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# RESULTS OF A LONGITUDINAL STUDY OF AIRSICKNESS INCIDENCE DURING NAVAL FLIGHT OFFICER TRAINING

by
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SUMMARY

This paper outlines the results of a longitudinal study of airsickness in a large sample population of Naval Flight Officers (NFOs) being trained to perform various nonpilot flight duties prior to assignment to operational fleet squadrons. The study has concentrated on the acquisition of airsickness data on an individual student basis as training progressed from the basic/primary level through the advanced/secondary level to the fleet readiness squadron phase for each of the major NFO training pipelines. The primary objectives of the study were to define the incidence of airsickness in each of the training squadrons and to identify differences in the motion stress exposure associated with the different pipelines that can affect decisions on the initial selection and assignment of NFO candidates. A secondary objective was to relate the inflight airsickness data to the results of several short tests of motion reactivity given to a segment of the study population prior to their beginning flight training.

## INTRODUCTION

This paper is a summary of a series of research reports (7-13) dealing with a longitudinal study of airsickness in Naval Flight Officer (NFO) students being trained to perform specialized nonpilot flight duties aboard various fleet aircraft. As a matter of background the longitudinal study originated as a result of numerous airsickness problems and questions that were directed to this activity by training command personnel responsible for delivering qualified NFOs to the fleet, by flight surgeons responsible for the medical management of naval aviation aircrews, and by career naval aviators and flight officers experiencing chronic airsickness difficulties during performance of their fleet flight duties. Training command personnel raised questions concerning the overall cost of the airsickness risk to the NFO training program. Specific problems included degraded flight performance of airsick students, the need to repeat hops when performance was inadequate, loss of personnel and training time due to airsickness-related attrition, the usage of airsickness medication over an extended period of the training program, and the occasional graduation of airsick NFO students who were able to complete the training program but could not perform adequately in the fleet. Concern was also expressed about the need for laboratory tests to medically screen airsickness susceptibles early in the training program to reduce the costs of mid- or late-term attrition.

Similar questions were raised by flight surgeons who were dealing with airsick flight personnel. They were interested in more specific knowledge of the profile of airsickness during NFO training and on into the fleet; the basic causes of airsickness; the probability of eventual adaptation to flight given by a particular history of motion sickness; the use of medication, especially with provocative hops, to assist in the adjustment period; and the probability of recurrence of motion sickness with new fleet assignments. They also were interested in the availability of preflight laboratory tests that might identify individuals in need of early treatment and/or alternative naval service, and in special clinical tests that would aid in a comprehensive evaluation of specific airsick cases. In addition, this activity was often contacted directly by fleet aircrew suffering repeated airsickness difficulties who raised questions similar to those of the flight surgeons.

Airsickness problems have long existed in military aviation and are neither new nor unique to the NFO population. During World War II, Hemingway (6) reviewed numerous field studies conducted by the military which indicated a high incidence of airsickness during various phases of flight training for both pilot and nonpilot aircrew groups. In this and later reviews (1, 18, 20) it was shown that though the pilot and nonpilot groups were both at risk relative to airsickness, the latter group generally suffered the highest incidence rate. Recognition of airsickness as a continuing biomedical problem is also marked by efforts that have been taken to develop desensitization procedures for susceptible military aircrew (2, 3, 4, 5, 14, 16).

Since few operational data were available on airsickness problem during NFO training, a first step in addressing some of the above stated questions and problems involved describing the incidence and severity of airsickness normally experienced by the NFO population. To this end, a longitudinal study of airsickness in a large sample NFO population was initiated to follow students through the basic (primary level), advanced (secondary level), and fleet readiness squadrons comprising the NFO training syllabus. The primary objectives of the study were to define the relative magnitude of the airsickness problem during each phase of training on an individual squadron basis; and to identify differences in motion stress exposure associated with the different pipelines that can affect decisions on the initial selection and assignment of flight personnel. The study also gained a secondary objective through the cooperation of the training command who allowed a large segment of the NFO study population to be exposed on a one-time noninterference basis to several short laboratory tests of motion sickness reactivity prior to beginning flight training. The objective here was to obtain some insight into the avenues that might be followed in the future to develop and validate tests of motion reactivity that will have high predictive value in the early identification of airsick susceptible individuals. In this respect, the inflight airsickness data collected during the longitudinal study were intended to serve the dual function of defining the magnitude of the NFO airsickness problem and establishing validation criteria for measurement of the relative effectiveness of candidate motion reactivity tests.

## PROCEDURE

A block diagram of the NFO training pipelines included in the study is shown in Figure 1. All NFO candidates receive their basic flight training in Training Squadron TEN (VT10) prior to being selectively assigned to one of four advanced pipelines that lead to type-specific training in 14 different fleet readiness squadrons. Advanced training in the Mather Air Force Base (MAFB) pipeline leads to Fleet Readiness Squadron (FRS) training in the P-3 aircraft. In Training Squadron EIGHTY SIX (VT86), students who follow the Advanced Jet Navigation (AJN) pipeline receive FRS training in attack/antisubmarine aircraft including the A-6, EA-6, and the S-3; while those who follow the Radar Intercept Officer (RIO) pipeline are assigned to F-4 or F-14 FRS fighter squadrons. Those students that follow the Airborne Tactical Data Systems (ATDS) pipeline receive FRS training in E-2 squadrons. Upon completion of FRS training, the graduate NFOs are generally assigned to an operational squadron for fleet duty.

The study was initiated in VT10 where the incidence and severity of airsickness that occurred on each hop by each participating student was documented by means of a questionnaire (7) with separate sections for the student and instructor evaluations of the students airsickness reactions on the given hop. In general, each hop (a formally defined component of the squadron flight syllabus with a specific training mission or objective) involved a single flight of the student. However, there were rare occasions when a student flew two different hops on a single flight. On the student component of the questionnaire, the students were asked to rate their airsickness symptoms as not present, mild, moderate, or severe with these responses scored (weighted) on an integer scale of 0 to 3, respectively. A second question asked the students to provide corresponding scaled judgments for the amount of inflight performance degradation that they may have experienced as a result of airsickness. A third question addressed the number of times vomiting occurred on a given hop with zero, one, two, or three or more vomiting incidents being scored on a 0 to 3 scale, respectively. The instructor questionnaire required the instructor to make similar judgments on the same three items.

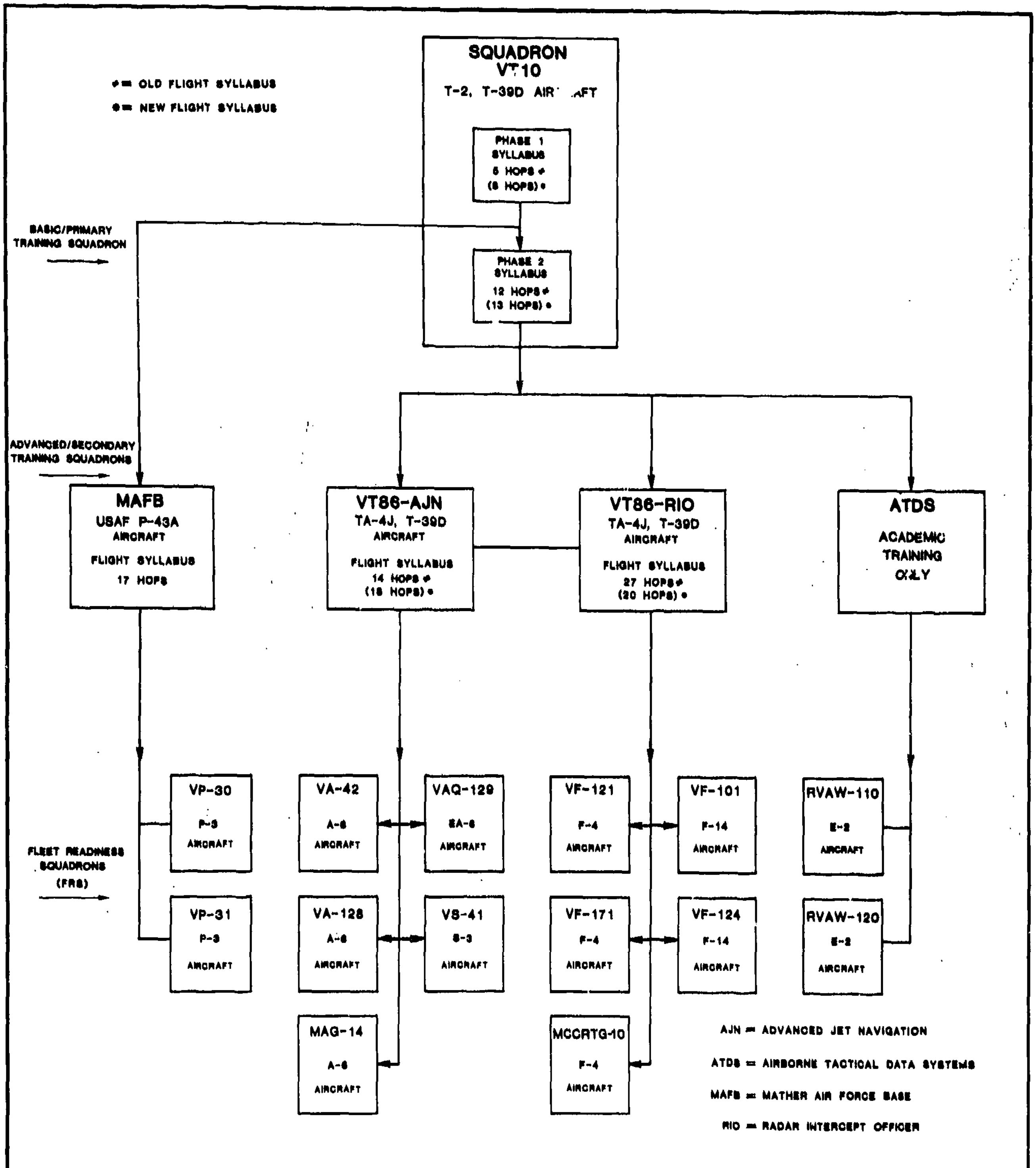
The same student/instructor questionnaire used to evaluate the incidence and severity of airsickness during basic training in VT10 was also used in the VT86-AJN and VT86-RIO advanced training pipelines. For the MAFB pipeline and for all of the individual fleet readiness squadrons, a modified questionnaire of near identical form was utilized to collect corresponding data on an individual hop basis with the exception that only the students rated the incidence and magnitude of their airsickness experiences. Throughout the course of the study, emphasis was placed on ensuring the participating students that their questionaire responses would be treated in confidential fashion.

As outlined in the first report (7) of the longitudinal study, the questionnaire responses were then computer-stored on an individual- student/individual-hop basis for each squadron involved in the study. The same computer file structure was also used to store the results of several laboratory-conducted motion reactivity tests given to a large segment of the NFO study population prior to their beginning flight training in VT10. These data included results from a motion sickness history questionnaire (19); a Brief Vestibular Disorientation Test (15); and a Visual/Vestibular Interaction Test (15).

As the students progressed through the basic, advanced, and FRS phases of NFO training, the computer-stored questionnaire data were extracted on an individual student basis and used to calculate unweighted and weighted indices that could be used to gauge individual susceptibility to airsickness during each phase of training. The function of these indices was to allow comparisons to be made among different squadrons and among different training pipelines. In addition, they served the further function of relating an individual's airsickness during basic training with subsequent airsickness in advanced and fleet readiness squadrons. For each student unweighted flight indices were calculated for the airsickness, vomiting, and performance degradation elements of the questionnaire as follows:

$$\text{UNWEIGHTED FLIGHT INDEX} = \frac{\text{Number of Hops Response Experienced}}{\text{Total Number of Hops Flown}} \times 100$$

where no weight was given to the severity of the response; i.e., attention was given only to the fact that a response such as airsickness occurred on a flight without regard to its severity. Accordingly, the unweighted indices simply represent the percentage of the total hops flown in a given squadron where the denoted response such as airsickness or vomiting occurred.




NAVAL FLIGHT OFFICER TRAINING PIPELINES

FIGURE I

Block diagram showing the major training pipelines followed by Naval Flight Officer (NFO) students as they progress through the NFO flight program. All students receive basic (primary level) flight training in Training Squadron TEN (VT10) and then are assigned to one of four advanced (secondary level) squadrons prior to receiving type-specific training in one of fourteen Fleet Readiness Squadrons (FRS). The MAFB pipeline leads to FRS training in the P-3 aircraft; the VT86-AJN attack pipeline to A-6, EA-6, and S-3 FRS training; the VT86-RIO fighter pipeline to F-4 and F-14 FRS training; and the ATDS pipeline to E-2 FRS training.

The weighted indices were derived similarly with the exception that the 0 through 3 integer values used to scale the magnitude of a given questionnaire item on a given hop was incorporated into the calculations. For example, if a student reported that on a given hop he was not airsick, he would be assigned a response rating of 0; if he reported experiencing mild, moderate, or severe airsickness, he would receive a response rating of 1, 2, or 3, respectively, for that particular hop. The response ratings received on each hop flown in a given squadron were then summed and used to calculate a weighted index that was normalized to have a maximum value of 100 as follows:

$$\text{WEIGHTED FLIGHT INDEX} = \frac{\text{Sum (Individual Flight Response Rating)}}{\text{Total Number of Hops Flown}} \times \frac{100}{3}$$

To illustrate, a student who reported being mildly airsick on half of his hops and not airsick on the remainder would have an unweighted airsickness index of 50.0 and a weighted index of 16.7, while a student who was severely airsick on half of his hops and not airsick on the remainder would also have an unweighted index of 50.0 but his weighted index would rise to 50.0. The instructor questionnaire data were also used to separately calculate instructor-based unweighted and weighted flight indices for each individual student.

## RESULTS AND DISCUSSION

Over the course of the longitudinal study, airsickness data were collected on a total of 28,383 hops flown by 796 students as they progressed through the NFO training program. A summary of the incidence of airsickness, vomiting, and inflight performance degradation due to airsickness as reported by the participating students is presented in Table I for each phase of training. In this table, incidence is expressed as the percentage of the total hops flown in a given phase where the denoted airsickness-related response was reported to have occurred without reference to the response magnitude. For the advanced and FRS phases, separate breakdowns are given for the principal training pipelines as well as a subtotal that combines the pipeline data.

TABLE I

Summary listing of the percent incidence of airsickness, vomiting, and performance degradation due to airsickness reported by the NFO population during the basic, advanced and FRS phases of flight training for different pipelines. Incidence is expressed as the percentage of the total hops flown in a given phase of training where the denoted airsickness event occurred.

| Phase of Training | Number of Students | Total Hops Flown | Airsickness Percent-hops | Vomiting Percent-hops | Perf.Degrad. Percent-hops |
|---|---|---|---|---|---|
| Basic Training | | | | | |
| VT10 | 796 | 10,759 | 19.4 | 9.2 | 12.7 |
| Advanced Training | | | | | |
| VT86-AJN (Attack) | 226 | 3,385 | 10.7 | 4.1 | 4.3 |
| VT86-RIO (Fighter) | 185 | 4,120 | 16.9 | 7.5 | 5.6 |
| MAFB (P-3) | 132 | 1,794 | 2.6 | 0.2 | 0.5 |
| Subtotal | 543 | 9,299 | 11.9 | 4.9 | 4.2 |
| FRS Training | | | | | |
| Attack | 120 | 3,269 | 9.2 | 3.9 | 4.1 |
| Fighter | 89 | 3,661 | 4.7 | 2.1 | 2.2 |
| P-3 | 128 | 900 | 15.8 | 4.7 | 8.3 |
| E-2 | 35 | 495 | 4.0 | 0.6 | 3.0 |
| Subtotal | 372 | 8,325 | 7.6 | 3.0 | 3.6 |
| Total - All Phases | 796 | 28,383 | 13.5 | 5.9 | 7.3 |

As shown in Table I, the highest incidence of airsickness problems occurred during basic training in VT10 as would be expected. Of a total of 10,759 hops flown, airsickness, vomiting, and performance degradation occurred on 19.4, 9.2, and 12.7 percent, respectively, of the flights. During advanced training, corresponding figures for all pipelines combined declined to 11.9, 4.9, and 4.2 percent, respectively. For the final FRS phase of training, a further decline to 7.6, 3.0, and 3.6 percent, respectively, was noted. These raw data show a general decline in airsickness difficulties as training progresses with the incidence during the FRS phase being roughly one-third the incidence during basic training which should be expected as the result of some adaptation to flight stress. The totalized data shown at the bottom in Table I indicates that 13.5 percent of the 28,383 hops flown by 796 NFO students involved airsickness. This is similar to the incidence data reported by McDonough (17) where 15.6 percent of 4,534 flights flown by navigation students involved airsickness.

Although the subtotal data presented in Table I for the advanced and FRS phases shows this gradual decline in incidence as training progresses, considerable variations occur when the pipelines are treated independently. For example, during advanced training in the attack pipeline, airsickness incidence (10.7 percent) was approximately half the 19.4 percent basic training incidence while the fighter pipeline incidence (16.9) percent showed a much slighter decline. However, when the FRS phase of training was encountered, the attack pipeline incidence (9.2 percent) remained near its advanced phase level while the fighter pipeline incidence (4.7 percent) fell to below one-third its advanced level. The most significant difference occurred in the P-3 pipeline where airsickness incidence fell to 2.6 percent during advanced training but rose to 15.8 percent during FRS training.

To further define these pipeline differences, a Kruskal-Wallis one-way analysis of variance by ranks test was utilized to compare the performance of the NFO students across the four different pipelines. The results of this test are summarized in Table II where the rows with the BAS-prefix represent the unweighted airsickness, vomiting, and performance degradation flight indices received during basic training in VT10 for each pipeline; the rows with the ADV-prefix represent the corresponding flight indices received during advanced training; and the rows with the FRS-prefix the same for fleet readiness squadron training. The rows with the MEAN-prefix represent the simple mean of the flight indices received by an individual during the basic, advanced, and FRS phases. For each of the pipelines, the mean, standard deviation of the observations, and number of students included in the analysis are separately tabulated for each flight index variable.

TABLE II

Results of a nonparametric Kruskal-Wallis one-way analysis of variance comparison of the unweighted airsickness flight indices received by the students in the four major training pipelines. See text for details.

| Flight Index variable (Unweighted) | H Stat. | VT86-AJN Attack Pipeline Mean | S.D. | N | VT86-RIO Fighter Pipeline Mean | S.D. | N | MAFB P-3 Pipeline Mean | S.D. | N | ATDS E-2 Pipeline Mean | S.D. | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BAS-Airsick | 29.2* | 17.0 | 15.3 | 115 | 12.5 | 14.0 | 84 | 27.3 | 23.4 | 120 | 20.7 | 16.4 | 34 |
| BAS-Vomit | 9.2 | 8.5 | 13.4 | 115 | 5.1 | 9.5 | 84 | 11.7 | 15.9 | 120 | 10.6 | 13.5 | 34 |
| BAS-Perf.Degr. | 19.2* | 9.9 | 10.7 | 115 | 6.9 | 9.5 | 84 | 17.2 | 19.3 | 120 | 16.3 | 18.3 | 34 |
| ADV-Airsick | 64.1* | 10.0 | 11.8 | 112 | 15.3 | 18.4 | 84 | 2.6 | 5.5 | 108 | -- | -- | -- |
| ADV-Vomit | 43.7* | 4.0 | 7.6 | 112 | 6.2 | 12.6 | 84 | 0.2 | 1.1 | 108 | -- | -- | -- |
| ADV-Perf.Degr. | 34.1* | 3.4 | 6.1 | 112 | 3.8 | 6.2 | 84 | 0.5 | 1.8 | 108 | -- | -- | -- |
| FRS-Airsick | 27.5* | 12.4 | 19.7 | 115 | 7.2 | 17.2 | 84 | 16.4 | 19.2 | 124 | 4.6 | 10.0 | 34 |
| FRS-Vomit | 13.8 | 6.0 | 15.1 | 115 | 3.2 | 10.0 | 84 | 4.6 | 11.8 | 124 | 0.7 | 2.3 | 34 |
| FRS-Perf.Degr. | 13.7 | 4.8 | 11.1 | 115 | 3.4 | 12.2 | 84 | 9.0 | 16.0 | 124 | 3.7 | 17.2 | 34 |
| MEAN-Airsick | 8.5 | 13.1 | 11.6 | 115 | 11.7 | 13.5 | 84 | 16.1 | 13.3 | 124 | 12.7 | 11.9 | 34 |
| MEAN-Vomit | 2.3 | 6.2 | 9.4 | 115 | 4.8 | 8.6 | 84 | 5.6 | 8.2 | 124 | 5.7 | 7.2 | 34 |
| MEAN-Perf.Degr. | 13.9# | 6.1 | 6.9 | 115 | 4.7 | 7.4 | 84 | 9.2 | 10.6 | 124 | 10.0 | 16.1 | 34 |

# = Significant beyond the .01 level; * = Significant beyond the .001 level.

The Kruskal-Wallis H-statistic corrected for tied scores is shown in the data column at the left in Table II where the assumption is made that H is distributed like chi squared with three degrees of freedom for all flight indices except those associated with advanced training. For these indices, only two degrees of freedom are involved since the ATDS pipeline received only academic-related training in the advanced phase. As shown by the significance symbols located adjacent to the H-statistic, the unweighted and weighted airsickness indices showed dissimilarities in the pipeline populations that were significant to the .001 level or better for all three phases of training. For the vomiting indices, differences occurred in only the advanced phase. In the case of the performance degradation indices, differences occurred during both basic and advanced training and were also reflected in the mean indices.

Prior to further discussion of these pipeline differences, reference will again be made to Figure 1 to describe some fundamental differences in the flight syllabi and student flow associated with the four different advanced training pipelines. As schematized by the two blocks drawn within the VT10 block at the top in Figure 1, the flight syllabus in this squadron was subdivided into two sequential phases. All NFO students, with the exception of those to be assigned to the MAFB advanced training pipeline, flew both phases of the flight syllabus. For those students following the MAFB pipeline, only the first phase was flown prior to assignment to advanced training. At the time the longitudinal study was initiated, the VT10 syllabus consisted of five hops in the first phase and 13 hops in the second phase. Midway in the study, the flight syllabus was modified to provide eight hops in the first phase and 13 hops in the second phase. Similar changes occurred in the VT86-AJN and VT86-RIO flight syllabi at about the same time while no changes occurred in the 17 hop MAFB flight syllabus. In subsequent discussion, the original and modified flight syllabi for these squadrons will be referred to as the "old" and "new" flight syllabi, respectively.

The incidence of airsickness in VT10, VT86-AJN, and VT86-RIO on an individual hop basis is displayed in Figure 2. The top three graphs (A, C, and E) pertain to the old flight syllabi associated with these squadrons and the bottom three (B, D, and F) to the

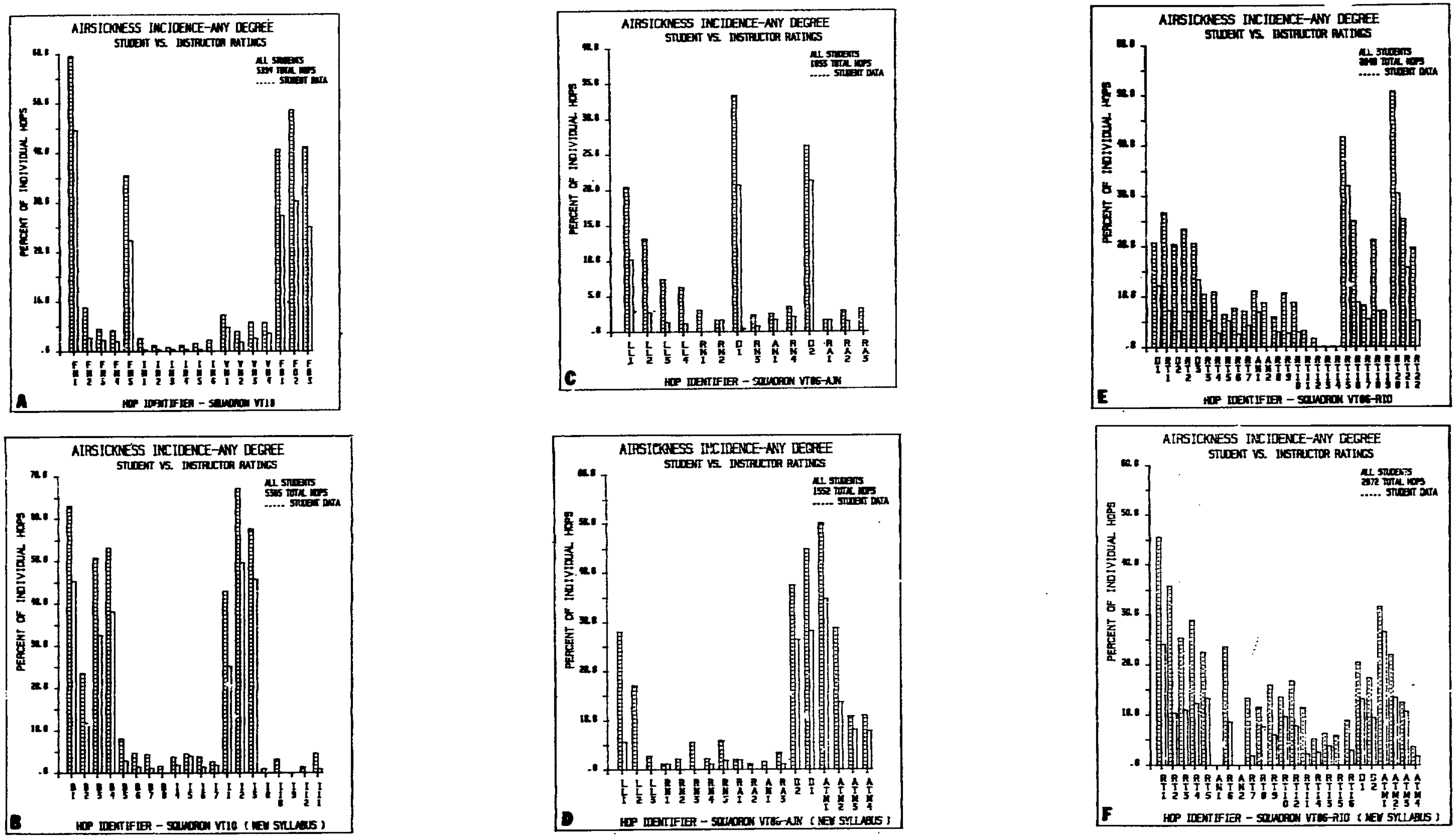



FIGURE 2

Percent incidence of airsickness reported to have occurred on the individual hops comprising the flight syllabi associated with VT10, VT86-AJN, and VT86-RIO. The top three graphs (A, C, and E) pertain to the student population who flew the old flight syllabi and the bottom three (B, D, and F) to those who flew the new flight syllabi. In each graph, two bars are shown above each hop identifier. The left (dotted) bar represents the percentage of the hops flown where the students reported experiencing airsickness and the right (clear) bar represents the percentage of the same number of hops where the instructors reported that the students experienced airsickness. The left-to-right sequence of hops shown in each graph corresponds in general to the sequence that the hops were actuallly flown by the NFO students.

new flight syllabi associated with the same three squadrons. For each graph, incidence is expressed as the percentage of the total hops flown of a given classification where airsickness (mild, moderate, or severe degree) was reported to have occurred. The dotted interior bars represent the incidence as derived from the student judgments and the adjoining clear bars the incidence as derived from the instructor judgments. The left-to-right sequence of hops identified at the bottom in each graph corresponds in general to the sequence the students flew the hops.

Examination of Figure 2A shows that during the first phase of VT10 training, composed of hops FM1 through FM5, two of the five hops involved relatively high motion stress with nearly 60 percent of the students reporting airsickness on FM1 and over 35 percent on FM5. Figure 2B shows that four of the eight hops (B1 through B8) comprising the first phase of the new VT10 flight syllabus involved a relatively high degree of airsickness. For the second phase under both the old and new flight syllabi, a smaller proportion of the total hops flown produced corresponding motion stress. Since the students following the MAFB or P-3 pipeline flew only the first phase of VT10, it would be expected that their VT10 airsickness indices would be higher than those students who flew both phases of the VT10 syllabus. This difference is the primary reason for the pipeline differences noted in the basic training rows of Table II.

In the case of the airsickness measures associated with advanced training, the data of Table II are distinguished again by the MAFB pipeline which had the least difficulties with airsickness. This would be expected since the MAFB flight syllabus involved training in the large, relatively stable P-43A with most hops involving straight and level flight. However, when the MAFB students reached the FRS phase of their training which involved long duration missions in the P-3 aircraft, airsickness rose considerably as reflected by the raw incidence data of Table I and the FRS flight index data of Table II. In effect, the MAFB group flies relatively few hops during basic training and receives only a mild exposure to motion stress during advanced training. A measure of airsickness susceptibility will thus not arrive until the FRS phase of training is reached. Since only a relatively few hops are flown in the P-3 FRS squadrons compared to the fighter and attack pipelines, there is a hazard that airsick susceptibles in the MAFB pipeline may not be identified until they receive their initial fleet assignments. Accordingly, when validated laboratory-based tests of airsickness susceptibility are finally developed, high priority must be given to their early application to the MAFB pipeline.

Examination of Figure 2 relative to the incidence of airsickness as a function of progress through the flight syllabus associated with a given squadron shows a general trend for a relatively high incidence rate for the first few hops of the syllabus. However, there is no pronounced trend for airsickness incidence to gradually decrease as training progresses within a squadron. Instead, as shown for all squadron data presented in Figure 2, airsickness incidence actually rose to a quite high level for certain hops flown toward the end of the syllabus. The high incidence rate for these hops is accounted for by their related flight missions which usually involved aerobatics or advanced tactical maneuvering. In effect, conclusions concerning airsickness adaptation of the NFO population as a function of flight exposure must be carefully weighed in relation to the motion stress level of each hop flown within a given flight syllabus.

Referring once again to Table I, these incidence data provide background data on the overall incidence of airsickness during the different phases of NFO training. However, no information is provided by these data relative to the wide variations always present in individual susceptibility to airsickness nor to the relative contribution of different students to the overall magnitude of the airsickness problem. To provide some insight into this problem, the questionnaire data were analyzed to determine the number of students who experienced repeated airsickness during the course of their training in selected squadrons. To emphasize the multiple contributions of a small number of students to the overall airsickness problem, the airsickness data derived from both the student and instructor questionnaires have been plotted in cumulative frequency distribution form in Figure 3 for VT10, VT86-AJN, and VT86-RIO. In this figure, the deviation between the student and instructor distributions reflects the tendency for the instructors to underestimate the incidence of airsickness using the student judgments as reference. This point is also demonstrated on an individual hop basis by the Figure 2 data. The percentage of the total number of students who were considered to have never experienced airsickness is represented in each Figure 3 graph by the intersection of the distribution curve with the ordinate axis. These distribution data graphically illustrate the point that a small number of airsick susceptible students make a most significant contribution to the hop incidence data of Table I.

Further insight into the overall incidence of airsickness and the multiple contributions of certain students is provided by the data listed in Table III. In this table, data columns 1 and 2 represent the number of students included in the study population and the total number of hops they flew, respectively, with separate listings for VT10, VT86-AJN, and VT86-RIO for both the old and new flight syllabi. Data columns 3-5 describe the percentage of the total hops flown in a given squadron where airsickness, vomiting or performance degradation was involved. (These data are of the same form as those presented in Table I.) Data columns 6-8 list the percentage of the students who reported experiencing airsickness, vomiting, or performance degradation on one or more hops. Data columns 9-11 list the percentage of the total number of students who were responsible for fifty (50) percent of the hops flown where airsickness, vomiting, or performance degradation was reported, i.e., those students who suffered

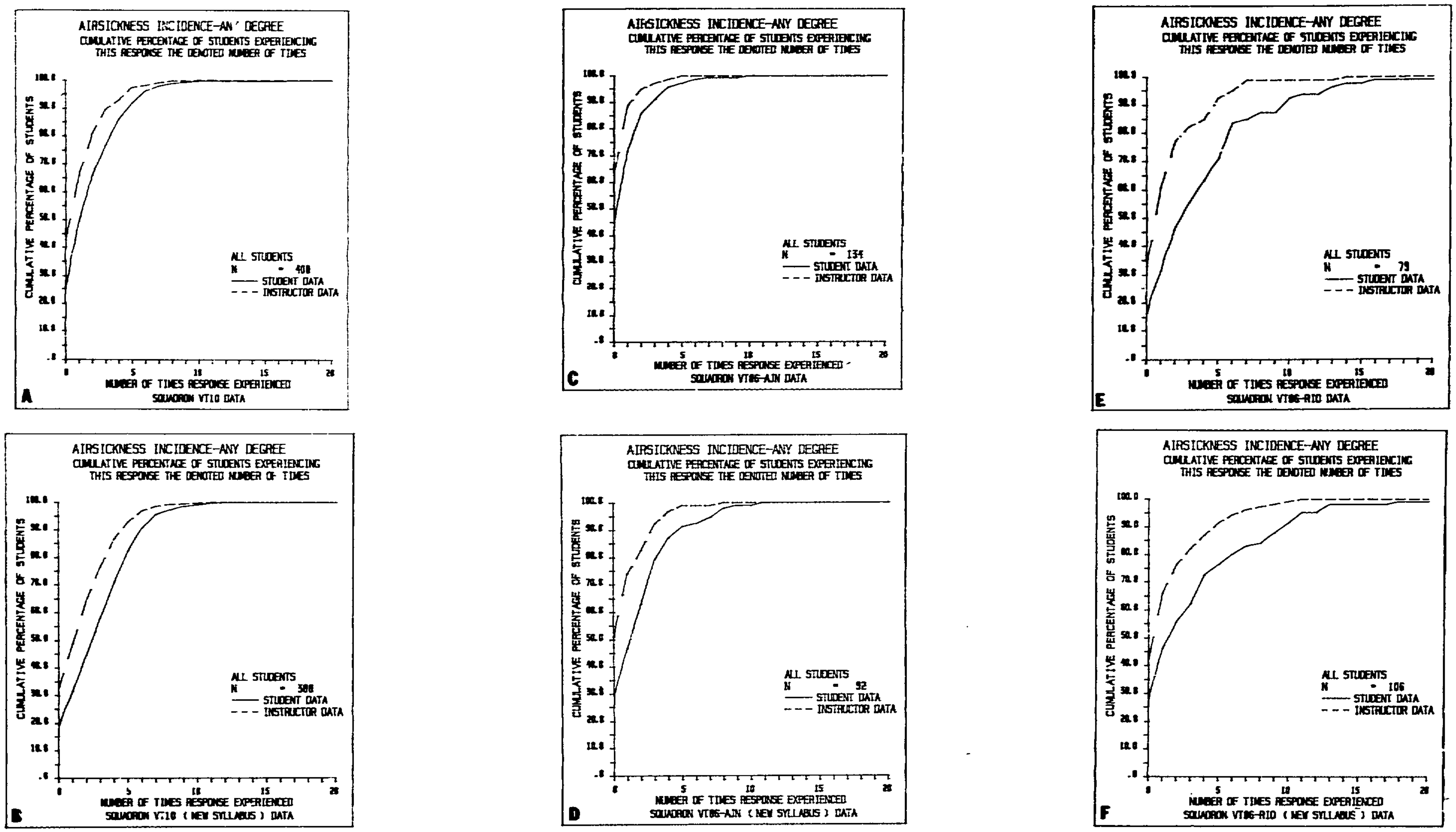



FIGURE 3

Normalized cumulative frequency distribution of students experiencing airsickness a different number of times during the course of their flight training in a given squadron. The top three graphs (A, C, E) pertain to the student populations who flew the old flight syllabi associated with VT10, VT86-AJN, and VT86-RIO and the bottom three (B, D, F) to those who flew the new syllabi. The solid-line distributions are based upon student data and the dashed-line distributions upon instructor data. The deviation between the two distributions reflects the tendency for the instructors to underestimate the incidence of airsickness as compared to the judgments of the students.

repeated airsickness experiences and fell into the upper portions of the Figure 3 distributions.

TABLE III

Incidence of airsickness during basic training in VT10 and advanced training in VT86 for the attack (AJN) and fighter (RIO) pipelines. Columns 1 and 2 represent the number of students studied in the squadron and the number of hops they flew. Columns 3, 4, and 5 represent the percentage of the hops flown where airsickness, vomiting, and inflight performance degradation occurred; columns 6, 7, and 8 show the percentage of the squadron students who reported experiencing the denoted response one or more times; and columns 9, 10, 11 show the percentage of the students that accounted for fifty percent of the total hops flown where the denoted responses occurred.

| Squadron | Total No. Stud. | Total Hops Flown | Percent of Total Hops Flown Where Response Occurred | | | Percent of Students Experiencing Response One or More Times | | | Percent of Students Causing 50% of Hop Responses | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Air Sick | Vomit | Perf. Degr. | Air Sick | Vomit | Perf. Degr. | Air Sick | Vomit | Perf. Degr. |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| VT10 # | 408 | 5,394 | 16 | 7 | 11 | 74 | 39 | 59 | 19 | 10 | 14 |
| VT10 * | 388 | 5,365 | 23 | 11 | 15 | 81 | 53 | 67 | 24 | 14 | 18 |
| VT86-AJN # | 134 | 1,833 | 9 | 4 | 3 | 55 | 28 | 31 | 13 | 8 | 8 |
| VT86-AJN * | 92 | 1,552 | 13 | 5 | 5 | 71 | 36 | 41 | 12 | 9 | 11 |
| VT86-RIO # | 79 | 2,048 | 16 | 6 | 4 | 83 | 47 | 48 | 19 | 8 | 12 |
| VT86-RIO * | 106 | 2,072 | 18 | 9 | 7 | 72 | 46 | 43 | 15 | 10 | 9 |

# = Old Flight Syllabus      * = New Flight Syllabus

From data columns 6-8, it can be seen that for the denoted basic and advanced training squadrons, the number of NFO students experiencing airsickness one or more times ranged from 55 to 83 percent of the total squadron population which again is comparable to that reported by McDonough (17) who found that 65.7 percent of a navigation student population experienced airsickness one or more times during training. Corresponding ranges were 28 to 53 percent for the vomit measure and 31 to 67 percent for the performance degradation measure. However, the incidence of airsickness shown in data columns 3-5 is not at all evenly distributed over the population represented in data columns 6-8. This is pointedly illustrated by data columns 9-11 which show that a relatively small proportion of students contributed most significantly to the overall incidence data. For example, column 9 indicates that half of the hops flown in the old VT10 flight syllabus where airsickness was reported to have occurred was caused by only 19 percent of the students. This figure ranged from 12 to 24 percent across the denoted squadrons. The contribution of students who suffered repeated experiences of airsickness was even more marked for the vomit measure where the percentage of the students accounting for half of the flights where vomiting occurred ranged from 8 to 14 percent of the total population. Corresponding ranges were 8 to 18 percent for the performance degradation measure. In effect, if the overall magnitude of the airsickness problem during NFO training is to be significantly reduced, then attention must be given to developing selection tests that have the potential to identify this most susceptible component of the NFO population prior to the time they begin flight training.

In the previous reports (7-13) detailing the results of the longitudinal study, correlation matrices were developed using a Spearman rank correlation analysis based upon corrected tied scores to explore the many relationships that existed among and between the flight airsickness indices and the laboratory motion reactivity test scores. One point of concern addressed in the report (13) dealing with the students who successfully completed the entire NFO training program involved the relationship between the airsickness experienced by a given individual during basic training with the airsickness he experienced during later phases of training. To this end, a Spearman rank correlation analysis was performed to determine the relationship between the unweighted airsickness indices received in basic training with the same indices received during advanced and FRS training for each of the major pipelines. The results of this analysis, presented in Table IV, show that the strongest relationship existed for the VT86-AJN and VT86-RIO pipelines where the correlation coefficients were in the range of .51 to .61 and significant to the .001 level or better. For these pipelines, it is probable that the airsickness experiences of a given student during basic training will carry over into the advanced and FRS phases. In the case of the MAFB or P-3 pipeline, a significant relationship between basic and advanced training was not realized. Again, this is accounted for by the low motion stress associated with advanced flight training in the P-43A aircraft at MAFB. However, a significant correlation was achieved for the FRS phase of this pipeline.

As described in the Procedure section, a large sample of the NFO population was given several laboratory tests of motion reactivity prior to beginning flight training. In the report (13) dealing with airsickness problems during FRS training, a tabulation was presented (Ref. 13, Table VIII) of the Spearman rank correlation coefficients between certain of these tests and the unweighted airsickness indices received during each phase of training for each of the pipelines. Table V shows the results of this analysis for all pipelines combined where separate listings are provided for three sets of tests. The first set involved a two-part motion sickness history questionnaire describing motion sickness incidence and exposure where the first part (variable 1) pertained to experiences prior to age 12 and the second part (variable 2) to experiences following age 12. The sum of these two scores is separately listed (variable 3) in Table V. The second set of tests pertain to the Brief Vestibular Disorientation Test (BVDT) which is

TABLE IV

Spearman rank correlation coefficients expressing the relationship between airsickness experienced during basic training with airsickness experienced during the following advanced and FRS phases for different pipelines.

| Pipeline | Basic Training Flight Index | Advanced Training ADV-Airsick | FRS Training FRS-Airsick |
|---|---|---|---|
| VT86-AJN | BAS-Airsick | .58* | .51* |
| VT86-RIO | BAS-Airsick | .61* | .53* |
| MAFB | BAS-Airsick | .13 | .38* |
| Combined | BAS-Airsick | .24* | .48* |

* = Significant beyond the .001 level.

TABLE V

Spearman rank correlation coefficients expressing the relationship between selected laboratory motion reactivity test scores and unweighted airsickness indices received during different phases of training.

| Laboratory Test Variables No. | Test Name | Airsickness Indices (Unweighted)-All Pipelines Combined: Basic Training | Advanced Training | FRS Training | Mean Index |
|---|---|---|---|---|---|
| 1 | MS History:Part 1 | .41* | .19# | .26* | .40# |
| 2 | MS History:Part 2 | .47* | .20* | .36* | .48* |
| 3 | MS History:Sum | .48* | .23* | .36* | .50* |
| 4 | BVDT:Rater Score | .37* | .16 | .26* | .38* |
| 5 | BVDT:Self-rating Score | .37* | .20* | .32* | .41* |
| 6 | BVDT:Post-rating Score | .28* | .14 | .25* | .31* |
| 7 | BVDT:Sum Scored | .42* | .26* | .33* | .46* |
| 8 | VVIT:Rater Score | .22# | .12 | .14 | .23# |
| 9 | VVIT:Self-rating Score | .23# | .23# | .28# | .30* |
| 10 | VVIT:Post-rating Score | .22 | .05 | .21 | .24 |
| 11 | VVIT:Sum Score | .27# | .15 | .21 | .29* |

# = Significant beyond the .01 level; * = Significant beyond the .001 level.

based upon cross-coupled angular acceleration stimuli produced by paced head motions on a rotating chair. The BVDT-Rater score (variable 4) involves the motion reactivity signs judged to be present by observers following the test; the BVDT Self-rating (variable 5) and Post-rating (variable 6) scores involve the rating of similar symptoms by the subject immediately following and 24 hours after completing the test. The sum of these three BVDT scores is represented by variable 7. The Visual/Vestibular Interaction Test (VVIT) is based upon the visual scan, acquisition, and identification of a matrix type numerical display while undergoing sinusoidal rotation. The symptoms were rated in a fashion similar to those of the BVDT with the related test scores listed as variables 8-11 in Table V.

All three of the motion sickness history scores showed significant correlations with the airsickness indices received during each phase of training. However, the strongest relationship existed during the basic phase with the sum score (variable 3) displaying the strongest relationship. In the case of the four components of the BVDT, sig nificant correlations existed with all airsickness indices except those received during advanced training. Again, the sum BVDT score (variable 7) showed the strongest relationship. The VVIT test scores showed a weaker relationship to the airsickness indices compared to the other two tests. However, the self-rating score (variable 9) was significantly correlated with all four indices. Though most of these test variables have statistically significant correlations to the listed airsickness indices, the correlated coefficients are not at all adequate for prediction applications. (An important point in evaluating the relative magnitude of the correlation coefficients presented in Table V is that the data are based upon only those NFO students who successfully completed the entire NFO training program. The analysis does not include those students who attrited from the program or those who decided to not continue their voluntary participation in the longitudinal study). That is, until an individual test or test battery is developed with much higher correlation coefficients, too many students will be rejected who could have successfully completed the program or vice versa.

A last point involves the need for inflight validation data to establish the relative strength of each candidate test undergoing development. Just as the individual motion reactivity tests must be designed to eliminate any bias that may be introduced by the student, so must the method used to document the actual incidence of airsickness during a given flight. In this respect, heavy dependence must be placed on the flight instructor to gauge the incidence and severity of airsickness experienced by a given student. Although the instructor will obviously identify an overt sign such as vomiting, it might be argued that there would be too many limitations imposed on his judgments where airsickness occurred with less obvious signs and symptoms.

The data of this study (1-6), however, have shown a high degree of correlation between the student and flight instructor ratings of airsickness present on a given hop. In Table VI, Spearman rank correlation coefficients adjusted for tied scores are presented which show the close relationship between student and instructor ratings (unweighted flight indices) of airsickness incidence as judged to have occurred in different training squadrons. For all three response variables, airsickness, vomiting, and performance degradation, the student and instructor ratings are significantly correlated to the .001 level or better. The correlation coefficients range from 0.85 through 0.97 for the vomiting response as would be expected. Equally important, the student and instructor ratings are highly correlated in the range of 0.69 through 0.86 for the airsickness measure as well. The weighted flight indices, though not listed in Table VI, also show correlation magnitudes of equal or slightly greater magnitude. In this respect, it would appear that instructor-based judgments of airsickness incidence and severity can well serve as validation criteria for identification of candidate tests with the highest potential for optimizing the aircrew selection process.

TABLE VI

Spearman rank correlation coefficients showing the close relationship between the student and instructor ratings of airsickness (unweighted flight indices) judged to have occurred during basic training in VT10 and advanced training in VT86-AJN and VT86-RIO for both the old and new flight syllabi populations.

| Student Data Squadron Flight Indices | Airsickness Flight Syllabus Old | Airsickness Flight Syllabus New | Instructor Data Vomiting Flight Syllabus Old | Instructor Data Vomiting Flight Syllabus New | Perf. Degradation Flight Syllabus Old | Perf. Degradation Flight Syllabus New |
|---|---|---|---|---|---|---|
| VT10 | | | | | | |
| Airsickness | .80* | .79* | | | | |
| Vomiting | | | .93* | .94* | | |
| Perf. Degradation | | | | | .71* | .75* |
| VT86-AJN | | | | | | |
| Airsickness | .71* | .69* | | | | |
| Vomiting | | | .92* | .87* | | |
| Perf. Degradation | | | | | .55* | .61* |
| VT86-RIO | | | | | | |
| Airsickness | .77* | .85* | | | | |
| Vomiting | | | .95* | .96* | | |
| Perf. Degradation | | | | | .63* | .48* |

* = Significant beyond the .001 level

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DISCLAIMER

Opinions or conclusions contained in this report are those of the authors and do not necessarily reflect the views or endorsement of the Navy Department.

DISCUSSION

CURRAN: What is the percentage overall NFO P-3 attrition for FRS? What is the incidence of motion sickness for NFO's in P-3 fleet operations, specifically low altitude, race track pattern?

GUEDRY: We do not have information on attrition rate in P-3 FRS but believe that it was relatively low in our study because we had a good return rate on our questionnaires. In answer to the second question, we have heard that the incidence of motion sickness in P-3 fleet operations involving low altitude race track patterns is high and we have included this as part of a proposal for study in the next fiscal year.