually do better than those with average blood pressure, as measured by a lower ratio of unsatisfactory to satisfactory flights. The other significant P-value can scarcely be regarded as proving that visual acuity defect results in poor progress in flight training since evidence from the other three schools does not support such a conclusion, and since the relation is due to cases having 6/9 and not 6/12 or 6/18. The P-value of .04 for diastolic blood pressure in Miami (see Table 2-a) occurs merely because 4 of the 11 cases over 90 in diastolic pressure have a ratio between .10 and .20 rather than 0 and .10 as would be expected (Table 5-a). This difference in performance is too small to have any significance.

If high blood pressure disqualifies, it seems likely that "high" should be over 140 systolic, and 90 diastolic. If low blood pressure disqualifies, "low" should be under 119 systolic and 68 diastolic. There is no evidence to support the hypothesis that less than 20/20 vision or less than 20/30 will prejudice the student against success.

It should be noted that the conclusions drawn in the preceding discussions are only tentative and are subject to the qualification that the early washouts (those eliminated during the early stages of primary training) were not included in the populations investigated.

RESULTS OF THE ANALYSIS OF SUCCESS AND FAILURE IN FLIGHT TRAINING IN RELATION TO MEDICAL RECORDS

The next and final step in this study was made to determine whether any difference existed between the washouts and retained student pilots with respect to their medical status. As in the foregoing analyses only those subjects whose medical records were available could be used, i.e., those cadets who washed out in the early stages of primary analysis are not included in the analyses.

The results of this final analysis are presented in Tables 8 to 12. Tables 8 and 8-a present a summary of the comparisons of eliminated with retained cases on the basis of the medical standards analyzed in this study. The P-value in this case represents the probability that eliminated cases belong to the same universe as the retained cases, the theoretical frequencies being obtained from the distribution of retained cadets in respect to the medical records. Tables 9, 10, 11 and 12 present the statistical details of this analysis.

It will be noted that all but three of the P-values in Table 8 are too large for significance. Each of these three is for a different medical factor and for a different school. They cannot therefore be regarded as conclusive nor as counteracting the weight of evidence already accumulated against the theory that the current physical standards are important determiners of subsequent success in flight training. It is hardly possible that instructors have some private prejudice which acts only in one place and in one way to affect their grading of cadets. It is more reasonable to consider the three low P-values as chance occurrences. This is substantiated by the circumstances in the Lancaster group. In this group, Visual Acuity shows a significant relation with flying progress as measured by the ratio of unsatisfactory to satisfactory flight (see Table 6) but not with success and failure in flight training (see Table 12). The reverse is true of the Ponca City group.

All of the P's in Table 8-a are too large for significance. The upper limits for systolic and diastolic blood pressure evaluated in this table are those now in effect for American Army Aviation Cadet candidates. The evidence here, and in Table 8, indicates that these limits are subject to serious question in regard to their relation to success in flight training.

Table 10 indicates the possibility that further investigation of low systolic blood pressure might show a prejudice toward failure. However, Table 10-a further indicates that if this prejudice exists it is likely to be around 125, not 119. Results for Ponca City (Table 4 and 4-a) point in the same direction.

TABLE 6

COMPARISON OF ELIMINATED WITH RETAINED CASES IN SELECTED FACTORS OF THE MEDICAL EXAMINATION[12]
(on cases eliminated in the later stages of flight training)

Medical Factor	School	N of Elim. Cases	N of Ret. Cases	X^2 (or K)	Degrees of Freedom	P
Pulse	Ponca City	10	118	.84	2	.60
78 and above	Miami	17	125	.10	2	.60
66 and below	Terrell	24	123	.46	2	.60
	Lancaster	21	128	7.58	2	.02
Systolic B.P.	Ponca City	10	118	1.63	1	.10
135 and above	Miami	17	125	1.89	2	[illegible]
124 and below	Terrell	24	123	9.34	4	.05
	Lancaster	21	128	3.05	2	.12
Diastolic B.P.	Ponca City	10	118	1.07	2	.59
85 and above	Miami	17	125	2.50	2	.30
74 and below	Terrell	24	123	2.66	2	.27
	Lancaster	21	128	1.12	2	.58
Visual Acuity	Ponca City	10	117	3.54	1	.0002
(worst eye)	Miami	17	125	.63	1	.43
6/19, 6/12, and	Terrell	24	123	.14	1	.89
6/18	Lancaster	21	128	.26	1	.79

[12] In this table and in Table 8-a the P-value expresses the probability that eliminated cadets belong to the same population as retained cadets in respect to medical records. The theoretical frequencies were obtained from the distribution of retained cadets in respect to the medical records.

One case in the Ponca City group had no record of visual acuity for the worst eye, hence the number of retained cases = 117.

TABLE 8-a

COMPARISON OF ELIMINATED WITH RETAINED CASES IN SELECTED FACTORS OF THE MEDICAL EXAMINATION
(using more lenient standards including 140 systolic and 90 diastolic)

	School	N of Elim. Cases	N of Ret. Cases	K	Degrees of Freedom	P
Pulse	Ponca City	10	118	.85	2	.60
84 and above	Miami	17	125	.60	2	.60
60 and below	Terrell	24	123	.40	2	.60
	Lancaster	21	128	3.05	2	.22
Systolic B.P.	Ponca City	10	118	4.15	2	.13
140 and above	Miami	17	125	.03	2	.60
119 and below	Terrell	24	123	1.40	2	.51
	Lancaster	21	126	.70	2	.60
Diastolic B.P.	Ponca City	10	118	1.06	2	.59
90 and above	Miami	17	125	2.10	2	.35
68 and below	Terrell	24	123	1.47	2	.49
	Lancaster	21	128	1.73	2	.17

TABLE 9

COMPARISON OF RETAINED AND ELIMINATED CADETS IN RESPECT TO PULSE[13]

Pulse	Retained Cadets	Eliminated Cadets	Eliminated Cadets if they were distributed as the retained cadets are
	Ponce City		
66 and under	17	2	1.44
67-77	49	5	4.15
78 and over	12	3	4.41
Total	118	10	10.00
	P = .60		
	Miami		
66 and under	16	2	2.45
67-77	49	7	6.66
78 and over	58	8	7.89
Total	125	17	17.00
	P = .60		
	Terrell		
66 and under	15	4	2.93
67-77	47	9	9.17
78 and over	61	11	11.90
Total	123	24	24.00
	P = .86		
	Longmire		
66 and under	18	6	2.95
67-77	60	4	9.84
78 and over	50	11	8.20
Total	128	21	20.99
	P = .02		

[13] In this table, as well as in Tables 9-a - 12, the P-value expresses the probability that eliminated cadets belong to the same population as retained cadets in respect to medical records. The theoretionls are obtained from the distribution of retained cadets in respect to the medical records.

TABLE 9-a

COMPARISON OF RETAINED AND ELIMINATED CADETS
IN RESPECT TO PULSE
(using 60 and 84 as cut-off points)

Pulse	Retained Cadets	Eliminated Cadets	Eliminated cadets if they were distributed as the retained cadets are
		Kansas City	
60 and under	13	2	1.10
61-83	63	5	5.34
84 and over	42	3	3.56
Total	118	10	10.00
		P = .60	
		Miami	
60 and under	15	1	2.04
61-83	62	9	8.43
84 and over	48	7	6.53
Total	125	17	17.00
		P = .60	
		Terrell	
60 and under	12	3	2.34
61-83	58	12	11.32
84 and over	53	9	10.34
Total	123	24	24.00
		P = .60	
		Lancaster	
60 and under	16	5	2.63
61-83	74	9	12.14
84 and over	38	7	6.23
Total	128	21	21.00
		P = .22	

TABLE 10

COMPARISON OF RETAINED AND ELIMINATED CADETS IN RESPECT TO SYSTOLIC BLOOD PRESSURE

Systolic B.P.	Retained Cadets	Eliminated Cadets	Eliminated cadets if they were distributed as the retained cadets are
		Ponca City	
124 and under	32	5	2.71
125 and over	86	5	7.29
Total	118	10	10.00
		P = .10	
		Miami	
124 and under	27	6	2.67
125-134	43	5	5.85
135 and over	55	6	7.48
Total	125	17	17.00
		P = .39	
		Terrell	
105-114	4	3	.78
115-124	27	7	5.27
125-134	42	7	8.20
135-144	37	4	7.22
145 and over	13	3	2.54
Total	123	24	24.01
		P = .054	
		Lawton	
124 and under	36	6	5.91
125-134	35	3	5.74
135 and over	51	6	9.35
Total	128	21	21.00
		P = .23	

TABLE 10-a

COMPARISON OF RETAINED AND ELIMINATED CADETS
IN RESPECT TO SYSTOLIC BLOOD PRESSURE
(using 119 as the lower limit and 140, the Army standard, as the upper limit)

Systolic B.P.	Retained Cadets	Eliminated Cadets	Eliminated cadets if they were distributed as the retained cadets are
Ponca City			
119 and under	13	1	1.10
120-129	74	4	6.27
140 and over	31	5	2.63
Total	118	10	10.00
P = .13			
Miami			
119 and under	8	1	1.09
120-139	71	10	9.66
140 and over	46	6	6.26
Total	125	17	17.01
P = .60			
Ferrell			
119 and under	12	4	2.34
120-139	74	14	14.44
140 and over	37	6	7.22
Total	123	24	24.00
P = .51			
Lancaster			
119 and under	12	3	1.97
120-139	73	12	11.98
140 and over	43	6	7.05
Total	128	21	21.00
P = .60			

TABLE 11

COMPARISON OF RETAINED AND ELIMINATED CADETS IN RESPECT TO DIASTOLIC BLOOD PRESSURE

Diastolic B.P.	Retained Cadets	Eliminated Cadets	Eliminated cadets if they were distributed as the retained cadets are
		Ponca City	
74 and under	42	5	3.56
75-84	53	3	4.49
85 and over	23	2	1.95
Total	118	10	10.00
		P = .59	
		Miami	
55-64	10	2	1.36
65-74	40	8	5.44
75 and over	75	7	10.20
Total	125	17	17.00
		P = .30	
		Terrell	
74 and under	45	9	5.78
75-84	52	13	10.15
85 and over	26	2	5.07
Total	123	24	24.00
		P = .27	
		Lancaster	
74 and under	38	8	6.33
75-84	69	11	11.32
85 and over	21	2	3.45
Total	128	21	21.00
		P = .58	

TABLE II-e.

COMPARISON OF RETAINED AND ELIMINATED CADETS IN RESPECT TO DIASTOLIC BLOOD PRESSURE
(using 68 as the lower limit and 90, the Army standard, as the upper limit)

Diastolic B.P.	Retained Cadets	Eliminated Cadets	Eliminated cadets if they were distributed as the retained cadets are
		Ponca City	
68 and under	13	1	1.10
69-89	94	9	7.97
90 and over	11	0	.93
Total	118	10	10.00
		P = .59	
		Miami	
68 and under	20	4	2.72
69-89	94	13	12.76
90 and over	11	0	1.50
Total	125	17	17.00
		P = .35	
		Terrell	
68 and under	17	3	3.32
69-89	95	21	18.54
90 and over	11	1	2.15
Total	123	24	24.01
		P = .49	
		Lancaster	
68 and under	14	4	2.30
69-89	105	15	17.23
90 and over	9	2	1.48
Total	128	21	21.01
		P = .17	

TABLE 12

COMPARISON OF RETAINED AND ELIMINATED CADETS IN RESPECT TO SNELLEN RECORD OF WORST EYE [14]

Worst Eye	Retained Cadets	Eliminated Cadets	Eliminated cadets if they were distributed as the retained cadets are
Ponca City			
6/6, 6/5, or 6/4	107	6	9.15
6/9, 6/12, or 6/18	10	4	.86
Total	117	10	10.01
		P = .0002	
Miami			
6/6, 6/5, or 6/4	103	15	14.01
6/9, 6/12, or 6/18	22	2	2.99
Total	125	17	17.00
		P = .53	
Terrell			
6/6, 6/5, or 6/4	104	20	20.29
6/9, 6/12, or 6/18	19	4	3.71
	123	24	24.00
		P = .89	
Lancaster			
6/6, 6/5, or 6/4	120	20	19.69
6/9, 6/12, or 6/18	8	1	1.31
	128	21	21.00
		P = .79	

[14] One case in the Ponca City group had no record for visual acuity of the worst eye, hence N of retained cases = 117

SUMMARY AND CONCLUSIONS

This study was undertaken with the view toward testing the stringency of the physical standards of acceptance for flight training now being employed by the American Air Forces. Most medical examiners agree that physical disability is a handicap to successful progress in flight training. It is reasonable to inquire, however, whether perfectly acceptable pilot material is being eliminated from flight training by the current arbitrary medical standards.

An opportunity to present evidence bearing on this problem was offered by the circumstance that the flight records and medical records of Royal Air Force cadets training in this country were available for study. As the physical standards for acceptance for flight training are somewhat lower in the RAF than in the American Air Forces it is possible to analyse the relevant data on two groups of RAF pilots, namely, (1) those retained and eliminated cadets acceptable to both British and American standards, and (2) those retained and eliminated cadets acceptable according to British but not to American standards. The reasoning is that if there is no greater incidence of failure in flight training among those cadets accepted by the British for training who would have been rejected by American standards than among those who would have been accepted by the American standards (i.e., if there is no significant difference in the degree of success between these two groups) then there is reason to suspect the stringency of the American standards of acceptance.

The relevant data on a total of 750 RAF cadets were collected and microfilmed for purposes of this study. Data used in the analyses were then taken directly from the microfilmed records by the investigators. Of these 750 students, 245 were washouts (dropped at various stages in flight training). These washouts fell into two groups: (1) a group made up of cadets who were eliminated during the early stages of primary training (prior to the collection of the data) for whom no medical records were available, and (2) a group composed of washouts during the later stages of primary training and those eliminated following completion of primary and on whom medical records were available. Only those in the latter group could be used in the study of medical records and the significance of the findings are reduced to the extent that such selection has taken place. The data from the total group were used in the analysis of criteria of progress in flight training (see Appendix B). Those on whom no medical records were available (cadets eliminated during the early stages of primary) had to be dropped from the analysis of the medical factors.

The first problem confronting this study was the choice of an adequate criterion of flying progress, i.e., one that would truly differentiate between washouts and retained cadets as well as allow an assignment of degrees of success to all pilots. By means of chi-squared techniques, four possible criteria of flying success were investigated in relation to the washout criterion: (1) the ratio of unsatisfactory flights to satisfactory flights, (2) the ratio of unsatisfactory to satisfactory grades, (3) the ratio of check flights to all other flights, and (4) time to solo. Of these four measures, the ratio of unsatisfactory flights to satisfactory flights proved most consistently to differentiate failure from success (see Appendix B). It was, however, only slightly superior to the ratio of unsatisfactory to satisfactory grades.

The ratio of check flights to all other flights was dropped because it showed too little variance, and time to solo proved the most unreliable of any of the measures. The first ratio was therefore employed in all subsequent analyses.

The primary concern of this investigation was an analysis of the relationship between the visual and cardiovascular measures and the criteria of flight success. Whenever possible, the actual medical standards (Army Regulations 40-105 and 40-110) were employed to determine the cut-off points to be analyzed. However, with the exception of pulse, Army Regulations only give standards (cut-off points) for the upper levels of the medical factors. At those upper levels, two possible cut-off points were analyzed: one which was the exact point prescribed by Army Regulations (or as nearly that point as the data warranted) and another determined from the frequency distributions of each factor. For purposes of this study, cut-off points at the lower levels (prescribed only for pulse in Army Regulations) were set up on the basis of the distributions. Two possible cut-offs were analyzed for each medical factor.

By means of chi-squared technique the association between these various cut-off points and degree of success in flying (the ratio of unsatisfactory to satisfactory flights) was studied. The final step in the analysis consisted in the comparison of the retained and eliminated (washed out) cadets in respect to each of the medical factors under consideration.

On the basis of these analyses, it may be concluded that:

1. The ratio of unsatisfactory to satisfactory flights is the most satisfactory measure of <u>degrees</u> of flight success (see Appendix B).

2. Within the limits of the Royal Air Force standards of acceptance, and exculsive of early washouts, there is no significant association between progress in learning to fly (as measured by the ratio of unsatisfactory to satisfactory flights) and the degree of visual or cardiovascular disability. That is to say, predisposition to poor progress or outright failure is not a function of defined deviation from average medical status (see Tables 1-6).

3. There is no difference between retained and washout cases with respect to visual acuity or cardiovascular factors within the limitations of this study (see Tables 8-12).

4. Within the limits of the Royal Air Force standards of acceptance, and exclusive of early washouts, there is no significant association between progress in learning to fly and height, weight, leg length, chest circumference, body build, elasticity of arterial walls, smoking and drinking habits, etc. Neither is it possible to distinguish between retained and eliminated cadets on the basis of these factors. (See Appendix A.)

5. Individuals who would have been excluded by American standards of acceptance but who were accepted by the RAF show no greater proneness to failure than more highly selected candidates. It is, of course, possible that these defects exercise an early effect on success and that, therefore, there may be a large difference in medical records between retained pilots and the washouts whose medical records were not available at the time of this study (i.e., those who were washed out in the early stages of primary flight training).

Keeping in mind that this discussion is based upon individuals well within the normal range, it must be apparent that relaxing the limits of acceptance will not materially affect the percentage of failure in aviation training schools. There is no reason to believe that RAF standards are not, themselves, too stringent. Probably still more leniency would fail to increase the percentage of failure.

APPENDIX A

ANALYSIS OF OTHER ANTHROPOMETRIC AND MEDICAL FACTORS

ANALYSIS OF OTHER ANTHROPOMETRIC AND MEDICAL FACTORS

Presented in this Appendix are the results of the analysis of other medical and personal factors which could be gathered from the records of the pilots used in this study. It must be noted that there is no appreciable difference in the American and British standards with respect to these factors. In fact, a number of them are not weighted heavily in the selection process of either the British or American Air Forces.

In Table A-1 are presented the age distributions of the retained and washout groups at each school. It will be noted that there is no great difference between retained and washout cases. Consequently, this factor (age) will have had little, if any, effect on the interpretation of the analysis of the medical factors.

Tables A-2 through A-7 present the total distributions and chi-squared analysis (for the collapsed distributions) for: chest circumference, leg length, body build,[15] weight, and height. No significant differences between the total retained and total washout groups were demonstrated in these factors.

Tables A-8 through A-18 present the analysis of the association between height, weight, body build, leg length, chest circumference, mentality (bright, average, and dull), 40 mm. Hg. (duration), arterial wall (elasticity), smoking and use of alcohol (heavy, moderate, none), and degrees of flight success (as measured by the ratio of the unsatisfactory to satisfactory flights). Table A-8 summarizes the results of these analyses. The P-value presented in these tables may be taken to indicate the probability that eliminated cadets belong to the same population as the retained cadets in respect to the medical factors analyzed. The theoretical frequencies were obtained from the distribution of retained cadets in respect to the medical records. Tables A-9 through A-18 present the details of this analysis.

Tables A-19 through A-29 present the analysis of the retained and washout groups with respect to each of the above medical factors. Table A-19 summarizes the results of these analyses and Tables A-20 through A-29 present the details of the analyses. It will be noted that in these tables the number of cases varies slightly in different schools. This, for the reason that the records were not complete for some of the pilots. The P-value in these tables may be taken to indicate the probability that the registered coordinate distribution would be as it is if there were no association between the flight criterion and the medical factor being analyzed. In these tables, "o" represents the observed frequency, and "e" the theoretical frequency if there were no association between the criterion (the ratio of unsatisfactory to satis-

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[15] Build in pounds is the deviation in pounds from a norm for height. It will be noted that other physical dimensions besides height are highly correlated with weight. Furthermore, the variance in weight is not of equal importance at all levels of height.

factory flights) and the factor under consideration.

As far as cadets accepted for training are concerned, the factors on the medical record have no predictive value as they now stand. Wherever a relation (P under .05) occurs for a given factor it is present in only one school and is insignificant in the other three. It will be noted, however, that there is some relation between medical records and success in three factors: alcohol, body build, and mentality. The first two have three P-values under .25 with the success criterion, and the last has two P-values under .10. It is possible that better measurement and more variance in these factors would show an acceptable association. Although the above evidence indicates a trend only and does not warrant the use of these factors as predictive measures. It is quite possible that if these factors were objectively redefined the relation would be enhanced.

These data provide further evidence for the hypothesis that the introduction of more leniency in the standards of acceptance would not retard the efficiency of the American Air Force.

TABLE A-1

DISTRIBUTION BY AGE

Age in Years	Ponca City		Miami		Terrell		Lancaster		Total	
	Re- tained	Wash- outs	Re- tained	Wash- outs	Re- tained	Wash- outs	Re- tained	Wash- outs	Re- tained	Wash- outs
19	16	1	16	2	20	6	19	4	71	13
20	26	2	27	2	35	7	29	6	117	17
21	32	2	31	4	32	3	37	2	132	11
22	10	1	8	-	4	2	13	2	35	5
23	6	-	3	3	6	-	4	1	19	4
24	3	1	4	-	4	2	6	1	17	4
25	3	-	7	-	4	-	4	-	18	-
26	4	2	6	-	3	1	5	-	19	3
27	2	1	3	4	6	-	2	2	13	7
28	2		10	1	2	-	1	-	16	1
29	3		3		1	-	1	1	8	1
30	5		3		3	2	3	1	14	3
31	1		2		2		2		7	-
32	2		1			1	-		3	1
33							1		1	-
None listed	2		1	1	1			1	4	2
Total	118	10	125	17	123	24	128	21	494	72

TABLE A-2

DISTRIBUTION BY HEIGHT

Height in Inches	Ponca City		Miami		Terrell		Lancaster		Total	
	Ret.	W.O.	Ret.	W.O.	Ret.	W.O.	Ret.	W.O.	Ret.	W.O.
60 or less					1				1	
61-65	7		11		5	3	10		33	3
66-70	81	6	82	[illegible]	83	14	85	16	331	50
71-75	30	4	32	3	32	7	33	5	127	19
76 or more					2				4	
Total	118	10	125	17	123	24	128	21	494	72

TABLE A-3

DISTRIBUTION BY BODY BUILD

Build in Pounds	Ponca City		Miami		Terrell		Lancaster		Total	
	Ret.	W.O.	Ret.	W.O.	Ret.	W.O.	Ret.	W.O.	Ret.	W.O.
-21 or less	1		5	1	2		3		11	1
-11 to -20	21	2	16	1	16	6	18	5	71	14
-1 to -10	25	4	42	3	48	8	41	6	156	21
0	15	-	8	4	10	3	8	1	41	8
+1 to +10	31	1	35	4	24	3	32	5	122	13
+11 to +20	11	1	8	3	9	3	13	4	41	11
+21 to +30	4	1	4	1	4		4		16	2
+31 to +40	1	1	2		3		2		8	1
+41 to +50	-		1		2				3	
+51 to +60	1				-				1	
+61 or more					1				1	
No record	8		4		4	1	7		23	1
Total	118	10	125	17	123	24	128	21	494	72

TABLE A-4

DISTRIBUTION BY LEG LENGTH

Leg Length in Inches	Ponca City		Miami		Terrell		Lancaster		Total	
	Ret.	W.O.	Ret.	W.O.	Ret.	W.O.	Ret.	W.O.	Ret.	W.O.
32-34							2		2	
35-37							-		-	
38-40	15	1	19		22	7	23	3	79	11
41-43	64	4	73	14	68	10	71	11	276	39
44-46	34	5	29	3	27	7	27	7	117	22
47-49	2		2		1		3		8	
No record	3		2		5		2		12	
Total	118	10	125	17	123	24	128	21	494	72

TABLE A-5

DISTRIBUTION BY WEIGHT

Weight in Pounds	Ponca City		Miami		Terrell		Lancaster		Total	
	Ret.	W.O.	Ret.	W.O.	Ret.	W.O.	Ret.	W.O.	Ret.	W.O.
120 or less	9		12	1	11	3	11		43	4
121-135	34	4	33	4	41	11	36	4	144	23
136-150	40	4	46	6	39	7	47	12	172	29
151-165	26	1	22	4	22	2	27	5	97	12
166-180	6	1	10	2	5	1	3		24	4
181-195			2		2		3		7	
196 or more	3				3		1		7	
Total	118	10	125	17	123	24	128	21	494	72

TABLE A-6

DISTRIBUTION BY CHEST CIRCUMFERENCE

Chest Circumference in Inches	Ponca City		Miami		Terrell		Lancaster		Total	
	Ret.	W.O.	Ret.	W.O.	Ret.	W.O.	Ret.	W.O.	Ret.	W.O.
29-30	1		4		3		1		9	
31-32	12	1	15	4	16	7	12	1	55	13
33-34	30	4	41	4	41	6	36	9	148	23
35-36	42	5	43	7	33	8	48	4	166	24
37-38	18		13	2	21	2	20	3	72	7
39-40	7		5		6	-	7	3	25	3
41-42	3		3		-	1	3		9	1
43-44					1				1	
No record	5		1		2		1	1	9	1
Total	118	10	125	17	123	24	128	21	494	72

CHI-SQUARED ANALYSES OF THE COMPARED DISTRIBUTIONS OF ADMITTED AND WASHOUT GROUPS WITH RESPECT TO HEIGHT, WEIGHT, LEG LENGTH, BODY BUILD, AND CHEST CIRCUMFERENCE

Chest Circumference

Chest Circum.	Ret.	W.O.
31 and less	64	13
33-34	148	23
35-36	166	24
37 and more	107	11
Total	485	71

$X^2 = 2.96$ $P = .39$

Body Build

Body Build	Ret.	W.O.
-11 and less	82	15
-1 to -10	156	21
0	41	8
+1 to +10	122	13
+11 and more	70	14
Total	471	71

$X^2 = 4.08$ $P = .40$

Height

Height	Ret.	W.O.
65 and less	34	3
66-70	331	50
71 and more	129	19
Total	494	72

$X^2 = .83$ $P = .60+$

Weight

Weight	Ret.	W.O.
135 and less	187	27
136-150	172	29
151 and more	135	16
Total	494	72

$X^2 = 1.31$ $P = .53$

Leg Length

Leg Length	Ret.	W.O.
40 and less	81	11
41-43	276	39
44 and more	125	22
Total	482	72

$X^2 = .81$ $P = .60+$

TABLE A-8

THE ASSOCIATION BETWEEN UNSATISFACTORY/SATISFACTORY FLIGHTS AND FACTORS OF THE PHYSICAL EXAMINATION USING ALL CASES HAVING MEDICAL RECORDS

Criterion with:	School	N	χ^2	Degrees of Freedom	P
Smoking (heavy, moderate none)	Ponca City	128	9.63	8	.29
	Miami	137	1.53	4	.82
	Terrell	145	4.59	6	.60
	Lancaster	145	12.32	4	.02
Alcohol (moderate, slight, none)	Ponca City	128	11.43	8	.18
	Miami	135	6.26	6	.40
	Terrell	140	8.60	6	.20
	Lancaster	142	5.98	4	.20
Height (65" or less, 66"-70", 71" or more)	Ponca City	128	15.53	8	.05
	Miami	142	4.59	4	.34
	Terrell	147	4.45	6	.62
	Lancaster	149	3.65	4	.46
Weight (135 lbs. or less, 136 lbs. to 150 lbs., 151 lbs. or more)	Ponca City	128	10.26	8	.25
	Miami	142	7.33	4	.12
	Terrell	147	7.72	6	.26
	Lancaster	149	3.49	4	.48
Body Build ("underweight" 11 lbs. or more, -1 to -10, 0, +1 to +10, "overweight" 11 lbs. or more)	Ponca City	123	21.88	16	.15
	Miami	39	13.55	8	.09
	Terrell	142	15.62	12	.21
	Lancaster	142	7.11	8	.53
Leg Length (40" or less, 41"-43", 44" or more)	Ponca City	127	14.78	8	.06
	Miami	140	2.31	4	.68
	Terrell	142	5.47	6	.49
	Lancaster	147	2.03	4	.74
Chest Circumference (32" or less, 33"-34", 35"-36," 37" or more	Ponca City	127	8.33	12	.76
	Miami	141	6.43	6	.38
	Terrell	145	6.60	9	.68
	Lancaster	147	2.29	6	.89

TABLE A-8 (continued)

Criterion with:	School	N	X^2	Degrees of Freedom	P
Mentality (Bright, Average or Dull)	Ponca City	128	18.77	8	.01
	Miami	142	.86	4	.91+
	Terrell	147	4.22	6	.65
	Lancaster	148	8.44	4	.08
40 mm. Hg. Test (duration) (54 or under, 55-64, 65-79 and 80 and over)	Ponca City	128	19.10	12	.09
	Miami	141	2.81	6	.83
	Terrell	144	3.00	9	.96
	Lancaster	148	4.25	6	.64
Arterial Walls (Elastic, normal or soft)	Ponca City	128	10.58	8	.23
	Miami	142	13.71	2	.001
	Terrell	147	3.39	3	.34
	Lancaster	148	1.91	4	.75

TABLE A-9

THE ASSOCIATION BETWEEN RATIO OF UNSATISFACTORY/SATISFACTORY TRAINING FLIGHTS AND SMOKING

Ratio of Unsatisfactory to Satisfactory Flights	Smoking Heavy		Smoking Moderate		Smoking None		
	o	e	o	e	o	e	
Ponca City							
0-9	3	2.63	33	29.25	12	16.13	
10-19	3	2.08	24	23.16	11	12.77	
20-29	0	.66	4	7.31	8	4.03	
30-39	0	.71	8	7.92	5	4.37	
40 and over	1	.93	9	10.36	7	5.71	
Total	7		78		43		128
	P = .29						
Miami							
0-9	3	3.21	78	77.88	29	28.91	
10-19	1	.38	9	9.20	3	3.42	
20 and over	0	.41	10	9.91	4	3.68	
Total	4		97		36		137
	P = .82						
Terrell							
0-9	2	1.43	44	45.68	23	21.89	
10-19	0	.81	28	25.82	11	12.37	
20-29	0	.52	16	16.55	9	7.93	
30 and over	1	.25	8	7.94	3	3.81	
Total	3		96		46		145
	P = .60						
Lancaster							
0-39	3	2.15	44	48.41	31	27.43	
40-69	0	.66	11	14.90	13	8.44	
70 and over	1	1.19	35	26.69	7	15.12	
Total	4		90		51		145
	P = .02						

TABLE A-10

THE ASSOCIATION BETWEEN RATIO OF UNSATISFACTORY/SATISFACTORY TRAINING FLIGHTS AND ALCOHOL

Ratio of Unsatisfactory to Satisfactory Flights	Alcohol Moderate		Alcohol Slight		Alcohol None		
	o	e	o	e	o	e	
Perry City							
0-9	13	9.00	17	14.63	18	24.38	
10-19	7	7.13	9	11.58	22	19.30	
20-29	0	2.25	3	3.66	5	6.09	
30-39	1	2.44	3	3.96	9	6.60	
40 and over	3	3.19	7	5.18	7	8.63	
Total	24		39		65		128
	P = .18						
Miami							
0-9	12	16.00	34	32.80	62	59.20	
10-19	4	1.93	4	3.95	5	7.13	
20 and over	4	2.07	3	4.25	7	7.67	
Total	20		41		74		135
	P = .40						
Terrell							
0-9	11	8.82	19	21.82	35	34.36	
10-19	4	5.29	10	13.09	25	20.61	
20-29	3	3.39	11	8.39	11	13.21	
30 and over	1	1.49	7	3.69	3	5.81	
Total	19		47		74		140
	P = .20						
Lancaster							
0-39	6	8.13	30	33.08	41	35.79	
40-69	4	2.43	8	9.88	11	10.69	
70 and over	5	4.44	23	18.04	14	19.52	
Total	15		61		66		142
	P = .20						

TABLE A-11

THE ASSOCIATION BETWEEN RATIO OF UNSATISFACTORY/SATISFACTORY TRAINING FLIGHTS AND HEIGHT

Ratio of Unsatisfactory to Satisfactory Flights	Height 65" or less		Height 66" to 70"		Height 71" or more		
	o	e	o	e	o	e	
Fresno City							
0-9	1	2.69	35	32.25	12	13.13	
10-19	2	2.08	21	25.53	15	10.39	
20-29	3	.66	8	8.06	1	3.28	
30-39	1	.71	9	8.73	3	3.55	
40 and over	0	.93	13	11.42	4	4.65	
Total	7		86		35		7.26
	P = .05						
Miami							
0-9	12	10.44	75	75.46	27	28.10	
10-19	0	1.28	8	9.27	6	3.45	
20 and over	1	1.28	11	9.27	2	3.45	
Total	13		94		35		3.42
	P = .34						
Terrell							
0-9	4	4.35	49	46.35	18	19.80	
10-19	1	2.39	24	25.73	14	10.88	
20-29	3	1.53	15	16.50	7	6.97	
30 and over	1	.73	9	7.92	2	3.35	
Total	9		97		41		2.47
	P = .62						
Lancaster							
0-39	5	5.03	53	53.02	21	20.35	
40-69	3	1.92	14	17.45	9	6.63	
70 and over	3	3.25	33	29.53	8	11.22	
Total	11		100		38		3.49
	P = .45						

TABLE A-12

THE ASSOCIATION BETWEEN RATIO OF UNSATISFACTORY/SATISFACTORY TRAINING FLIGHTS AND WEIGHT

Ratio of Unsatisfactory to Satisfactory Flights	Weight 135 lbs. or less		Weight 136-150 lbs.		Weight 151 lbs. or more		
	o	e	o	e	o	e	
Ponca City							
0-9	13	17.63	18	15.75	17	14.63	
10-19	13	13.95	11	12.47	14	11.58	
20-29	4	4.41	5	3.94	3	3.66	
30-39	6	4.77	5	4.27	2	3.96	
40 and over	11	6.24	3	5.58	3	5.18	
Total	47		42		39		128
	P = .25						
Miami							
0-9	45	40.94	38	40.94	31	32.11	
10-19	4	5.03	4	5.03	6	3.94	
20 and over	2	5.03	9	5.03	3	3.94	
Total	51		51		40		142
	P = .12						
Terrell							
0-9	36	32.36	20	22.22	15	16.42	
10-19	16	17.78	14	12.20	9	9.02	
20-29	13	11.39	5	7.82	7	5.78	
30 and over	2	5.47	7	3.76	3	2.78	
Total	67		46		34		147
	P = .26						
Lancaster							
0-39	26	26.51	29	31.81	24	20.68	
40-69	11	8.72	9	10.47	6	6.81	
70 and over	13	14.77	22	17.72	9	11.52	
Total	50		60		39		149
	P = .48						

TABLE A-13

THE ASSOCIATION BETWEEN RATIO OF UNSATISFACTORY/SATISFACTORY TRAINING FLIGHTS AND BODY BUILD

Ratio of Unsatisfactory to Satisfactory Flights	Body Build "Underweight" 11 lbs.& more		Body Build -1 lb. to -10 lbs.		Body Build 0		Body Build +1 lb.to +10 lbs.		Body Build "Overweight" 11 lbs.&more		
	o	e	o	e	o	e	o	e	o	e	
Ponca City											
0-9	6	9.15	6	10.24	10	5.85	13	12.07	10	7.68	
10-19	8	7.52	9	8.42	3	4.81	10	9.93	7	6.32	
20-29	3	2.24	3	2.50	0	1.43	3	2.95	2	1.88	
30-39	1	2.64	5	2.96	3	1.69	4	3.49	0	2.22	
40 and over	7	3.46	5	3.87	0	2.21	3	4.56	2	2.90	
Total	25		28		16		33		21		123
	P = .35										
Miami											
0-9	34	28.75	21	24.76	9	9.58	32	32.74	15	15.17	
10-19	2	3.63	7	3.12	1	1.21	3	4.13	1	1.91	
20 and over	0	3.63	3	3.12	2	1.21	6	4.13	3	1.91	
Total	36		31		12		41		19		139
	P = .09										
Terrell											
0-9	10	12.45	31	25.86	6	6.23	9	12.93	12	10.54	
10-19	8	6.96	11	14.45	4	3.48	11	7.23	4	5.89	
20-29	8	4.58	6	9.51	3	2.29	5	4.75	3	3.87	
30 and over	0	2.01	6	4.18	0	1.07	2	2.09	3	1.70	
Total	26		54		13		27		22		142
	P = .21										
Lancaster											
0-39	13	13.55	28	23.97	3	5.21	17	18.24	13	13.03	
40-69	4	4.39	9	7.77	1	1.69	6	5.92	4	4.23	
70 and over	9	8.06	9	14.25	6	3.10	12	10.85	8	7.75	
Total	26		46		10		35		25		142
	P = .52										

TABLE A-14

THE ASSOCIATION BETWEEN RATIO OF UNSATISFACTORY/SATISFACTORY TRAINING FLIGHTS AND LEG LENGTH

Ratio of Unsatisfactory to Satisfactory Flights	Leg Length 40" or less		Leg Length 41" - 43"		Leg Length 44" or more		
	e	n	e	n	e	n	
Ponca City							
0-9	3	6.29	32	25.54	12	15.17	
10-19	6	5.09	19	20.65	13	12.27	
20-29	3	1.61	6	6.52	3	3.87	
30-39	4	1.74	6	7.06	3	4.20	
40 and over	1	2.28	6	9.24	10	5.49	
Total	17		69		41		127
	P = .06						
Miami							
0-9	17	15.34	67	70.22	29	27.44	
10-19	1	1.90	10	8.70	3	3.40	
20 and over	1	1.76	10	8.08	2	3.16	
Total	19		87		34		140
	P = .68						
Terrell							
0-9	13	14.15	42	36.33	12	16.51	
10-19	7	8.03	20	20.62	11	9.37	
20-29	7	5.28	10	13.56	8	6.16	
30 and over	3	2.54	5	6.51	4	2.96	
Total	30		77		35		142
	P = .49						
Lancaster							
0-39	17	15.19	40	42.95	20	18.86	
40-69	6	5.13	15	14.50	5	6.37	
70 and over	6	8.68	27	24.54	11	10.78	
Total	29		82		36		147
	P = .74						

TABLE A-15

THE ASSOCIATION BETWEEN RATIO OF UNSATISFACTORY/SATISFACTORY TRAINING FLIGHTS AND CHEST CIRCUMFERENCE

Ratio of Unsatisfactory to Satisfactory Flights	Chest Circumference: 32" or less		33" - 34"		35" - 36"		37" or more		
	o	e	o	e	o	e	o	e	
Ponca City									
0-9	5	5.18	12	13.32	16	17.39	14	11.10	
10-19	2	4.19	10	10.77	15	14.06	11	8.98	
20-29	2	1.32	3	3.40	5	4.44	2	2.83	
30-39	2	1.43	4	3.69	6	4.81	1	3.07	
40 and over	3	1.87	7	4.82	5	6.29	2	4.02	
Total	14		36		47		30		127
	P = .76								
Miami									
0-9	21	18.45	36	36.87	36	40.07	20	17.63	
10-19	1	2.28	4	4.57	8	4.96	1	2.18	
20 and over	1	2.28	6	4.57	6	4.96	1	2.18	
Total	23		46		50		22		141
	P = .38								
Terrell									
0-9	12	12.55	27	22.69	20	20.76	11	14.00	
10-19	10	6.81	9	12.32	11	11.27	8	7.60	
20-29	3	4.48	8	8.10	8	7.41	6	5.00	
30 and over	1	2.15	3	3.89	4	3.56	4	2.40	
Total	26		47		43		29		145
	P = .68								
Lancaster									
0-39	8	7.43	27	24.41	27	28.12	16	18.04	
40-69	3	2.48	6	8.14	11	9.37	6	6.01	
70 and over	3	4.10	13	13.46	15	15.50	12	9.95	
Total	14		46		53		34		147
	P = .89								

TABLE A-16

THE ASSOCIATION BETWEEN RATIO OF UNSATISFACTORY/SATISFACTORY TRAINING FLIGHTS AND MENTALITY

Ratio of Unsatisfactory to Satisfactory Flights	Mentality Bright		Mentality Average		Mentality Dull		
	o	e	o	e	o	e	
Ponca City							
0-9	32	26.25	16	21.00	0	.75	
10-19	21	20.78	17	16.63	0	.59	
20-29	6	6.56	6	5.25	0	.19	
30-39	6	7.11	7	5.69	0	.20	
40 and over	5	9.30	10	7.44	2	.27	
Total	70		56		2		128
	P = .01						
Miami							
0-9	55	53.79	57	58.61	2	1.61	
10-19	6	6.61	8	7.20	0	.20	
20 and over	6	6.61	8	7.20	0	.20	
Total	67		73		2		142
	P = .91+						
Terrell							
0-9	31	31.39	36	35.74	4	3.86	
10-19	19	17.24	17	19.63	3	2.12	
20-29	12	11.05	12	12.59	1	1.36	
30 and over	3	5.31	9	6.04	0	.65	
Total	65		74		8		147
	P = .65						
Lancaster							
0-39	52	47.51	27	29.89	0	1.60	
40-69	11	15.03	12	9.46	2	.51	
70 and over	26	26.46	17	16.65	1	.89	
Total	89		56		3		148
	P = .08						

TABLE A-17

THE ASSOCIATION BETWEEN RATIO OF UNSATISFACTORY/SATISFACTORY TRAINING FLIGHTS AND 40 sec. HG. TEST (DURATION)

Ratio of Unsatisfactory to Satisfactory Flights	Duration 54 and under		Duration 55 - 64		Duration 65 - 79		Duration 80 and over		
	o	e	o	e	o	e	o	e	
Ponca City									
0-9	4	10.88	25	22.50	13	9.75	6	4.88	
10-19	11	8.61	16	17.81	7	7.72	4	3.86	
20-29	6	2.72	5	5.63	1	2.44	0	1.22	
30-39	3	2.95	4	6.09	3	2.64	3	1.32	
40 and over	5	3.85	10	7.97	2	3.45	0	1.73	
Total	29		60		26		13		128
	P = .09								
Miami									
0-9	15	16.03	60	59.30	28	28.05	10	9.62	
10-19	2	1.99	6	7.35	4	3.48	2	1.19	
20 and over	3	1.99	3	7.35	3	3.48	0	1.19	
Total	20		74		35		12		141
	P = .03								
Terrell									
0-9	18	15.78	28	31.06	21	20.22	4	3.94	
10-19	7	8.67	17	17.05	12	11.10	3	2.17	
20-29	5	5.56	13	10.94	6	7.12	1	1.39	
30 and over	2	2.00	5	3.94	2	2.56	0	.50	
Total	32		63		41		8		144
	P = .96								
Lancaster									
0-39	18	15.28	32	37.42	18	16.34	10	8.96	
40-69	3	5.09	16	12.47	4	5.45	3	2.99	
70 and over	8	8.62	23	21.11	9	9.22	4	5.05	
Total	29		71		31		17		148
	P = .64								

TABLE A-18

THE ASSOCIATION BETWEEN RATIO OF UNSATISFACTORY/SATISFACTORY TRAINING FLIGHTS AND ARTERIAL WALLS

Ratio of Unsatisfactory to Satisfactory Flights	Arterial Walls Elastic		Arterial Walls Normal		Arterial Walls Soft		
	o	e	o	e	o	e	
Ponca City							
0-9	0	.38	41	40.88	7	6.75	
10-19	0	.30	32	32.36	6	5.34	
20-29	1	.09	10	10.22	1	1.69	
30-39	0	.10	11	11.07	2	1.83	
40 and over	0	.13	15	14.48	2	2.39	
Total	1		109		18		128
	P = .23						
Miami							
0-9			94	90.72	20	23.28	
10-19			6	11.14	8	2.86	
20 and over			13	11.14	1	2.86	
Total			113		29		142
	P = .001						
Terrell							
0-9			61	56.99	10	14.01	
10-19			30	31.31	9	7.69	
20-29			19	20.07	6	4.93	
30 and over			8	9.63	4	2.37	
Total			118		29		147
	P = .34						
Lancaster							
0-39	2	1.05	60	60.61	16	16.34	
40-69	0	.35	20	20.20	6	5.45	
70 and over	0	.59	35	34.19	9	9.22	
Total	2		115		31		148
	P = .75						

TABLE A-19

COMPARISON OF ELIMINATED AND RETAINED CASES IN SELECTED FACTORS OF THE MEDICAL EXAMINATION

Criterion with:	School	N of Elim. Cases	N of Ret. Cases	X^2	Degrees of Freedom	P
Smoking (heavy, moderate, none)	Ponca City	10	118	.79	2	.61+
	Miami	15	122	.91	2	.61+
	Terrell	24	121	1.48	2	.49
	Lancaster	20	125	9.04	2	.01
Alcohol (moderate, slight, none)	Ponca City	10	118	.82	2	.61+
	Miami	14	121	3.78	2	.15
	Terrell	21	119	3.00	2	.22
	Lancaster	18	124	.82	2	.61+
Height (65" or less, 66"-70", 71" or more)	Ponca City	10	118	1.39	2	.51
	Miami	17	125	3.08	2	.22
	Terrell	24	123	3.13	2	.21
	Lancaster	21	128	2.19	2	.34
Weight (135 lbs. or less, 136 lbs. to 150 lbs., 151 lbs. or more)	Ponca City	10	118	.07	2	.61+
	Miami	17	125	.66	2	.61+
	Terrell	24	123	2.89	2	.24
	Lancaster	21	128	3.89	2	.15
Body Build ("underweight" 11 lbs. or more, -1 to -10, 0, +1 to +10, "overweight" 11 lbs. or more)	Ponca City	10	113	3.35	4	.50
	Miami	17	122	11.21	4	.02
	Terrell	23	119	4.77	4	.31
	Lancaster	21	121	2.44	4	.66
Leg Length (40" or less, 41"-43", 44" or more)	Ponca City	10	117	1.73	2	.43
	Miami	17	123	4.54	2	.11
	Terrell	24	118	4.72	2	.10
	Lancaster	21	126	1.44	2	.50
Chest Circumference (32" or less, 33"-34", 35"-36", 37" or more)	Ponca City	10	117	6.39	3	.10
	Miami	17	124	1.70	3	.64
	Terrell	24	121	4.39	3	.23
	Lancaster	20	127	4.62	3	.21
Mentality (bright, average, dull)	Ponca City	10	118	1.35	2	.52
	Miami	17	125	1.69	2	.44
	Terrell	24	123	1.89	2	.39
	Lancaster	21	127	7.58	2	.02

TABLE 4-19 (continued)

Criterion with:	School	N of Elim. Cases	N of Ret. Cases	X^2 (Chi)	Degrees of Freedom	P
40 mm. Hg. Test(Duration) (54 and under, 55-64, 65-79, 80 and over)	Ponca City	10	118	4.03	3	.26
	Miami	17	124	5.19	3	.16
	Terrell	23	121	1.87	3	.60
	Lancaster	21	127	9.80	3	.02
Arterial Walls (elastic, normal, soft)	Ponca City	10	118	2.76	2	.26
	Miami	17	125	.37	1	.71
	Terrell	24	123	5.14	1	.00
	Lancaster	21	127	.43	2	.61+

TABLE A-20

COMPARISON OF RETAINED AND ELIMINATED CADETS IN RESPECT TO SMOKING

Smoking	Retained Cadets	Eliminated Cadets	Eliminated cadets if they were distributed as the retained cadets are
Ponca City			
Heavy	7	0	.59
Moderate	71	7	6.02
None	40	3	3.39
Total	118	10	10.00
	P = .61+		
Miami			
Heavy	4	0	.50
Moderate	87	10	10.69
None	31	5	3.81
Total	122	15	15.00
	P = .61+		
Terrell			
Heavy	3	0	.60
Moderate	78	18	15.48
None	40	6	7.92
Total	121	24	24.00
	P = .49		
Lancaster			
Heavy	2	2	.32
Moderate	78	12	12.48
None	45	6	7.20
Total	125	20	20.00
	P = .01		

TABLE A-21

COMPARISON OF RETAINED AND ELIMINATED CADETS
IN RESPECT TO ALCOHOL

Alcohol	Retained Cadets	Eliminated Cadets	Eliminated cadets if they were distributed as the retained cadets are
	Ponca City		
Moderate	23	1	1.95
Slight	35	4	2.97
None	60	5	5.08
Total	118	10	10.00
	P = .61+		
	Miami		
Moderate	16	4	1.85
Slight	36	5	4.17
None	69	5	7.98
Total	121	14	14.00
	P = .15		
	Terrell		
Moderate	16	3	2.81
Slight	37	10	6.53
None	66	8	11.66
Total	119	21	21.00
	P = .22		
	Lancaster		
Moderate	14	1	2.03
Slight	52	9	7.54
None	58	8	8.43
Total	124	18	18.00
	P = .61+		

TABLE A-22

COMPARISON OF RETAINED AND ELIMINATED CADETS IN RESPECT TO HEIGHT

Height	Retained Cadets	Eliminated Cadets	Eliminated cadets if they were distributed as the retained cadets are
	Ponca City		
65" or less	7	0	.59
66"-70"	80	6	6.78
71" or more	31	4	2.63
Total	118	10	10.00
	P = .51		
	Miami		
65" or less	13	0	1.77
66" - 70"	80	14	10.88
71" or more	32	3	4.35
Total	125	17	17.00
	P = .22		
	Tonkawa		
65" or less	6	3	1.18
66" - 70"	83	14	16.20
71" or more	34	7	6.62
Total	123	24	24.00
	P = .21		
	Lancaster		
65" or less	11	0	1.80
66" - 70"	84	16	13.78
71" or more	33	5	5.42
Total	128	21	21.00
	P = .34		

TABLE A-23

COMPARISON OF RETAINED AND ELIMINATED CADETS IN RESPECT TO WEIGHT

Weight	Retained Cadets	Eliminated Cadets	Eliminated cadets if they were distributed as the retained cadets are
	Ponca City		
135 lbs. or less	45	4	3.64
136 lbs. - 150 lbs.	39	3	3.31
151 lbs. or more	36	3	3.05
Total	118	10	10.00
	P = .61+		
	Miami		
135 lbs. or less	46	5	6.26
136 lbs. - 150 lbs.	45	6	6.12
151 lbs. or more	34	6	4.62
Total	125	17	17.00
	P = .61+		
	Terrell		
135 lbs. or less	53	14	10.34
136 lbs. - 150 lbs.	39	7	7.61
151 lbs. or more	31	3	6.05
Total	123	24	24.00
	P = .24		
	Lancaster		
135 lbs. or less	46	4	7.54
136 lbs. - 150 lbs.	48	12	7.87
151 lbs. or more	34	5	5.59
Total	128	21	21.00
	P = .15		

TABLE A-24

COMPARISON OF RETAINED AND ELIMINATED CADETS IN RESPECT TO BODY BUILD

Body Build	Retained Cadets	Eliminated Cadets	Eliminated cadets if they were distributed as the retained cadets are
Ponca City			
"Underweight" 11 lbs. or more.	23	2	2.04
-1 lb to -10 lbs.	24	4	2.12
0	16	0	1.42
+1 lb. to +10 lbs.	31	2	2.74
"Overweight" +11 lbs. or more.	19	2	1.68
Total	113	10	10.00
	P = .50		
Miami			
"Underweight" -11 lbs. or more.	34	2	4.75
-1 lb. to -10 lbs.	28	3	3.89
0	8	4	1.12
+1 lb. to +10 lbs.	37	4	5.15
"Overweight" +11 lbs. or more.	15	4	2.09
Total	122	17	17.00
	P = .02		
Terrell			
"Underweight" -11 lbs. or more.	19	7	3.68
-1 lb. to -10 lbs.	47	7	9.09
0	10	3	1.93
+1 lb. to +10 lbs.	24	3	4.64
"Overweight" +11 lbs. or more.	19	3	3.66
Total	119	23	23.00
	P = .31		
Lancaster			
"Underweight" -11 lbs. or more.	21	5	3.65
-1 lb. to -10 lbs.	41	5	7.12
0	8	2	1.39
+1 lb. to +10 lbs.	31	4	5.38
"Overweight" +11 lbs. or more.	20	5	3.46
	121	21	21.00
	P = .66		

TABLE 4-25

COMPARISON OF RETAINED AND ELIMINATED CADETS IN RESPECT TO LEG LENGTH

Leg Length	Retained Cadets	Eliminated Cadets	Eliminated Cadets if they were distributed as the retained cadets ar
	Ponca City		
40" or less	16	1	1.37
41" - 43"	65	4	5.55
44" or more	36	5	3.08
Total	117	10	10.00
	P = .43		
	Miami		
40" or less	19	0	2.64
41" - 43"	73	14	10.08
44" or more	31	3	4.28
Total	123	17	17.00
	P = .11		
	Terrell		
40" or less	22	8	4.49
41" - 43"	68	9	13.82
44" or more	28	7	5.69
Total	118	24	24.00
	P = .10		
	Lancaster		
40" or less	26	3	4.33
41" - 43"	71	11	11.84
44" or more	29	7	4.83
Total	126	21	21.00
	P = .50		

TABLE A-26

COMPARISON OF RETAINED AND ELIMINATED CADETS
IN RESPECT TO CHEST CIRCUMFERENCE

Chest Circumference	Retained Cadets	Eliminated Cadets	Eliminated Cadets if they were distributed as the retained cadets are
	Ponca City		
32" or less	14	0	1.20
33" - 34"	31	5	2.65
35" - 36"	42	5	3.59
37" or more	30	0	2.56
Total	117	10	10.00
	P = .10		
	Miami		
32" or less	19	4	2.60
33" - 34"	42	4	5.76
35" - 36"	43	7	5.90
37" or more	20	2	2.74
Total	124	17	17.00
	P = .64		
	Terrell		
32" or less	19	7	3.77
33" - 34"	41	6	8.13
35" - 36"	35	8	6.94
37" or more	26	3	5.16
Total	121	24	24.00
	P = .23		
	Lancaster		
32" or less	13	1	2.04
33" - 34"	37	9	5.82
35" - 36"	49	4	7.72
37" or more	28	6	4.42
Total	127	20	20.00
	P = .21		

TABLE A-27

COMPARISON OF RETAINED AND ELIMINATED CADETS IN RESPECT TO MENTALITY

Mentality	Retained Cadets	Eliminated Cadets	Eliminated cadets if they were distributed as the retained cadets ar
	Ponca City		
Bright	66	4	5.59
Average	50	6	4.24
Dull	2	0	.17
Total	118	10	10.00
	P = .52		
	Miami		
Bright	61	6	8.30
Average	62	11	8.43
Dull	2	0	.27
Total	125	17	17.00
	P = .44		
	Terrell		
Bright	57	8	11.11
Average	60	14	11.71
Dull	6	2	1.18
Total	123	24	24.00
	P = .39		
	Lancaster		
Bright	81	8	13.40
Average	43	13	7.10
Dull	3	0	.50
Total	127	21	21.00
	P = .02		

TABLE A-28

COMPARISON OF RETAINED AND ELIMINATED CADETS IN RESPECT TO 40 mm. HG. TEST (DURATION)

40 mm. Hg. Test (Duration)	Retained Cadets	Eliminated Cadets	Eliminated Cadets if they were distributed as the retained cadets are
	Ponca City		
54 and under	25	4	2.12
55-64	57	3	4.83
65-79	23	3	1.95
80 and over	13	0	1.10
Total	118	10	10.00
	P = .26		
	Miami		
54 and under	16	4	2.19
55-64	63	11	8.64
65-79	33	2	4.52
80 and over	12	0	1.65
Total	124	17	17.00
	P = .16		
	Terrell		
54 and under	27	5	5.13
55-64	51	12	9.68
65-79	37	4	7.04
80 and over	6	2	1.15
Total	121	23	23.00
	P = .60		
	Lancaster		
54 and under	24	5	3.97
55-64	56	15	9.26
65-79	30	1	4.96
80 and over	17	0	2.81
Total	127	21	21.00
	P = .02		

TABLE A-29

COMPARISON OF RETAINED AND ELIMINATED CADETS IN RESPECT TO ARTERIAL WALLS (ELASTICITY)

Arterial Walls	Retained Cadets	Eliminated Cadets	Eliminated Cadets if they were distributed as the retained cadets
	Ponca City		
Elastic	1	0	.09
Normal	102	7	8.64
Soft	15	3	1.27
Total	118	10	10.00
	P = .26		
	Miami		
Normal	100	13	13.60
Soft	25	4	3.40
Total	125	17	17.00
	P = .71		
	Terrell		
Normal	106	12	20.69
Soft	17	12	3.31
Total	123	24	24.00
	P = .000000		
	Lancaster		
Elastic	2	0	.34
Normal	98	17	16.21
Soft	27	4	4.45
Total	127	21	21.00
	P = .61+		

APPENDIX B

ANALYSIS OF THE CRITERIA OF PROGRESS IN FITTING

ANALYSIS OF THE CRITERIA OF PROGRESS IN FLYING

INTRODUCTION

As was stated earlier in this report certain flight data were available from the microfilm for each of the students. These data were originally recorded in the trainee's Flight Record and in the Dispatcher's Flight Logs. For purposes of this study, it was found convenient to classify the flight data into the following categories.[16]

1. Number of flights which are:
   a. Satisfactory
   b. Unsatisfactory
   c. Check

2. Number of grades which are:
   a. Satisfactory
   b. Unsatisfactory

3. Number of satisfactory and unsatisfactory grades in specific maneuvers which had been listed as:
   a. Preliminary
      (1) Cockpit familiarization
      (2) Controls
      (3) Air familiarization

   b. Basic
      (1) Taxiing
      (2) Straight and level flight
      (3) Turns
         (a) Medium
         (b) Rectangular course
         (c) Stalled turns
         (d) Steep turns
      (4) Climbs and climbing turns
      (5) Glides and gliding turns
      (6) Take-off and landing
         (a) Into wind
         (b) Cross-wind
         (c) Out-of-wind
         (d) Gliding approach
         (e) Side-slip approach
         (f) Power approach
      (7) Slips
      (8) Stalls and spins
      (9) Spirals
      (10) First solo
      (11) Forced, precautionary, accidental landing
      (12) Coordination (S's and S's)

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[16] It is not the intention of this study to provide a complete analysis of those individual maneuvers listed above. Such an analysis will be presented in a later report (see footnote 4). In this investigation, the primary interest is in the study of possible measures of over-all progress in training.

c. Advanced
   (1) Coordination (chandelles, lazy 8's, 180° side and overhead, 360° overhead)
   (2) Navigation and unusual position rectified
   (3) Instruments
   (4) Compass
   (5) Spotting pin points
   (6) Use of time-scale
   (7) Formation flying
   (8) Night flying
   (9) Acrobatics (rolls, vert. rev., Immelmann, loops, pylon 8's)
   (10) Low flying
   (11) Abandoning an aircraft
   (12) Action in event of fire
   (13) Restarting engine in flight

d. Progress

e. Judgment

This preliminary analysis was undertaken with the view to determining the best means of assessing the degree of success in progress achieved during flight training. Toward this end, each of the four possible measures of flight performance (the ratio of unsatisfactory to satisfactory flights; the ratio of unsuccessful to successful grades; the ratio of check flights to all other flights; and time to solo) was analyzed and evaluated against the pass-fail or washout criterion of flight success.

It has been pointed out that at the time of this study it was possible to study two groups of washouts: (1) a group composed of those trainees eliminated from flight training during the early stages of primary training (a group on whom no medical records were available) and (2) a group of washouts two-thirds of whom were eliminated after completion of primary training and one-third eliminated during the later stages of primary (medical records were available for this last group of washouts). These two groups are treated separately throughout the analysis of the criteria of progress for the reason that only the latter group (those with medical records) could be employed in the remainder of the study concerned with the relation of the medical factors to progress in flying.

RESULTS

The ratio of check flights to all other flights was abandoned early in the study because it was found that the distribution of pilots in terms of this criterion showed too little variance for practical use. The other three criteria were evaluated against the pass-fail criterion by means of the chi-squared technique.[17]

Presented in Tables B-1 and B-2 is a summary of the results obtained when the remaining three measures of progress (the ratio of unsatisfactory to satis-

[17] A sample computation of chi-squared as used in deriving the data presented in Tables B-1, B-2, B-3, B-4, and B-5 is presented in Appendix D, Table D-2.

factory flights; the ratio of unsatisfactory to satisfactory grades; and time to solo) are evaluated in relation to the pass-fail criterion. Table B-1 presents the comparison of the retained cadets and the first group of washouts, i.e., those cadets who were eliminated (washed out) during the early stages of primary training and on whom no medical records were available. Table B-2 presents the comparison of the retained cadets and the second group of washouts two-thirds of whom were eliminated following successful completion of primary training, and one-third of whom were eliminated during the later stages of primary.[18] The P-value in both tables expresses the probability that the two groups of cadets (the retained and the eliminated or washout groups) belong to the same population.

TABLE B-1

COMPARISON OF ELIMINATED WITH RETAINED CASES, TO SHOW VALIDITY OF CRITERIA OF FLYING PROGRESS[19]
(on cases eliminated in the early stages of primary training)

Flight Criterion	School	N of Elim. Cases	N of Ret. Cases	X^2	Degrees of Freedom	P
Unsatis./satis. Flights	Ponca City	60	117	347.16	4	.000000
	Miami	40	121	353.39	2	.000000
	Terrell	47	123	695.30	4	.000000
	Lancaster	29	125	35.28	2	.000000
Unsatis./satis. Grades	Ponca City	60	117	367.41	5	.000000
	Miami	40	121	259.73	2	.000000
	Terrell	47	123	513.28	2	.000000
	Lancaster	29	125	165.49	2	.000000
Time to solo	Ponca City	30	114	90.04	4	.000000
	Miami	26	121	5.84	3	.121
	Terrell	26	120	22.64	5	.00041
	Lancaster	20	124	12.21	4	.016

[18] It will be recalled that this later group of washouts was the group employed in the analysis of the medical factors presented in the body of this report. They were the only washouts on whom medical records were available.

[19] The P-value in this table expresses the probability that the two groups belong to the same population in respect to the flight index in question. The theoretical frequencies were obtained from the distribution of retained cadets and the chi-squared expresses deviation from this distribution by the eliminated cadets.

TABLE B-2

COMPARISON OF ELIMINATED WITH RETAINED CASES TO SHOW VALIDITY OF CRITERIA OF FLYING PROGRESS[20]
(on cases eliminated in later stages of training)

Flight Criterion	School	N of Elim. Cases	N of Ret. Cases	X^2 (Chi)	Degrees of Freedom	P
Unsatis./satis. Flights	Ponca City	10	117	8.75	2	.013
	Miami	15	121	24.20	2	.0000006
	Terrell	24	123	11.74	2	.0029
	Lancaster	21	125	17.10	2	.0002
Unsatis./satis. Grades	Ponca City	10	117	10.65	3	.014
	Miami	15	121	8.80	2	.013
	Terrell	24	123	5.68	3	.13
	Lancaster	21	125	29.65	5	.00002
Time to Solo	Ponca City	10	117	2.42*	1	.016
	Miami	15	121	1.26	3	.74
	Terrell	24	123	20.08	5	.0013
	Lancaster	21	125	2.81	6	.83

Examination of Tables B-1 and B-2 illustrates clearly that the two ratios (the ratio of unsatisfactory to satisfactory flights and the ratio of unsatisfactory to satisfactory grades) are reliable means by which to distinguish failure from success in flight training. It will be noted that time to solo is uniformly more unreliable than the other criteria of success. This is particularly true for Miami and Lancaster (see Table B-2; P-value of .74 and .83 respectively). Inasmuch as the ratio of unsatisfactory flights was slightly better than the grade ratio, the former was used in all subsequent analyses to express the degree of the cadet's progress in flight training.

It should be noted that the P-values are larger for the later washouts versus retained cases than for those washed out earlier in the course versus those retained at the time. This finding is to be expected since those who remained in the course longer (those who were washed out at later stages of training) may be credited with having made a better progress in flight training.

The statistical details of these relations are presented in Tables B-3, B-4, and B-5.

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[20]The P-values for both chi and X^2 indicate the probability that the two gro belong to the same population in respect to the flight index in question. The theoreticals are obtained from the distribution of retained cases and the chi-squared expresses deviation from the distribution by eliminated cadets. Chi, indicated by the asterisk, was employed when there was only one degree of freedom

TABLE B-3

COMPARISON OF RETAINED AND ELIMINATED CADETS IN RESPECT TO RATIO OF UNSATISFACTORY TO SATISFACTORY TRAINING FLIGHTS

Ratio of Unsatisfactory to Satisfactory Flights (in 100ths)	Retained Cadets	Eliminated Cadets	Eliminated Cadets if they were distributed as Retained Cadets are
Ponca City			
0-9	46	2	23.59
10-19	35	2	17.95
20-29	11	2	5.64
30-39	12	2	6.16
40 and over	13	52	6.67
Total	117	60	60.01
	P = .000000		
Miami			
0-9	103	6	34.05
10-19	11	4	3.64
20 and over	7	30	2.32
Total	121	40	40.01
	P = .000000		
Terrell			
0-9	65	5	24.84
10-19	32	5	12.23
20-29	18	4	6.88
30-39	5	3	1.91
40 and over	3	29	1.15
Total	123	47	47.01
	P = .000000		
Vernon			
0-29	58	5	13.46
30-69	36	3	8.35
70 and over	33	21	7.19
Total	127	29	29.00

P = .000000

TABLE B-4

COMPARISON OF RETAINED AND ELIMINATED CADETS IN RESPECT TO RATIO OF TOTAL UNSATISFACTORY TO TOTAL SATISFACTORY GRADES

Ratio of Unsatisfactory to Satisfactory Flights (in 100ths)	Retained Cadets	Eliminated Cadets	Eliminated Cadets if they were distributed as Retained Cadets are
	[illegible]		
0-9	[illegible]	[illegible]	[illegible]
10-19	[illegible]	2	[illegible]
20-29	[illegible]	7	11.28
30-39	8	5	4.10
40-49	6	7	3.08
50 and over	6	[illegible]	3.08
Totals	[illegible]	60	60.00
	P = [illegible]		
	Miami		
0-9	92	[illegible]	30.41
10-19	23	7	7.27
20 and over	7	26	2.32
Totals	[illegible]	40	40.00
	P = .000000		
	Terrell		
0-9	77	4	29.42
10-19	29	10	10.32
20-29	16	6	6.11
30 and over	3	33	1.15
Totals	[illegible]	47	[illegible]
	P = .000000		
	Lancaster		
0-29	74	5	17.17
30-69	41	4	9.74
70 and over	2	20	2.09
Totals	125	29	29.00
	P = .000000		

TABLE B-5

COMPARISON OF RETAINED AND ELIMINATED CADETS IN RESPECT TO TIME TO SOLO

Time to Solo	Retained Cadets	Eliminated Cadets	Eliminated Cadets if they were distributed as Retained Cadets are
	Ponca City		
14 and over	2	5	.52
12-13:30	4	8	1.06
10-11:30	14	2	3.68
8-9:30	72	9	18.95
7:30 and under	22	5	5.79
Totals	114	30	30.00
	P = .000000		
	Miami		
12 and over	11	5	2.37
10-11:30	29	9	6.23
8-9:30	62	9	13.32
7:30 and under	19	3	4.08
Totals	121	26	26.00
	P = .121		
	Tonkawa		
14 and over	2	3	.41
12-13:30	6	3	1.25
10-11:30	27	6	5.63
8-9:30	29	4	6.04
6-7:30	21	6	4.38
5:30 and under	35	3	7.29
Totals	120	25	25.00
	P = .00041		
	Lexington		
16 and over	10	5	1.61
14-15:30	17	5	2.74
12-13.30	17	2	2.74
10-11:30	15	3	2.42
9:30 and under	65	5	10.49
Totals	124	20	20.00

APPENDIX C

A SAMPLE RECORD CARD

A SAMPLE RECORD CARD

Flight Record

Name: _____

Time:		S	U		S	U		S
Dual	1. Prelim.			Take-off & land			Navig., unus. pos.	
Solo	Ckpt. Fam.			Into wind			Instrument	
T.	Controls			Cr-w out of W.			Formation	
Type:	Air Fam.			Gl. app.			Night	
Cr-cty.				Side-slip app.			Acrobatics(rolls)	
Form 2.	Basic			Power app.			vert. rev., Immel.	
Instru.	Taxiing			Slips			Loops, Pylon 8's	
	St. & L.			Stalls, spins			Low Flying	
Grade:	Turns			Spirals			Aband. an aircrf.	
No. Un. Med.				1st Solo			Action in fire	
No. Ch. Rect. cour.				Forced, precaut.			Restart, eng.	
No. Sat. Gls. & Gl.t.				acc. land				
T.uns.gr. Gls. & Gl.t.								
T. sat. gr.	Stalled t.			3. Advanced			4. Progress	
	Steep t.			Coor. (chn., lazy 8's, 180°s, ovhd. 360°			5. Judgment	

Remarks:

Medical Record

NAME: _____ Age: _____

1. Pulse rate sitting (aft. ex.) Remarks:
2. Pulse rate standing (1st.) (2nd)
3. Time of return to normal:
4. Blood pressure: systolic diastolic
5. Visual acuity: R L corr.: R L
6. Color vision: R L Red-green test
7. Maddox rod test
8. Accommodation
9. Diaphragm & convergence
10. Other
11. Hearing acuity R L

APPENDIX D

SAMPLE COMPUTATIONS OF CHI-SQUARED FOR TABLES 1 to 6 and B-1 to B-5

TABLE D-1

SAMPLE COMPUTATION OF CHI-SQUARED AS USED IN TABLES 7 - 11

Ponca City

	PULSE: 66 and under		PULSE: 67 to 77		PULSE: 78 and over		Total
Criterion: 0-9	9	(7.13)	15	(20.25)	24	(20.63)	48
10-19	4	(5.64)	20	(16.03)	14	(16.33)	38
20-29	2	(1.78)	4	(5.06)	6	(5.16)	12
30-39	1	(1.93)	7	(5.48)	5	(5.59)	13
40 and over	3	(2.52)	8	(7.17)	6	(7.30)	17
Totals	19		54		55		128

(o-e)	$\frac{(o-e)^2}{e}$	(o-e)	$\frac{(o-e)^2}{e}$	(o-e)	$\frac{(o-e)^2}{e}$
1.87	.49	-5.25	1.36	3.37	.55
-1.64	.48	3.97	.98	-2.33	.33
.22	.03	-1.06	.22	.84	.14
-.93	.45	1.52	.42	-.59	.06
.48	.09	.83	.10	-1.30	.23

χ^2 = sum of $\frac{(o-e)^2}{e}$, here 5.93

n (degrees of freedom) = 8

P = .65

Values in parentheses in each cell are theoretical frequencies, obtained as follows:

For first cell, $7.13 = \frac{19 \times 48}{128}$; second cell, $5.64 = \frac{19 \times 38}{128}$, etc.

TABLE B-2

A SAMPLE COMPUTATION OF THE CHI-SQUARED METHOD AS USED IN TABLES B-1 to B-5

Ponca City

Ratio of Unsatisfactory to Satisfactory Flights (in 100ths)	Retained Pilots	Percent Retained Pilots	Washouts e	Washouts o	(o-e)	$\frac{(o-e)^2}{e}$
0-9	46	39.32	23.59	2	-21.59	19.76
10-19	35	29.91	17.95	2	-15.95	14.17
20-29	11	9.40	5.64	2	-3.64	2.35
30-39	12	10.26	6.16	2	-4.16	2.81
40 and over	13	11.11	6.67	52	45.33	308.07
Total	117	100.00	60.01	60		347.16 (x^2)

n = 4 P = .000000

"e," which refers to occurrence of washouts expected if they were distributed in the same manner as retained pilots, is found by multiplying "% retained" times total washouts (here 60). Thus, 23.59 = 39.32 x 60.

"o," refers to actual or obtained occurrence of washouts.

"n," refers to "degrees of freedom."

"p," refers to the probability that the two groups are distributed in the same manner with respect to the criterion.