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The Effect of a Monocular Helmet-Mounted Display on Aircrew Health: A Cohort Study of Apache AH Mk1 Pilots Two-Year Baseline Review

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13. ABSTRACT *(Maximum 200 words)*

A collaborative occupational health study has been undertaken by Headquarters Director Army Aviation, Middle Wallop, UK, and the U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama, under the auspices of The Technical Cooperative Program (TTCP), Subgroup U, Technical Panel 7 (Human Factors in the Aviation Environment) to determine if the use of the monocular Integrated Helmet and Display Sighting System (IHADSS) helmet-mounted display (HMD) in the British Army's Apache AH Mk 1 attack helicopter has any long-term effect on visual performance.

This first interim report covers the period of January 2000 - May 2002. It documents the baseline data for 117 subject pilots (14 AH Mk 1 exposed, 103 control) enrolled from the period 17 November 2000 - 23 May 2002.

At this early stage of the study, the constrained selection process for exposed subjects has resulted in an older and more experienced exposed group. This is a result of the current Apache aviator population consisting of entirely experienced aviators. An additional consequence of this selection process is a higher proportion of exposed subjects requiring vision correction. In turn, the higher proportion of exposed subjects requiring vision correction resulted in a higher proportion of contact lens usage, which is also driven by incompatibility issues between the IHADSS and use of spectacles.

At this early stage of the study, there are only minor differences between the two groups in terms of refractive status and visual performance. The exposed group is more myopic than the control group, which is in keeping with the age differences between the two groups, as the exposed group is older. The control group has a lower level of accommodative range by age, which was not an expected finding; however this difference is probably due to the greater accommodative capability of a few exposed subjects within a much smaller sample size than the control subject pool. For all other visual measures, there is not a significant difference.

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Executive summary

Purpose and scope of document

This is the first interim report for the study titled *The Effect of a Monocular Helmet-Mounted Display on Aircrew Health: A Cohort Study of Apache AH Mk 1 Pilots*. The principal aim of this occupational health study is to determine if the use of the monocular Integrated Helmet and Display Sighting System (IHADSS) helmet-mounted display (HMD) in the British Army's Apache AH Mk 1 attack helicopter has any long-term effect on visual performance. Additional information concerning other unique problems of the Apache AH Mk 1 aircrew is elicited as a secondary objective. This study is a collaborative effort between the British Army and the U.S. Army and is conducted under the auspices of The Technical Cooperative Program (TTCP), Subgroup U, Technical Panel 7 (Human Factors in the Aviation Environment).

This first interim report covers the period of January 2000 – May 2002. It documents the baseline data for 117 subject pilots (14 AH Mk 1 exposed, 103 control) enrolled from the period 17 November 2000 - 23 May 2002.

Methods

A cohort of British Apache AH Mk 1 pilots (exposed group) and a control group of British Army helicopter pilots who do not fly the Apache AH Mk 1 are being followed over a 10-year period. At yearly intervals, the subjects complete questionnaires and undergo expanded flight physical examinations. The questionnaires address flight experience, vision history, disorientation, neck and back pain, helmet usage, contact lens use, and handedness. The expanded physical examination consists of a battery of vision tests designed to assess both monocular and binocular visual performance.

Demographics

The total number of exposed (Apache) subjects enrolled as of 31 July 2002 (over the period November 2000 - April 2002) was 14. All exposed subjects were male, with a mean age of 39 years, and total flight hours ranging from 1750-6580, with a mean and median of 3720 and 4115, respectively. The total number of control subjects enrolled over the same period was 103. The control subjects were predominately male (95%), with a mean age of 31. The total flight hours for the control group ranged from 13-7000, with a mean and median of 805 and 180, respectively. The exposed subjects had a mean of 28 flight hours using the Apache's monocular IHADSS HMD.

Summary

The following table summarizes the comparison among demographics, visual examination data, and questionnaire responses of the exposed and control groups for major study parameters.

Table.
Executive summary.

Variable	Exposed	Control	Findings
DEMOGRAPHICS			
Sample size	14	103	
Age	Mean = 39	Mean = 31	Difference statistically significant (p = 0.000)
Gender	Male 100%	Male 95%; Female 5%	
Total flight hours	Mean = 3720 Median = 4115	Mean = 805 Median = 180	Differences statistically significant (p= 0.001)
Night vision device flight hours	IHADSS Mean = 28 Median = 27	NVG Mean = 102 Median = 84	
VISION HISTORY			
Vision correction	64% required vision correction	26% required vision correction	Difference statistically significant (p = 0.004)
Sighting eye preference	79% right; 14% left; 7% bilateral	64% right; 12% left; 8% bilateral	Differences not significantly significant (p = 1.000)
Contact lens usage	36% wore contacts	6% wore contacts	Difference statistically significant (p = 0.001)
VISUAL PROBLEMS			
Visual symptoms	Headache (43%) and visual discomfort (36%) most frequently reported symptoms *during* flight	Disorientation (36%) and headache (29%) most frequently reported symptoms *during* flight	Difference in frequency of reported headaches not statistically significant (p = 0.211)
	Headache (43%), nausea (14%) and visual discomfort (14%) most frequently reported symptoms *after* flight	Headache (17%) and after images (6%) most frequently reported symptoms *after* flight	Difference in frequency of reported headaches statistically significant (p = 0.010)
Eye fatigue	91% reported experiencing eye fatigue	73% reported experiencing eye fatigue	Difference not statistically significant (p = 0.217)
Full field-of-view	Yes – 64% No – 36%	Yes – 71% No – 29%	Difference not statistically significant (p = 0.616)
DISORIENTATION			
Episodes of disorientation	70% reported experiencing disorientation	29% reported experiencing disorientation	Difference statistically significant (p = 0.010)
NECK PAIN			
Presence of neck pain	*During* flight – 69% *After* flight– 54% Centre of neck as main site of pain – 56%	*During* flight– 26% *After* flight– 19% Centre of neck as main site of pain – 68%	Difference significantly different both *during* (p = 0.002) and *after* (p = 0.006) flight

Table.
Executive summary (continued).

BACK PAIN			
Presence of back pain	*During* flight– 69% *After* flight– 60% Lower back as main site of pain – 88%	*During* flight– 61% *After* flight– 39% Lower back as main site of pain – 83%	Difference not significantly different both *during* (p = 0.576) and *after* (p = 0.208) flight
HELMET USAGE			
Quality of fit	Mean rating: 4.5	Mean rating: 6.9	Difference statistically significant (p = 0.002)
Helmet stability	Mean rating: 6.4	Mean rating: 7.0	Difference not statistically significant (p = 0.164)
Overall comfort	Mean rating: 5.6	Mean rating: 6.7	Difference statistically significant (p = 0.033)
Noise protection	Mean rating: 4.5	Mean rating: 6.9	Difference not statistically significant (p = 0.004)
HANDEDNESS			
Edinburgh Handedness Inventory (EHI)	85% right; 15% left Mean EHI = 55	91% right; 9% left Mean EHI = 62	Difference in proportion and EHI scores not statistically significant (p = 0.509 and 0.703, respectively)
EYE EXAMINATION			
Refractive error (spherical equivalent)	Right eye -0.45D; Left eye -0.38D	Right eye -0.03D; Left eye +0.02D	Differences statistically significant (Right, p = 0.02; Left, p = 0.03)
Bailey-Lovie high contrast visual acuity	Right 0.16 logMAR; Left 0.12 logMAR (n = 9)	Right 0.12 logMAR; Left 0.11 logMAR (n = 93)	Differences not statistically significant (Right, p = 0.11; Left, p = 0.35)
Bailey-Lovie low contrast visual acuity	Right 0.37 logMAR; Left 0.41 logMAR (n = 5)	Right 0.36 logMAR; Left 0.37 logMAR (n = 93)	Differences not statistically significant (Right, p = 0.43; Left, p = 0.22)
Small letter contrast	Right 0.90 logCS; Left 0.91 logCS (n = 9)	Right 0.98 logCS; Left 0.97 logCS (n = 93)	Differences not statistically significant (Right, p = 0.13; Left, p = 0.18)
Depth perception	25" arc - 70% 30" arc - 30%	20" arc - 7% 25" arc - 75% 30" arc - 19% 50" arc - 1%	Difference not statistically different (p = 0.62)
Colour perception	Right 66.7; Left 67.9	Right 64.9; Left 64.3	Differences not statistically significant (Right, p = 0.31; Left, p = 0.17)
Accommodation (20 to 29 yr old)	N/A	Right 8.5D; Left 8.7D (n = 50)	N/A
Accommodation (30 to 39 yr old)	Right 8.0D; Left 8.2D (n = 7)	Right 6.7D; Left 6.7D (n = 45)	Differences statistically significant (Right, p = 0.04; Left, p = 0.02)
Accommodation (40 to 49 yr old)	Right 6.8D; Left 6.7D (n = 6)	Right 4.1D; Left 4.0D (n = 8)	Differences not statistically significant (Right, p = 0.14; Left, p = 0.13)
Eye muscle balance (distance)	77% ortho; 23% eso	78% ortho; 16% eso; 3% exo; 1% hyper	Difference not statistically significant (p = 0.77)
Eye muscle balance (near)	92% ortho; 8% eso	92% ortho; 5% eso	Difference not statistically significant (p = 0.80)
Eye preference	77% right; 23% left	87% right; 13% left	Difference not statistically significant (p = 0.521)

Vision history

Both sample groups predominately prefer their right eye for sighting tasks. The exposed group has a statistically significant higher proportion requiring vision correction (64% versus 26%) as compared to the larger control group. The ratio of contact lens wearers for the exposed to the control group is 36% to 6%.

Visual problems

The two most reported visual symptoms *during* flight are headache (43%) and visual discomfort (36%) for the exposed group and disorientation (36%) and headache (29%) for the control group. For the shared complaint of headache, the difference between the exposed and control groups is not statistically significant (p = 0.211). The symptom of headache is the most reported for both exposed (43%) and control (17%) groups *after* flight; the difference being statistically significant (p = 0.010). The proportion of the exposed group reporting experiencing eye fatigue (to some extent) *during* flight with the IHADSS HMD is 91%, as compared to 73% for the control group flying with night vision goggles (NVGs); this difference is not statistically significant (p = 0.217).

Thirty-six percent of exposed Apache subjects report an inability to achieve a full field-of-view with the IHADSS HMD, as compared to 29% of control subjects who are also unable to achieve a full field-of-view with NVGs. This difference is not statistically significant (p = 0.616).

Disorientation

Spatial disorientation, defined as a failure to perceive correctly one's position, motion or attitude with respect to the Earth's surface or the acceleration due to gravity, is reported by 70% of the exposed group and by 29% of the control group, a difference that is statistically significant (p = 0.010).

Neck/Back pain

A greater proportion of the exposed group reported neck pain both *during* (69%) and *after* (54%) flight, as compared to the control group (*during* [26%] and *after* [19%]); these differences are statistically significant (p = 0.002 and p = 0.006, respectively). Similarly, reports for back pain are numerically higher for the exposed group both *during* (69%) and *after* (60%) flight, as compared to the control group (*during* [61%] and *after* [39%]); however, these differences are not statistically significant (p = 0.576 and p = 0.208, respectively). Both groups reported the lower back region as the main site of back pain.

Helmet usage

For helmet usage, the exposed group provides a statistically lower satisfaction rating for quality of fit (4.5 versus 6.9, p = 0.002), overall comfort (5.6 versus 6.7, p = 0.033), and noise protection (4.5 versus 6.9, p = 0.004). The mean ratings for helmet stability are not statistically different (6.4 versus 7.0, p = 0.168).

Handedness

As measured by absolute and relative scores, handedness for both the exposed and control groups is predominately right (exposed – 85%, control – 91%). Mean relative handedness scores, as measured by the Edinburgh Handedness Inventory (EHI) are as follows: exposed = +55; control = +62. The difference in proportions is not statistically significant (p = 0.509).

Eye examination

The expanded vision examination shows no statistically significant difference between exposed and control groups for high and low contrast visual acuity, small letter contrast, depth perception, colour perception, near and far eye muscle balance, and eye preference. The exposed group shows a statistically significant higher mean refractive error; exposed subjects within the 30 to 39 year old age group have a statistically higher mean accommodative power.

Conclusions

At this early stage of the study, the forced selection process for exposed subjects has resulted in an older and more experienced exposed group. This is a result of the Apache aviator population consisting entirely of experienced aviators. An additional consequence of this selection process is a higher proportion of exposed subjects requiring vision correction. In turn, the higher proportion of exposed subjects requiring vision correction resulted in a higher proportion of contact lens usage, which is also driven by incompatibility issues between the IHADSS and use of spectacles.

The exposed group reported significantly higher incidences of headache, neck pain *during* and *after* flight, and SD. The use of the specialized IHADSS helmet by exposed subjects resulted in a lower acceptance rating for both quality and comfort of helmet fit.

At this stage of the study, there are only minor differences between the two groups in terms of refractive status and visual performance. The exposed group is more myopic than the control group, which is in keeping with the age differences between the two groups, as the exposed group is older. The control group has a lower level of accommodative range by age, which was not an expected finding; however this difference is probably due to the greater accommodative capability of a few exposed subjects within a much smaller sample size than the control subject pool. For all other visual measures, there is not a significant difference.

One of the primary concerns with prolonged use of the IHADSS system is the potential for differential vision changes between eyes. The vision test battery was specifically designed to include monocular measurements, such as refractive error, accommodation and visual acuity, to be able to assess differences between pilots who fly standard aircraft and those who fly with the monocular head-up display used in the Apache. To date, the only evidence of the impact of the IHADSS system on one eye versus the other has come from pilot reports on surveys or anecdotal reports. As the study progresses, we will be looking for any trends in visual performance or refractive error between eyes that may support or refute the presence of these differential changes.

Recommendations

As the study progresses, it is recommended that the following issues be addressed:

- The current small sample size for the exposed group can result in each response having an inflated effect on data means and proportions and statistical tests. Study administrators must take appropriate actions to increase exposed sample size.
- A common problem associated with the initial phase of cohort studies is developing stringent oversight of data collection. A small percentage of study questionnaires were not completed, resulting in missing data values. A tighter oversight of questionnaire completion is recommended.
- There is concern that study subjects having minimal flight experience may adversely affect study results. It is recommended that student pilots not be recruited for this study.
- A high percentage of exposed subjects require vision correction. It is recommended, where appropriate, that vision tests be conducted with and without vision correction.
- The current muscle balance test is complicated and difficult to administer by non-optometric medical personal, which can result in problems with accuracy and repeatability. It is recommended that some form of automated testing for this function be investigated.

<u>Preface</u>

This is the first interim report for the study titled *The Effect of a Monocular Helmet-Mounted Display on Aircrew Health: A Cohort Study of Apache AH Mk 1 Pilots.* The principal aim of this occupational health study is to determine if the use of the monocular helmet-mounted display (HMD) in the British Army's Apache AH Mk 1 attack helicopter has any long-term effect on visual performance. Additional information concerning other unique problems of the Apache AH Mk 1 aircrew is elicited as a secondary objective. This study is a collaborative effort between the British Army and the U.S. Army, and is conducted under the auspices of The Technical Cooperative Program, Subgroup U, Technical Panel 7 (Human Factors in the Aviation Environment). An initial report describing the study's protocol, methodology, development and initial execution phase was published as USAARL Report No. 2002-04. Interim reports, of which this is the first, will be published on a biennial basis and will discuss progress made over the preceding years and provide any identified data trends. Scientific and Human Use protocols were approved by responsible UK and USAARL parties within the period December 1999 – January 2000. This first interim report covers the period of January 2000 – May 2002. It documents the base line data for 117 subject pilots enrolled from the period 17 November 2000 – 23 May 2002. Additional interim reports will be provided in approximate two-year intervals. A final technical report will be published in approximately 10 years time from the start of the study (~2010).

The Apache AH Mk 1 cohort study logo.

Acknowledgments

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The ambitious scope of this study has necessitated a large effort by a great number of individuals over an extended time period. This list of contributors will continue to grow. The role and contributions of the major contributors are as follows (in alphabetical order):

- COL Malcolm G. Braithwaite, OBE, L/RAMC, Consultant Advisor in Aviation Medicine, Headquarters Director Army Aviation, Middle Wallop, UK, co-authored the original study protocol and currently serves as UK study leader.

- COL John S. Crowley, MD, MPH, U.S. Army Medical Corps, Director, Aircrew Protection Division, U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama, U.S., co-authored the original study protocol while former Aeromedical Exchange Officer to UK and currently serves as U.S. medical consultant to study.

- LTC (Retired) Allison J. Eke, RAMC, Consultant in Aviation Medicine, formerly at Defence Evaluation and Research Agency, Centre for Human Sciences, Farnborough, UK, participated in development of study protocol.

- LTC Keith L. Hiatt, MD, MPH, U.S. Army Medical Corps, Aerospace Medicine Consultant - Apache Systems, Headquarters Director Army Aviation, Middle Wallop, UK, was the Aeromedical Exchange Officer to UK and the study's principal investigator for period of FY00-02.

- Melissa L. Isaak, BS, MS, Student Researcher, Aircrew Health and Performance Division, U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama, U.S., performed data entry and extensive analysis.

- LTC Ron King, MD, MPH, U.S. Army Medical Corps, Aerospace Medicine Consultant - Apache Systems, Headquarters Director Army Aviation, Middle Wallop, UK, is the Aeromedical Exchange Officer to UK and is the study's current principal investigator (FY02-Present).

- SPC Lisa J. Lewis, BS, Research Technician, Aircrew Health and Performance Division, U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama, U.S., has performed database entry and analysis.

- LTC Corina van de Pol., OD PhD, Director, Aircrew Health and Performance Division, U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama, U.S., serves as US vision consultant to study.

- Daniel J. Ranchino, BS, Computer Specialist, Research Support Division, U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama, U.S., developed architecture for and maintains study database.

- Clarence E. Rash, BS, MS, Research Physicist, Aircrew Health and Performance Division, U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama, U.S., developed visual test battery and serves as U.S. technical coordinator.

- LTC William K. Statz, DO, MPH, U.S. Army Medical Corps, formerly at DERA Centre for Human Sciences, Farnborough, UK, participated in development of study protocol as former Aeromedical Exchange Officer to UK.

Table of contents

Table of contents (continued)
List of figures

Page

Table of contents (continued)
List of figures (continued)

Page

Table of contents (continued)

List of tables

Page

Introduction

As of mid-2002, the British government has purchased 67 Apache AH Mk 1 attack helicopters (formerly identified as the WAH-64). The Apache AH Mk 1 is the latest version of the highly successful AH-64A "Apache" helicopter flown extensively by the U.S. Army, and it incorporates many significant improvements (Figure 1). Among these are fire-control radar, improved weapons processors, a glass cockpit, improved data modem, and a multitude of engineering enhancements to overall system architecture and components (Sale and Lund, 1993). This acquisition program is considered an "off-the-shelf" buy, and in many respects, the Apache AH Mk 1 is similar to the Apache Longbow AH-64D helicopter being acquired by the U.S. Army.

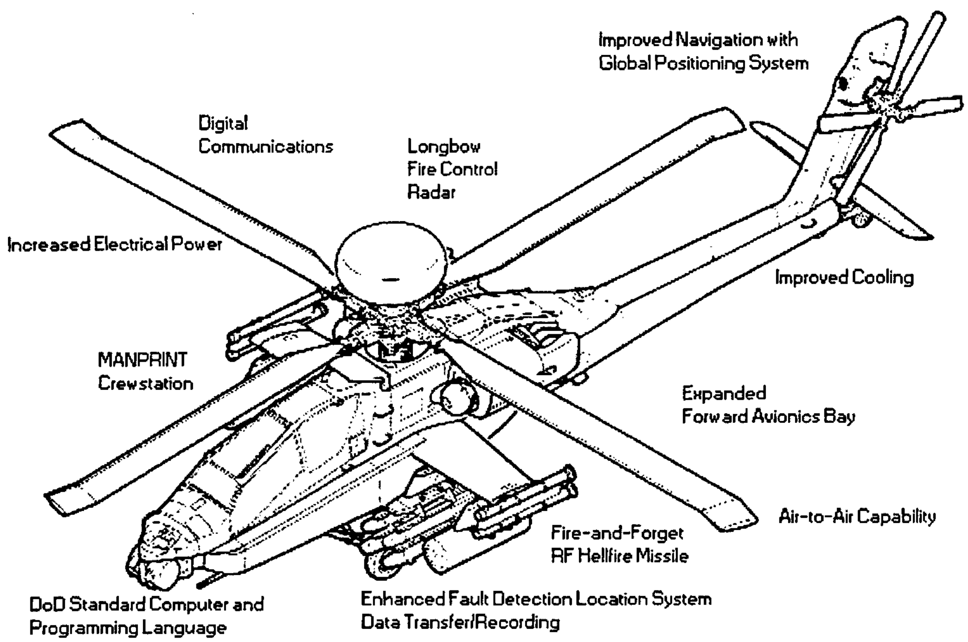

Figure 1. Features of the Westland Apache AH Mk 1, similar to the Boeing Longbow AH-64D (Sale and Lund, 1993).

The protective flight helmet used to date by AH-64A pilots is the Integrated Helmet and Display Sighting System (IHADSS) (Figure 2) (Rash and Martin, 1988). The IHADSS provides sensor video and/or symbology to each crewmember via a helmet display unit (HDU). The HDU contains a 1-inch diameter cathode ray tube (CRT) attached to the right side of the helmet, positioning a combiner lens directly in front of the pilot's right eye. When in use, the HDU usually rests on the pilot's right maxilla/zygomatic arch (right cheekbone); when not needed, it can be rotated away from the face.

The sensor video imagery presented by the IHADSS can originate from either of two thermal sensors mounted on the nose of the aircraft. Pilotage imagery is provided by the Pilot's Night Vision System (PNVS); targeting imagery is provided by the Target Acquisition and Designation System (TADS).

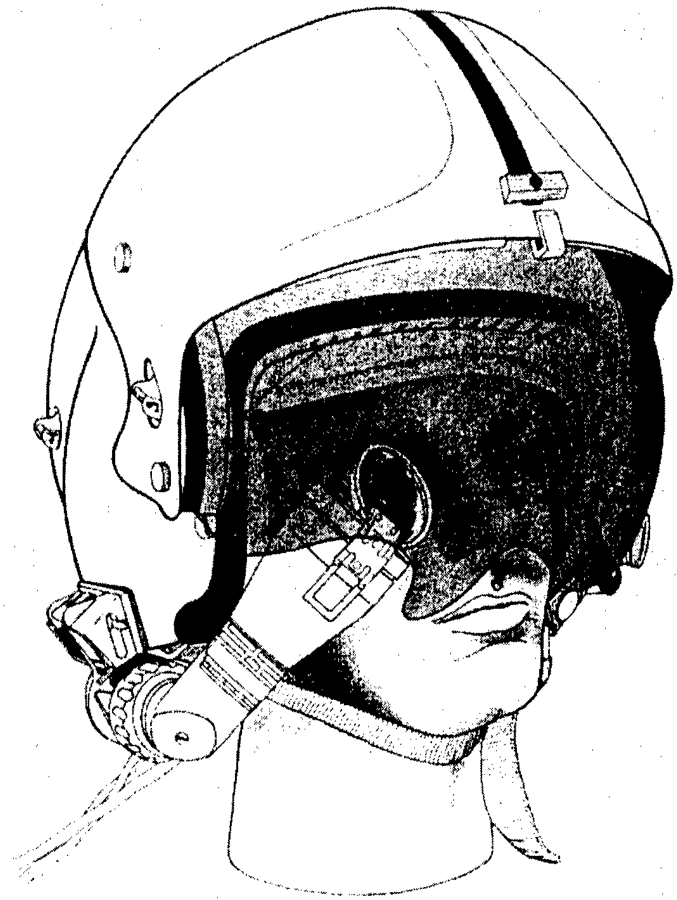

Figure 2. The AH-64 Integrated Helmet and Display Sighting System (IHADSS) (Rash and Martin, 1988).

The Apache pilot's primary source of visual information about the aircraft's state and the outside environment is the HDU. Compelling the aviator to rely on a degraded unnatural view of the world, which is provided only to the right eye, has been noted to cause psychological and physiological problems for many Apache pilots (Behar et al., 1990; Rash and Martin, 1988). Experience has shown that these problems can be generally overcome with training. However, there are residual long-term concerns that have not been completely investigated.

The principal aim of this occupational health study is to determine if the use of the monocular helmet-mounted display (HMD) in the British Army's Apache AH Mk 1 attack helicopter has any long-term effect on visual performance. An initial report described the study's protocol, methodology, development and initial execution phase in detail (Hiatt et al., 2002). The report herein documents progress during the period January 2000 – May 2002. It presents the baseline data for 117 subject pilots (14 exposed and 103 controls) enrolled in the study from the period 17 November 2000 - 23 May 2002.

Study design

General

A cohort of British Apache AH Mk 1 pilots (exposed group) and a control group of British Army helicopter pilots who do not fly the Apache AH Mk 1 are being followed over a 10-year period. At yearly intervals, the subjects complete questionnaires and undergo expanded flight physical examinations. The questionnaires address flight experience, vision history, disorientation, neck and back pain, helmet usage, contact lens use, and handedness. The expanded physical examination consists of a battery of vision tests designed to assess both monocular and binocular visual performance. The rate of change in physiological state and symptomatology will then be compared between the control and exposed groups.

Exposed group

All British Army pilots scheduled for conversion to the Apache AH Mk 1 were recruited as subjects. Fourteen exposed subjects were enrolled during the first two years of the study, and 40-50 more are expected to be enrolled every subsequent year. Although plans for manning the Apache AH Mk 1 fleet are incomplete at this time, it is reasonably certain that for the first 4-5 years of the program only experienced pilots will be selected for Apache AH Mk 1 training. Assuming an approximate 10 percent annual dropout rate plus a 5-year average Apache AH Mk 1 flying career (a conservative estimate), the Apache exposed subject group is expected to reach a steady state of approximately 190 pilots by the seventh year of the study.

Control group

All British Army pilots actively flying helicopters other than the Apache were recruited as control subjects. A total of 103 control subjects have been enrolled during the first two years, and 40-50 more are expected to be enrolled each subsequent year.

The initial control subjects have been identified during the last phase of their rotary-wing training program. This choice was due to ease of access to the individuals as well as to the higher probability that most of these pilots will remain in the British Army Air Corps (AAC) for the majority of the study. Additionally, over the next 4-5 years, it is expected that some of the control group subjects, having become the more experienced aviators, will transition into the Apache and cross over to the exposed group. Control subjects will continue to come from this pool over the next 6 years (based on the statistical presumption that at least 5 years of data are required for each individual). Additional control subjects will be entered from the AAC regiments during the initial 6 years as well – primarily targeting younger ranks, again due to prospective retention. Baseline data have and will be collected in a similar fashion for the exposed population.

Since all initial examinations are off-cycle with most individual's annual aircrew medical examination, it has been determined that the initial exam will be adequate for up to 18 months in order to synchronize the study with the annual aircrew medical exam. Thereafter, data will be collected annually at the time of either group's aircrew medical examination. Those participants who are not located near a Specialist in Aviation Medicine (SAM) may only be able to contribute data at 2-year intervals. Some measures (e.g., autorefraction) may be collected off-cycle (but annually) when the necessary equipment is brought to aircrew locations on a recurring basis. Subjects will be examined at a minimum of 12 hours postexposure flight to allow for resolution of short-term effects.

It should be noted that the study is designed for cross-over (control group individuals receiving Apache transition and Apache aviators transitioning into non-Apache airframes). For example, control group members who are selected for training as Apache AH Mk 1 pilots will be recruited for the Apache exposed group, and "disenrolled" from the control group. If they consent, their most recent data as a control will be considered their baseline data as an Apache subject.

Subject data collection

Figure 3 is a detailed flowchart for the path of a subject through the data collection process during the subject's participation in the study. All new subjects (control and exposed) are enrolled by the United States Army Exchange Officer (USXO). The USXO will administer the questionnaire and eye exam and enter the individuals into a local database. All data then will be forwarded to the USAARL master database at Fort Rucker, Alabama. Annually thereafter, the enrolled subjects will fall into one of two groups: 1) they will remain in the local catchment area of the USXO or 2) they will be posted at another unit. In the case of the former, the USXO will administer the annual exams and forward the data to USAARL. In the later case, if the subject is posted at a unit with a Regimental Specialist in Aviation Medicine, the SAM will administer the questionnaire and all portions of the eye exam with the exception of the autorefraction and phoria tests. If a subject is posted in an area without a regimental SAM (e.g., deployed to Northern Ireland, Germany, etc.), the USXO will obtain the questionnaire via mail. The USXO will attempt to obtain all missing eye exam data on all non-local subjects. In all cases, the USXO will forward all available data to the USAARL database.

Timeline

The study has been delayed in its execution due to a number of factors. The primary factors have been delays in both the initial military airworthiness release of the airframe and of the Apache simulator, which directly affected the training program. The timeline and current status of the study is provided in Table 1.

Ethical considerations and safety

Medical screening

Army pilots awarded an unrestricted flying medical category (A1 or A2) at their annual aircrew medical examination have been deemed medically qualified to participate in this study. No further medical screening is required. All subjects have the objectives and procedures of the study explained to them, and are encouraged to ask questions. If willing to participate, they are asked to sign a consent form, which is kept on file. They are completely free to withdraw from the study at any time.

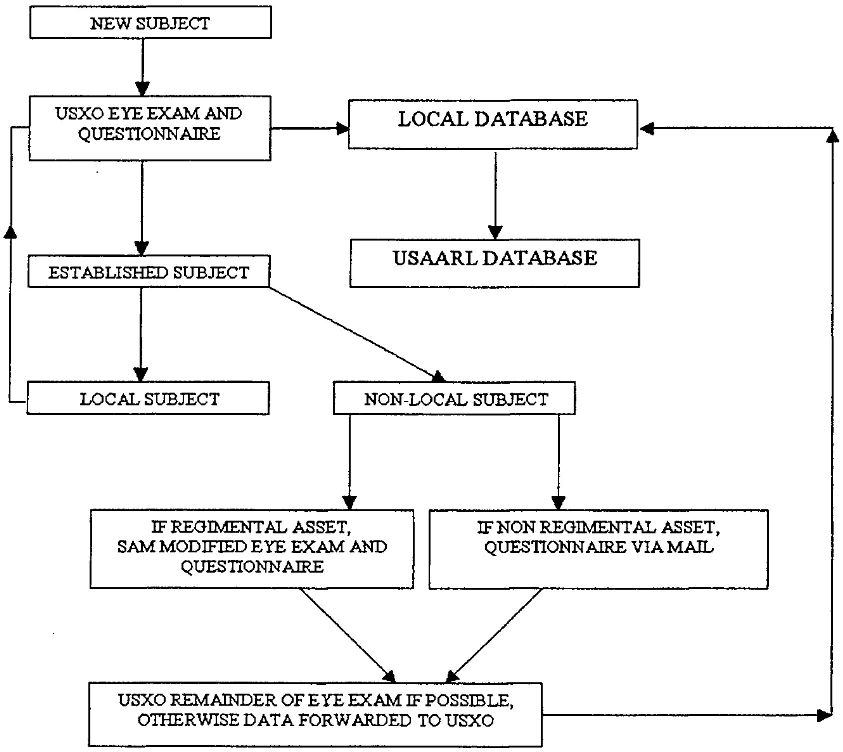

Figure 3. Subject study participation flowchart.

Table 1.
Study timeline.

PHASE	DATES	OBJECTIVE	EXECUTION
ONE	1998-00	Protocol development Ethical approval	Complete
TWO	2000-01	Initial report submission Database development	Complete
THREE	2001-10	Enrollment of exposed /unexposed subjects	Ongoing
FOUR	2002-10	Biennial interim reports • 2000-2002 • 2002-2004 • 2004-2006 • 2006-2008 • 2008-2010	 This report Pending Pending Pending Pending
FIVE	2010	Final report	Pending

Confidentiality

All subjects have been assigned a number that is used to identify their data. No individual will be identified by name in any ensuing publication or presentation.

Hazards and precautions

All tests performed on subjects in this study are free from discomfort or risk of injury. Similar or identical tests are part of the existing annual aircrew medical examination. No specific precautions are necessary as there are no significant hazards or risks to the subjects. Trained medical professionals who have been specifically briefed as to the study methods and objectives do all testing.

Limits

If the subject requests, or if the medical or scientific supervisors determine it necessary, the subject's participation in the study will be terminated. All data obtained prior to "disenrollment" will be eligible for inclusion in the analysis. Other reasons for termination are: 1) subject ceases to fly helicopters for a period longer than 2 years, or 2) subject leaves military service.

Medical responsibility

A supervising medical officer will provide medical oversight during the study. As there are no safety or medical risks to the subjects, no formal medical monitor is necessary. The supervising medical officer will be one of the following: CA Avn Med, HQ DAAvn or U.S. Army Consultant Aerospace Medicine, HQ DAAvn.

Materials and methods

The study consists of a number of annual optometric and anthropometric measurements (objective measures) as well as a series of questionnaires (subjective and self-reported measures) that are administered to both groups.

Visual measures

All tests of visual performance are conducted monocularly and binocularly in all cases except where impractical (e.g., in eye dominance testing). Visual acuity and contrast sensitivity are measured with and without correction (spectacles or contact lenses), if used. A summary of all visual test measures is provided in Table 2. A full description of tests has been presented in Hiatt et al. (2002).

Table 2.
Summary of measures taken.

Test	Dependent measure	Units
Visual acuity (High-Low contrast)	Log of minimal angle resolved (logMAR); smallest readable letter	Arc seconds
Refractive error (Autorefractor)	Spherical and cylindrical power	Dioptres
Contrast sensitivity	Lowest contrast letters readable	LogCS
Colour vision	Selected sequence of colour tabs	Colour error score
Eye dominance	Eye determined to be 'sighting'	None
Eye muscle balance (Maddox rod)	Horizontal and vertical phorias	Prism dioptres
Depth perception (Stereo circles)	Smallest detectable disparity	Arc seconds
Nearpoint of accommodation	Shortest distance to read fine print	Centimeters (converted to Dioptres)
Questionnaire	Various	N/A

Subjective measures

Upon entry to the study, each subject completes a Subject Consent Form, a Demographic Questionnaire (A), and either an annual questionnaire for non-Apache (control) pilots (Appendix B) or for Apache (exposed) pilots (Appendix D). These latter questionnaires address flight experience, vision history, disorientation, neck and back pain, and helmet usage. For those individuals wearing contact lenses, an additional questionnaire (Appendix F) is provided. Finally, all subjects complete the Edinburgh Handedness Inventory (Oldfield, 1971), a 10-item measure of laterality (Appendix G).

Data management

As the data collected for the study are medical in nature and include biographical data, they are being treated as any other medical record with regard to confidentiality. A secure long-term storage system for paper and electronic copies of the data has been identified as being essential. To date, initial data collection has been via paper copy. Data then have been entered into a Microsoft Access® database. A full description of the database management system is available in Hiatt et al. (2002).

Sample demographics

The total number of exposed (Apache) subjects enrolled as of 31 July 2002 was 14; all were enrolled during the period November 2000 - April 2002. Exposed subjects ranged in age from 34-47 years, with a mean and median of 39 and 38 years, respectively. Seventy-nine percent (11) of the exposed subjects were Qualified Helicopter Instructors (QHI). All 14 exposed subjects were male.

The total flight hours for the exposed group ranged from 1750-6580, with a mean and median of 3720 and 4115, respectively. Within the year prior to enrollment in the study, total flight hours ranged from 0-430, with a mean and median of 137 and 80, respectively. Total flight hours in the Apache ranged from 1.5-4430, with a mean and median of 373 and 43, respectively. Flight time using the IHADSS had a mean and median of 28 and 27 hours, respectively. For reported night vision goggle flight hours, the mean and median were 229 and 183, respectively; only 1 subject reported being night vision goggle (NVG) current.

The total number of control (non-Apache) subjects enrolled as of 31 July 2002 was 103; all were enrolled during the period February 2001- July 2002. Control subjects ranged in age from 23-49 years, with a mean and median of 31 and 30 years, respectively. Sixty-three percent (65) of the control subjects were student pilots. The gender breakdown for control subjects was 98 males and 5 females.

The total flight hours for the control group ranged from 13-7000, with a mean and median of 805 and 180, respectively. Within the year prior to enrollment in the study, total flight hours ranged from 0-1880, with a mean and median of 131 and 100, respectively. For the 45 subjects who reported NVG flight hours, the mean and median were 102 and 84 respectively; only 24 subjects reported being NVG current at the time of entry into the study.

See Appendix A for complete demographics data.

When the two subject groups were compared, the similarities were that both groups are predominately male and were enrolled in the study in the same general timeframe. The differences between the two groups were: a) The exposed group was older (mean age of 39 years vs. 31 for control group) ($p = 0.000$), b) the exposed group had considerably more overall flight experience (mean 3720 hours vs. 805 for control group; median 4115 vs. 180 for control group [mean, $p = 0.001$; median, $p = 0.000$]), c) the exposed group had a lower proportion of NVG current pilots, but with a higher mean flight time (229 hours vs. 102 hours for control group), and d) the control group had a slightly lower mean NVG flight time during the preceding year (19 hours vs. 23 for exposed).

The gender distribution for exposed and control subjects is presented in Figure 4.

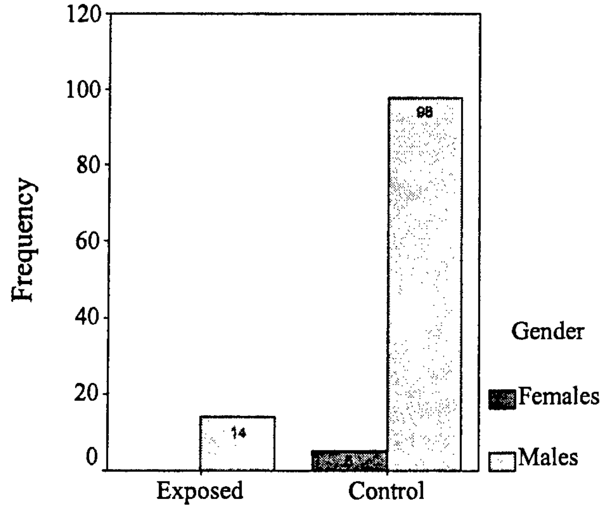

Figure 4. Frequency distribution of gender for exposed and control subjects.

Baseline data for non-Apache (control) pilots

The following sections present those issues considered most pertinent to this study. A full presentation of all data is provided in the various appendices (A-C, F-G). Percentages reported in the appendices are based on the total number of subjects, including null responses. Except where noted, percentages in the sections below are based on the proportion of subjects who provided responses to the individual questions or for whom visual test measurements were obtained.

Annual questionnaire (control)

Vision history

Of the 103 control subjects, 26% indicated having been prescribed vision correction (Question 10), with flying and reading correction being the most reported reasons. Ages for first prescription were extremely variable, ranging from age 7 to 48 years, with a median value of 27 years. Period of time since most recent prescription varied greatly, from the current year to 14 years, with a mode of 7 months (n = 3). Six percent of all respondents indicated they wore contact lenses at the time of the study (Question 11); 20% wore spectacles. The ratio of contact lens to spectacle wearers for respondents requiring vision correction was 6:21. (Note: Additional contact lens data for subjects who currently or recently [within past year] wore contact lenses were collected in a separate questionnaire [Appendix F].)

Night flight by control subjects is usually accomplished using NVGs. Some aviators require corrective flying spectacles (CFS) to achieve vision correction during NVG flight. Only eight control subjects reported using the CFS (Question 12). Three of these subjects reported experiencing interference by the CFS in viewing NVG imagery. One additional subject, who requires spectacles for flying but uses neither CFS nor contact lenses, did report experiencing difficulty viewing cockpit instruments during NVG flight (Question 13).

Six subjects (6%) reported having been treated for an eye disease or injury (Question 14). Five subjects (5%) reported experiencing headaches on a frequent basis from close work for extended periods (Question 15); 20% reported routinely experiencing eyestrain (Question 16).

Sixty-four percent (66 subjects) reported their right eye as their preferred sighting eye; 12% (12 subjects) reported left (Question 17). Eight percent (8) of subjects reported equal preference, and 15% (15 subjects) reported they did not know. For the specific viewing tasks of sighting with a telescope and viewing through a keyhole (Questions 18-19), 84% indicated right eye preference for telescope viewing, and 80% indicated right eye preference for viewing through a keyhole.

When control subjects were asked to report on the presence ("Sometimes" or "Always") of visual/physiological problems *during* flight (Question 21), disorientation (36%) and headache (29%) were the most frequently cited symptoms; *after* flight (Question 22), headache was the most frequently reported symptom (17%). Tables 3 and 4 summarize the reported symptoms for both *during* and *after* flight, respectively.

Of the 49 subjects responding, 36 (73%) reported eye fatigue, to some extent, during night flight as a result of using NVGs (Question 25).

Use of the visor (in the "down" position) was reported as 90% during day flights and 56% during night flights (Question 26). In general, visors cannot be deployed when wearing NVGs.

Of the 48 responding control subjects, 28 (58%) reported experiencing colour perception problems after flying with NVGs. Most subjects reported a persistent "browned vision" for up to 15 minutes postflight (Question 29). This colour anomaly has been well documented and has been called "brown eye syndrome" (Glick and Moser, 1974).

Table 3.
Reported visual/physiological symptoms *during* flight for control subjects. (n=103)

	Never	Sometimes	Always	No response
Visual discomfort	92%	8%	0%	0%
Headache	71%	29%	0%	0%
Double vision	99%	1%	0%	0%
Blurred vision	97%	3%	0%	0%
After images	92%	8%	0%	0%
Disorientation	63%	36%	1%	1%
Dizziness	98%	2%	0%	0%
Nausea	74%	25%	1%	0%

Table 4.
Reported visual/physiological symptoms *after* flight for control subjects. (n=103)

	Never	Sometimes	Always	No response
Visual discomfort	94%	5%	0%	0%
Headache	83%	17%	0%	0%
Double vision	100%	0%	0%	0%
Blurred vision	97%	3%	0%	0%
After images	94%	6%	0%	0%
Disorientation	100%	0%	0%	0%
Dizziness	100%	0%	0%	0%
Nausea	96%	4%	0%	0%
Unsteadiness or balance problem	99%	1%	0%	0%

Ten percent (8) of responding control subjects reported experiencing symptoms of faintness, graying or loss of vision during periods of "aggressive" flying (Question 30). Only one subject reported actually being at the controls during this type of incident.

Disorientation

Spatial disorientation (SD) is defined in the U.K. as "a failure to perceive correctly one's position, motion or attitude with respect to the earth's surface (horizontal reference) or the acceleration due to gravity (vertical reference)." (Durnford et al., 1995)

Of the sixty-three responding control subjects, 18 (29%) reported having experienced SD during flight with NVGs (Question 32). Most of these occurrences were associated with episodes of "white out" or degraded NVG imagery.

Neck pain

Neck pain as used in this questionnaire was defined as pain above (but not including) the level of the shoulder blades. There were separate questions on neck pain for *during* and *after* flight. These questions were included because head-supported mass is an important factor with HMD systems, including NVGs. The NVG head-supported mass is typically reported at 2.6 kilograms (5.73 pounds) (Rash, 2000).

Twenty-six percent of control subjects reported having experienced neck pain *during* flight (Question 40), with an onset of 0 (immediately) to 110 minutes into flight and an average onset time of 45 minutes. Of the 27 subjects who reported neck pain episodes, 30% reported experiencing more than 10 episodes during their flight history; another 37% reported a frequency of 4-10 episodes. Of subjects reporting neck pain during flight, the most frequently cited aircraft was the Lynx or the Squirrel.

The main site of neck pain reported by responding subjects was the centre of the neck (68%); the next most frequently cited locations were the left side (20%) and right side (12%) of the neck. The factor most frequently cited as the cause of neck pain episodes was the wearing of NVGs (81%).

A similar set of questions was asked regarding neck pain *after* flight. Only 19% (18) of subjects reported *after*-flight episodes (Question 41). Such episodes were reported having onsets of 0 (immediately) to 65 minutes into flight. Thirty-two percent of these 18 subjects reported a total number of neck pain episodes of more than 10 during their flight history. An additional 26% reported a total of neck pain episodes of "4-10." Based on just the previous flight year, frequencies of 3, 4 and 5 episodes were each reported by approximately 11% of these subjects. The predominant cause for neck pain *after* flight was cited as NVG use (11, 58%).

Subjects who reported neck pain were asked to grade the severity of their worst episode of neck pain (Question 42), both *during* and *after* flight, on a scale of 1 to 9, with 9 being defined as "incapacitating." For *during* flight, the most frequent value was 3 (33%), and the mean and median severity ratings were 3.7 and 4, respectively. For *after* flight, the most frequent value was also 3 (42%), and the mean and median severity ratings were 4.2 and 3, respectively.

Subjects who had reported experiencing neck pain were asked to indicate an "average" severity of each pain episode. Using the same scale of 1 to 9, for the 27 subjects who reported experiencing pain *during* flight, the most frequent value was 4 (15%), with the mean and median ratings at 3.3 and 4, respectively. For *after* flight (n = 19), the most frequent value was 1 (21%), with the mean and median ratings at 2.9 and 2.5, respectively (Question 43).

When asked to indicate the persistence of the worst episode of neck pain (either *during* or *after* flight) (Question 44), a third of the responding subjects (35%) reported "during flight only," followed by 26% for "less than 2 hours after flight."

The duration of the "average" episode of neck pain (Question 45) was reported to be "during flight only" (46%), "less than 2 hours after flight" (35%), "2-11 hours after flight" (8%), "12-24 hours after flight" (8%), and "1-4 days after flight (4%)." Of the subjects who reported experiencing neck pain *during* and/or *after* flight, 29% indicated having sought treatment for flight-related neck pain (Question 46). Of these 10 subjects, all reported having actually received treatment for their neck pain. Of the 37 respondents who reported flight-related neck pain, 38% indicated having taken action to minimize or avoid such pain. Such actions included use of a chiropractor, NVG counterweights, prophylactic anti-inflammatories, and physical therapy exercises.

Of the 37 control subjects who reported experiencing flight-related neck pain, only 3 (8%) reported having ever been grounded as a result of this condition (Question 47). These individuals represent only 3% of the control group sample.

Back pain

Back pain, as defined in this questionnaire, is pain at or below the level of the shoulder blades. There were separate questions on back pain for *during* and *after* flight. Poor posture (seat position), repeated landing impacts, and constant aircraft vibration are contributing factors to back pain.

Subjects reported two major reasons for adjusting seat position (Question 48): To obtain optimum control position (76%) and to obtain a compromise between optimum control position and optimum vision (17%).

Based on their normal seat position and flying posture (Question 49), 74% of subjects reported having no problem in reaching and operating the critical and emergency controls and switches. However, 23% reported having "slight difficulty;" 2% reported having "moderate difficulty;" and one subject (1%) reported a total inability to perform this task.

Twenty-one percent (22) of responding subjects reported having a previous back injury (Question 50).

Sixty-one percent (60) of responding subjects reported having experienced back pain *during* flight (Question 51). The most commonly reported duration before onset of pain *during* flight was "30 minutes." Sixty-nine percent of subjects reported onset periods of 30 minutes or longer. Fifty percent of subjects reported having experienced more than 10 total episodes of back pain during their flight history. Based on just the preceding year, the median reported frequency of back pain was 3 episodes, ranging from 1 to 100 episodes (See Figure 5). The aircraft types most frequently reported as associated with back pain episodes were the Squirrel (48%) (listed as "Other"), the Gazelle (30%) and the Lynx (22%), an association previously documented by Braithwaite and Vyrnwy-Jones (1986).

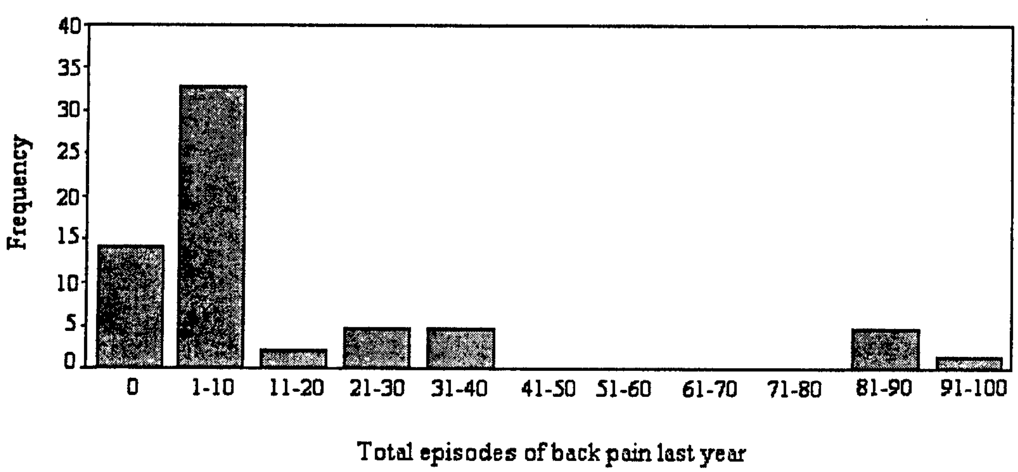

Figure 5. Frequency of control back pain episodes *during* flight for previous year.

The lower back (83%) was the most frequently cited "main site" of back pain; the mid back (13%) was the second most cited. Based on comments, unsatisfactory seat position and length of flight were the most frequently cited factors considered by the subjects to have influenced incidence of back pain *during* flight.

Thirty-nine percent (35) of subjects reported having experienced back pain *after* flight (Question 52). Fifty-one percent (18) of responding subjects reported having experienced more than 10 total episodes of back pain *after* flight over their flight history; 26% indicated "1-3" episodes. Based on just the preceding year, the median frequency of back pain episodes was 3, ranging from 0 to 100 episodes (See Figure 6).

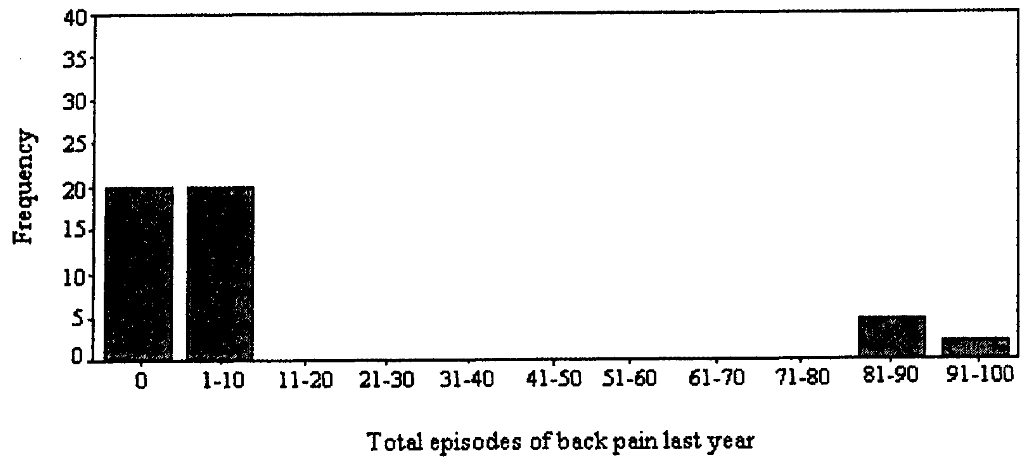

Figure 6. Frequency of control back pain episodes *after* flight for previous year.

Subjects were asked to grade the severity of their worst episode of back pain (Question 53), both *during* and *after* flight, on a scale of 1 to 9, with 9 being defined as "incapacitating." For *during* flight, the most frequent values reported were 3 (40%) and 4 (23%), and the mean and median severity ratings were 4.1 and 4, respectively; two subjects reported an "incapacitating" rating of 9. For *after* flight, the mean and median severity ratings were 4 and 3.5, respectively; one subject reported an "incapacitating" rating of 9.

Of the 60 subjects who reported experiencing back pain *during* flight, 36 indicated this was a "common" condition (Question 54). Again on a scale of 1 to 9, the mean and median ratings were 2.8 and 3, respectively. For the 31 subjects who indicated "commonly" experiencing back pain *after* flight, the mean and median severity ratings were 2.7 and 2, respectively.

When asked about duration of symptoms for their worst episode of back pain (Question 55), 38% reported "during flight only," 28% reported "less than 2 hours after flight," 13% reported "2-11 hours after flight," and 12% reported "1-4 days after flight."

Fifty-three percent of responding subjects reported the average duration of back pain as "during flight only;" 27% of subjects reported "less than 2 hrs after flight;" and 14% of subjects reported "2-11 hours after flight" (Question 56).

Forty-one percent of subjects (27 out of 66) who cited flight-related back pain sought treatment (Question 57), with 78% (21 of 27) of these having sought this treatment from their

Specialist in Aviation Medicine (SAM). Subjects also reported seeking treatment from other sources, e.g., osteopath, chiropractor, acupuncturist etc. Eighty-five percent of these subjects (23 of 27) received medical treatment for their flight-related back pain.

Approximately one-third of all subjects (36%) reported having taken some action to minimize or avoid flight-related back pain. Actions taken included physical therapy treatments, use of anti-inflammatories and cushions, or other forms of back support.

Only 5% of the 66 subjects who reported having back pain have been grounded for this condition (Question 58), with a grounding period of "1 to 2 weeks" being the most frequent (67%).

Eighteen percent of responding control subjects reported that current seat adjustment procedures and mechanisms did not allow them to achieve "a good flying position" (Question 59). When asked to rate the overall comfort of their aircraft seat on a scale of 1 to 9 (1 = extremely uncomfortable, 5 = adequate, and 9 = extremely comfortable), the mean and median comfort ratings were both 5 (Question 60). Sources of discomfort cited included lack of lumbar support and poor seat designs.

Helmet usage

All control subjects wore the Mk-4 aviator's helmet. This helmet serves the protective role of all aviation helmets with the added function of mounting NVGs. The helmet is available in five sizes: small, medium (regular), medium long, medium broad, and large. The majority of subjects (79%) reported wearing a version of the medium sized helmet (regular, long or broad) (Question 61). See Figure 7.

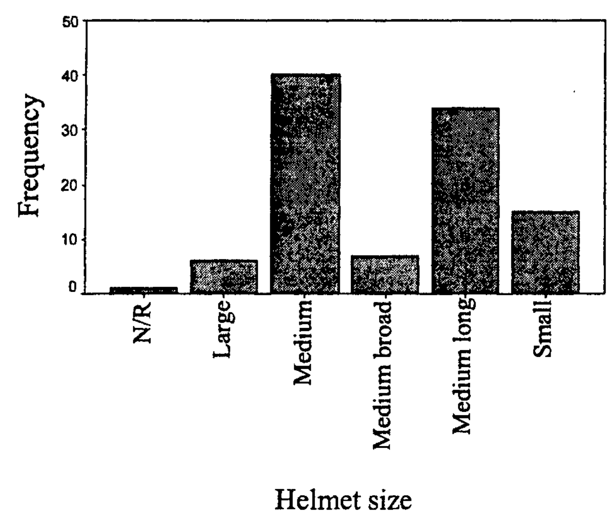

Figure 7. Helmet size distribution for control subjects.

When asked to rate the current quality fit of their Mk-4 helmet on a scale of 1 to 9 (1 = unsatisfactory, 5 = adequate, and 9 = excellent), the mean and median ratings were 6.9 and 7, respectively (Question 62). These statistics were appreciably greater than the "adequate" rating of 5. When a less than adequate rating was reported, reasons cited included hot spots, increased pressure due to wearing NVG, and ear cup pressure.

Only 3% of control subjects reported having fit adjustments made by personnel other than Safety Equipment Section fitters (Question 63).

Table 5 presents the frequency and relative percentage of reported component breakage, binding, slipping, or other malfunction with the Mk-4 helmet (Question 65). The microphone and communication cable had the highest reported malfunction rates, 31% and 27%, respectively.

Table 5.
Reported incidents of component breakage, binding, slipping, or other malfunction with Mk-4 helmet.

	Yes	No	No response
Microphone	32 (31%)	63 (61%)	8 (8%)
Communication cable	28 (27%)	65 (63%)	10 (10%)
Microphone boom	22 (21%)	71 (69%)	10 (10%)
Helmet internal speakers	16 (16%)	78 (76%)	9 (9%)
Visors	16 (16%)	77 (75%)	10 (10%)
Earcups	13 (13%)	79 (77%)	11 (11%)
Suspension assembly	11 (11%)	78 (76%)	14 (14%)
Visor activators	9 (9%)	80 (78%)	14 (14%)
Electronics cable	9 (9%)	75 (73%)	19 (18%)
Chinstrap	8 (8%)	80 (78%)	15 (15%)
HDU mounting bracket	7 (7%)	71 (79%)	25 (24%)

NVGs are attached to the helmet in such a manner as to allow a breakaway capability during crash scenarios. However, it is possible for the NVG to inadvertently release when accidentally bumped or struck. Less than 4% of responding control subjects reported having experienced inadvertent release of the NVG during flight (Question 68).

NVGs provide a 40-degree circular field-of-view (FOV). Twenty-nine percent of responding control subjects reported an inability to achieve the full FOV (Question 69). (Note: A large number of control subjects were pilots in training with no NVG experience. This situation resulted in a number of non-responses to this question.)

Aviator helmets employ visors that provide sun shading and minimal protection against facial injuries. Ninety percent of responding control subjects reported that their visor, when deployed, extended sufficiently (Question 71). However, 15% of responding subjects indicated that the extended visor contacted their nose or face (Question 73). Three-fourths (77%) indicated that their visors were easily scratched (Question 74). (Note: While visor use is strongly encouraged during all flights, visors cannot be deployed during night flights when NVGs are in use.)

When asked to rate the overall comfort of their helmet on a scale of 1 to 9 (1 = extremely uncomfortable, 5 = adequate, and 9 = extremely comfortable), the mean and median comfort ratings were 6.7 and 7, respectively (Question 76). Figure 8 provides a distribution of overall comfort ratings. The mode was a 7 rating (n = 27). When asked specifically to rate thermal comfort, on the same scale, the mean and median comfort ratings were 5.8 and 5, respectively, with a mode of 5 (n=55) (Question 75). When helmet stability was rated on a similar scale (1 = extremely unstable, 5 = adequate, and 9 = extremely stable) (Question 78), the mean and median ratings were 7.0 and 7, respectively. Three subjects (3%) indicated that they felt they needed a smaller sized helmet (Question 77); two subjects (2%) felt a larger sized helmet was needed.

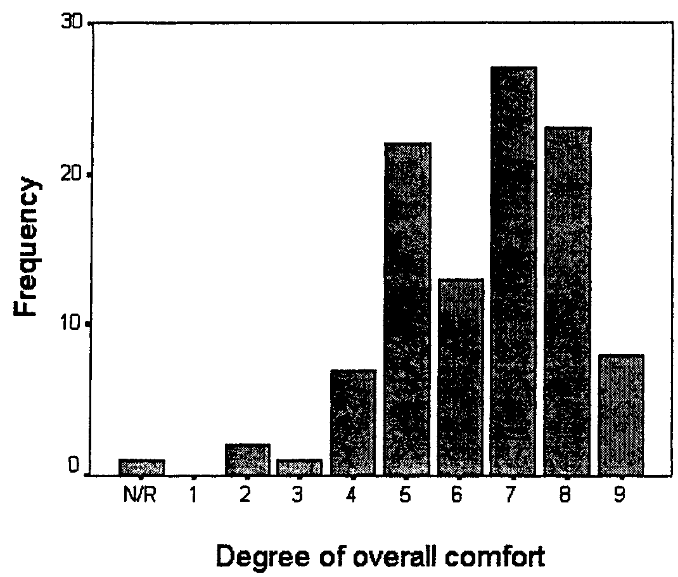

Figure 8. Overall Mk-4 helmet comfort ratings for control subjects.

When asked to rate the overall noise protection of their helmet on a scale of 1 to 9 (1 = extremely noisy, 5 = adequate, and 9 = extremely quiet), the mean and median ratings were 6.9 and 7, respectively (Question 80). Figure 9 provides a distribution of noise protection ratings. Using a similar scale (1 = extremely poor, 5 = adequate, and 9 = extremely good), the mean and median ratings for the quality of the radio and intercom audio were 6.6 and 7, respectively (Question 81).

The final question in the control subject questionnaire asked if the capabilities of the MK-4 helmet were sufficient to allow the aviator to safely meet all mission requirements (Question 82). Ninety-eight percent of responding subjects reported a "Yes" response.

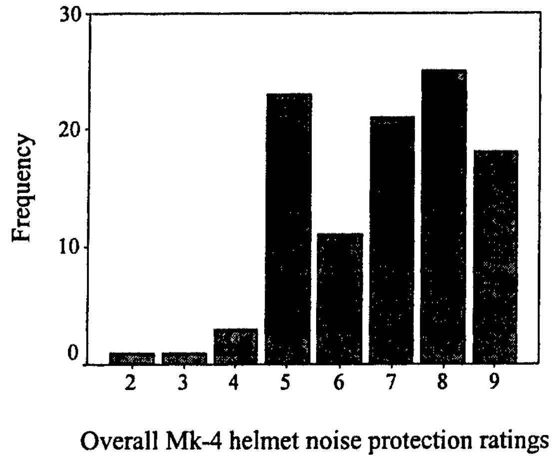

Figure 9. Distribution of noise protection ratings for the Mk-4 helmet.

Contact lens usage

Even with stringent entry-level vision requirements, a significant proportion of Army aviators do, or will, require vision correction as they age. Historically, spectacles have been the primary method employed. However, spectacles are not the ideal solution to providing vision correction in the cockpit. Spectacles are not compatible with numerous aviation systems, and spectacle frames can compromise hearing protection by breaking the ear cup seal. Within the past decade, contact lenses, while not an optimal solution, have helped to overcome some of these problems. However, the cockpit can be a dusty and polluted environment, a hostile environment for contact lenses (Rash, Kalich, and van de Pol, 2002).

The British Army sanctions the use of contact lenses for their aviators. Apache aviators have been officially provided with contact lenses, as contact lenses have been identified as the most cost effective method to solve the physical eye relief incompatibility with vision correction with the IHADSS. Other British Army aviators must provide their own contact lenses. The objective of the contact lens usage questionnaire was to determine if the use of contact lenses has been an advantage. Appendix F contains the contact lens user survey that was provided to both exposed and control subjects.

There were a total of six control subjects (out of 103) who completed the contact lens user survey, indicating they used contact lenses in the cockpit. Subjects were asked to rate the severity of problems they have experienced while inserting contact lenses using a scale of 1 to 9 (1 = no problem and 9 = severe problems) (Question b). Two subjects gave a rating of 1; 2 subjects gave a rating of 5; and one subject each gave ratings of 2 and 3. The mean and median ratings were 2.8 and 2.5, respectively. When asked to apply the same rating scale to the removing of contact lenses (Question c), five (83%) subjects gave a rating of 1 (no problems), while one subject (17%) gave a rating of 2. The mean and median ratings were 1.2 and 1, respectively.

When asked to rate the level of comfort of their contact lenses (1 = very comfortable, 5 = neither comfortable nor uncomfortable, 9 = very uncomfortable) (Question d), four subjects (67%) gave a rating of 1; one subject (17%) each gave a rating of 2 and 7. The mean and median ratings were 2.3 and 1, respectively.

Subjects were asked to compare their vision with contact lenses as opposed to spectacles (Question e). Given a scale of 1 to 9 (1 = vision is better with contact lenses, 5 = no difference in vision between contact lenses and glasses, and 9 = vision is better with glasses), three subjects (50%) gave a rating of 1; two subjects (33%) gave a rating of 5; and one (17%) gave a rating of 6. The mean and median scores were and 3.2 and 3, respectively.

Only one (17%) subject reported having experienced difficulty in caring for his contact lenses in the field environment. None of the subjects reported having experienced difficulty in the home or in the barracks (Question f). When asked to indicate the types of weather conditions that made the wearing of contact lenses difficult (Question g), four subjects cited such conditions as dusty conditions, dry weather, windy weather or other, defined as "extended periods in the field [with] dirty hands."

Table 6 provides a summary of responses given by control subjects when asked to indicate problems experienced with contact lenses *while flying* (Question h). Of the six subjects who reported wearing contact lenses, three subjects (50%) indicated having problems: Two subjects reported "Rarely" for "Eye irritation," and one subject reported "Rarely" for "Dry eye."

Table 6.
Problems indicated with contact lenses while flying.

	Never	Rarely	Occasionally	Often	N/R
Eye irritation	3 (50%)	2 (33%)	0 (0%)	0 (0%)	1 (17%)
Eye pain	4 (67%)	0 (0%)	0 (0%)	0 (0%)	2 (33%)
Blurred vision	4 (67%)	0 (0%)	0 (0%)	0 (0%)	2 (33%)
Dry eye	2 (33%)	1 (17%)	0 (0%)	0 (0%)	3 (50%)
Light sensitivity	3 (50%)	0 (0%)	0 (0%)	0 (0%)	3 (50%)

All three subjects who indicated these symptoms rated the discomfort as "Minor" (Question i).

Table 7 provides a summary of responses given by control subjects when asked to indicate if these same problems were experienced with contact lenses *while on the ground* (Question j). Three subjects reported problems, with one report each for "Eye irritation," "Blurred vision," and "Dry eye." Each of these symptoms was reported as being experienced "Rarely."

The three subjects who reported the problems above all rated the severity as "Minor" (Question k).

Of the six control subjects who reported using contact lenses during flight, the majority (83%) rated overall comfort (on a scale of 1 to 9) as a "7" or higher, with a mean and median of 8.2 and

Table 7.
Problems indicated with contact lenses while on the ground.

	Never	Rarely	Occasionally	Often	N/R
Eye irritation	3 (50%)	1 (17%)	0 (0%)	0 (0%)	2 (33%)
Eye pain	4 (67%)	0 (0%)	0 (0%)	0 (0%)	2 (33%)
Blurred vision	3 (50%)	1 (17%)	0 (0%)	0 (0%)	2 (33%)
Dry eye	3 (50%)	1 (17%)	0 (0%)	0 (0%)	2 (33%)
Light sensitivity	4 (67%)	0 (0%)	0 (0%)	0 (0%)	2 (33%)

8, respectively (Question l). When asked about any difficulties the wearing of contact lenses may have caused with respect to any specific flight, no incidents were reported (Question m).

Two subjects indicated that they had begun wearing contact lenses within the past year. Both evaluated their training in the application and removal of their contacts as "Good" (Question n). Army Aviation Medicine does not provide formal contact lens logistical support for non-Apache aviators. Therefore, the control subjects who wish to wear contact lenses must provide their own lenses and logistical support (e.g., solution, lens cases etc.). Only three of the control subjects who indicated using contact lenses provided a rating of the Army Aviation Medicine's programme for contact lenses. All three of these subjects provided a "5-Fair" rating (Question o). When asked to provide comments on possible improvements to the contact lens programme, only one subject did so, by suggesting that "the Army should pay for them (contact lenses)" (Question p).

Handedness inventory

Subject handedness was assessed using a 10-item self-reporting questionnaire (Appendix G) adapted from the Edinburgh Handedness Inventory (EHI) from Oldfield (1971). Ninety-five of the 103 control subjects completed the EHI questionnaire. Subjects were asked to indicate their preference in use of hands for various activities, e.g., writing, throwing, using a toothbrush, etc. Both absolute and relatives scores were computed for each subject. The absolute score was based on the majority of the 10 responses in deciding between "right-" and "left-" handedness for the various activities. The EHI relative score was a number between –100 and +100, as calculated by the expression [(#R - #L)/(#R + #L)] X 100, where #L and #R were the total number of left and right hand responses, respectively. A negative score indicates a tendency toward left-handedness; a positive score indicates a tendency toward right-handedness. See Appendix G for a full presentation of data responses to this questionnaire.

The absolute handedness scores were predominately "right" with 86 (91%) responding subjects indicating a preference for right-handedness and 9 (9%) indicating left-handedness. The EHI relative scores confirmed this finding with the same distribution: 91% indicating right-handedness and 9% indicating left-handedness (Figure 10). The median EHI relative score was +80, with 32 subjects (37%) indicating an overwhelming preference (+100) for right-handedness and with 3 subjects (3%) indicating an overwhelming preference (-100) for left-handedness.

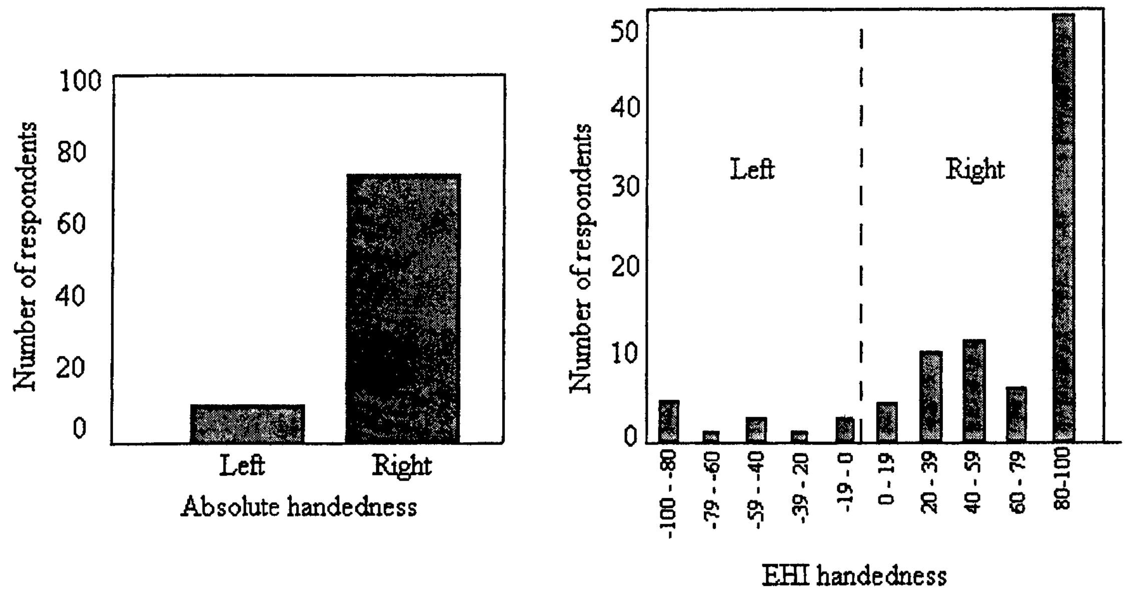

Figure 10. Absolute and relative handedness for control subjects.

Eye examination (control)

A series of nine visual tests were administered as an extended eye examination component of the regular annual flight physical. Tests of visual performance were conducted monocularly and/or binocularly, as required, except where inapplicable (e.g., in eye dominance testing). Visual acuity and contrast sensitivity were measured with the subject's habitual vision correction (spectacles or contact lenses), if the subject presented with correction at the time of the examination. Full eye examination data for control subjects are presented in Appendix C. A total of 103 control subjects underwent eye examinations.

Refractive error

Each subject's refractive error was measured monocularly using an autorefractor (Model AR-600, Nidek Co., LTD., Tokyo, Japan). A single reading was taken for each eye. Each recorded measurement consisted of a sphere, cylinder and axis value.

One hundred and three control subjects were measured. The range for spherical and cylindrical refractive error (across both eyes) was -2.50 to +3.0 dioptres and -2.00 to 0.00, respectively. The mean spherical refractive error was +0.19 (SD=0.61), +0.25 (SD=0.72) and +0.22 (SD=0.67) dioptre for right eye, left eye, and both eyes, respectively. The mean cylindrical refractive error was -0.47 (SD=0.44), -0.46 (SD=0.39) and -0.45 (SD=0.41) dioptre for right eye, left eye and both eyes, respectively. The spherical equivalent power is a convenient way to summarize refractive error into one number and is determined by combining the spherical power with half of the cylinder power. The spherical equivalent (average power) was –0.03 (SD = 0.64), +0.02 (SD = 0.69) and –0.01 (SD=0.66) dioptre for right, left and both eyes, respectively. Box plots of the spherical equivalent refractive error for the right and left eyes for control subjects are presented in Figure 11.

Bailey-Lovie high contrast visual acuity

This test is designed to measure static visual acuity in a high contrast lighting environment. A chart illumination of approximately 100 candelas per square meter (cd/m^2) was used. Unlike most visual acuity charts, the lines are arranged five letters per line, and the spacing is proportional to ensure equal visual demand near threshold. The Bailey-Lovie charts (Figure 12) allow the expression of acuity as the logarithm of the minimum resolvable angle (logMAR) and since each letter is scored, the scoring of acuity as a more continuous variable than the conventional Snellen charts (Bailey and Lovie, 1976). This test was conducted monocularly for both left and right eyes using the habitual correction. The test was scored as the total number of

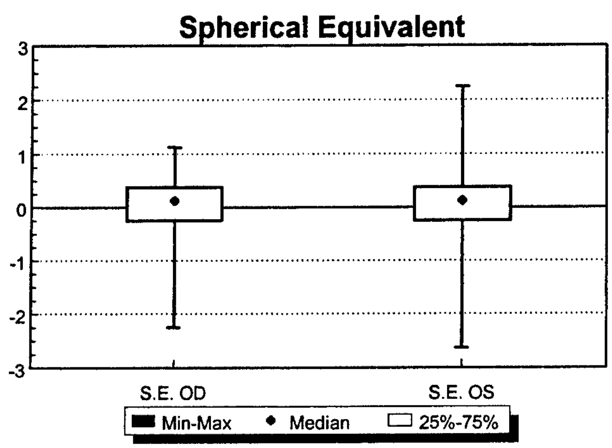

Figure 11. Box plot of spherical equivalent refractive error for the right and left eyes for control subjects.

letters missed (incorrectly or unidentified letters). Values were taken for 93 of the 103 control subjects. Ten subjects performed this test without the use of vision correction, and their data was deemed unacceptable for analysis. The remaining subjects were tested in their habitual condition (either prescribed glasses or no glasses) for all the visual acuity and contrast sensitivity tests. For clinical interpretation, the mean scores have been converted into logMAR using the formula logMAR = -0.3 + N(0.02) where N is the number of letters missed. Conversion from logMAR to Snellen acuity is accomplished using the formula to determine the Snellen denominator: (20/xx) $= 20 \times 10^{logMAR}$.

For the right eye, the mean visual acuity was 0.12 logMAR (Snellen equivalent of 6/8 [20/27]) with a standard deviation of 0.09 logMAR. For the left eye, the mean visual acuity was 0.11 logMAR (Snellen equivalent of 6/8 [20/26]) with a standard deviation of 0.09 logMAR. Included in this sample are six subjects that presented without spectacles and were found to have uncorrected refractive error less than 0.5 dioptres of myopia (spherical equivalent) and no more

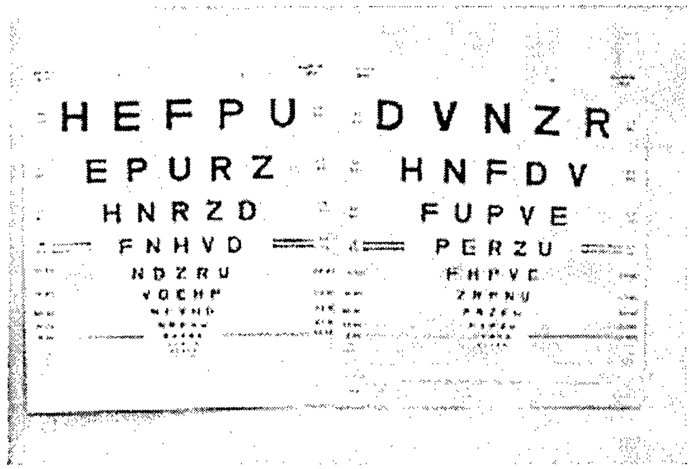

Figure 12. Bailey-Lovie acuity charts.

than 0.75 dioptres of astigmatism on autorefraction. Since this is their natural flying condition, their results are included. The mean visual acuities in logMAR, based on the Bailey-Lovie high contrast chart, for the right and left eyes are presented in Figure 13.

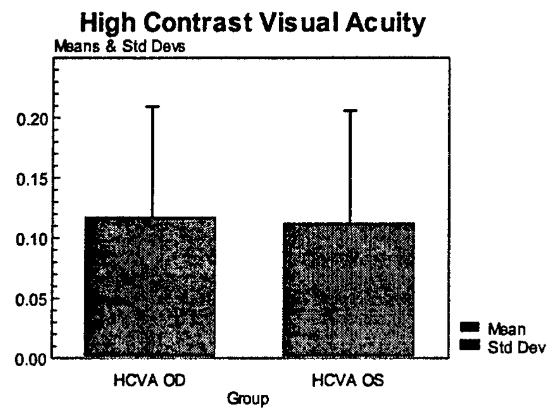

Figure 13. Mean Bailey-Lovie high contrast logMAR acuity for right (OD) and left (OS) eyes.

Bailey-Lovie low contrast visual acuity

This test was designed to measure static visual acuity in a low contrast environment. The letters on the low contrast side of the chart are 10% (Michelson) contrast. All criteria of the high contrast test above were applied to this test. This test was conducted monocularly for both right and left eyes. Data were collected for 93 subjects.

For the right eye, the mean low contrast acuity was 0.36 logMAR (Snellen equivalent of 6/14 [20/48]) with a standard deviation of 0.11 logMAR. For the left eye, the mean low contrast acuity was 0.37 logMAR (Snellen equivalent of 6/14 [20/48]) with a standard deviation of 0.12 logMAR. The mean 10% low contrast visual acuities in terms of logMAR for the right and left eyes are presented in Figure 14.

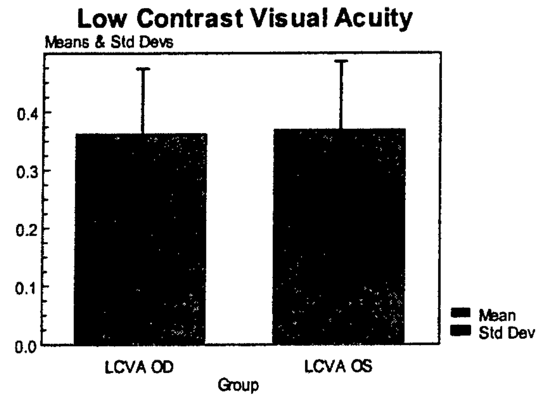

Figure 14. Mean Bailey-Lovie low contrast Snellen acuity for right (OD) and left (OS) eyes.

<u>Small letter contrast sensitivity</u>

This test [small letter contrast test (SLCT)] used a chart developed at the USAARL (Figure 15) that presents rows of letters of one size decreasing in contrast level by 0.1 log for each row on the chart. It is a measure of small letter contrast sensitivity (CS) and has been shown to be sensitive to slight changes in visual performance (Rabin and Wicks, 1996). The subject was asked to read down the chart's left side, giving the first letter of each row. When the subject appeared to hesitate at a specific row, that row was used as the threshold for beginning the test. The subject was asked to begin reading the preceding entire row of letters, continuing as far down the chart as possible. This test was conducted monocularly for both left and right eyes using habitual correction. Ten subjects did not have their spectacles and were not included in

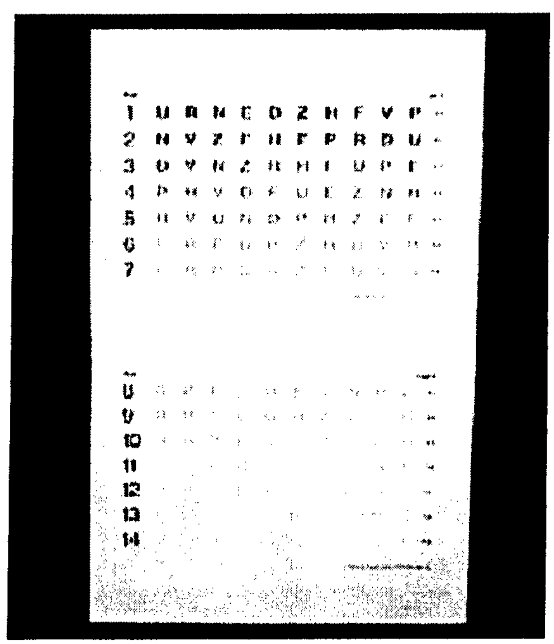

Figure 15. Test chart for small letter contrast sensitivity.

this analysis. The results are presented based on the remaining 93 subjects. The measured data value is the total number of incorrect (unreadable) letters. Each score is converted into a meaningful value of logCS using the formula logCS = 1.3 – N(0.01), where N is the total number of missed letters. The mean expected score on this test is logCS = 1.1. Scores below 0.8 are considered below normal (Rabin, 2003; van de Pol, 2003).

For the right eye, the mean contrast sensitivity was 0.98 logCS (SD=0.2; range = 0.32 to 1.26 logCS). For the left eye, the mean was 0.97 logCS (SD=0.19; range = 0.1 to 1.28 logCS). The mean small letter contrast sensitivity is shown in Figure 16.

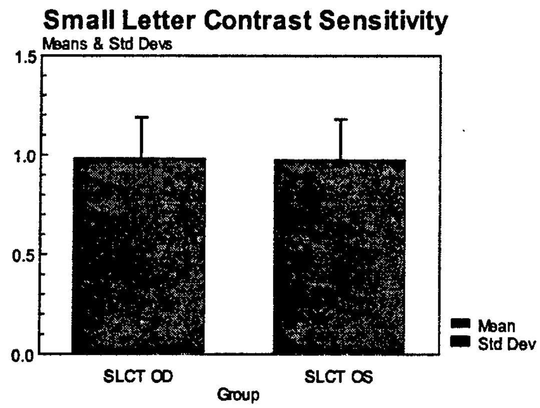

Figure 16. LogCS scores for the right (OD) and left (OS) eyes.

Depth perception

Depth perception (stereopsis) was measured using the Stereotest-Circles test (Stereo Optical Co., Inc., Chicago, Illinois) (Figure 17). Wearing polarized glasses, subjects viewed arrangements of three circles and determined which circle in each group of three appeared closest. The recorded data point was the angular measure of the last correct answer, expressed in seconds of arc. The test was performed binocularly. A total of 103 subjects were measured.

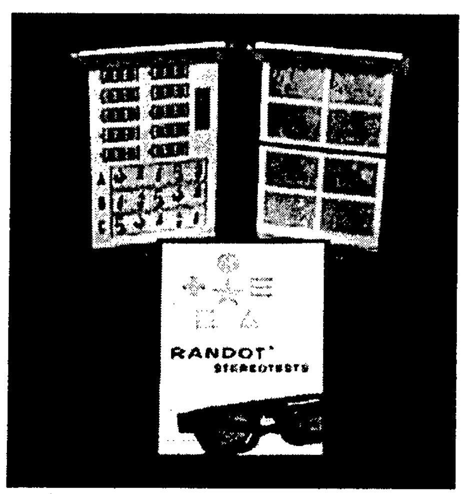

Figure 17. The Stereotest-Circles depth perception test

Depth perception values ranged from 20 to 50 seconds of arc with a mean of 26.1 seconds of arc (SD= 4.2). Figure 18 gives frequency distribution for depth perception values for control subjects.

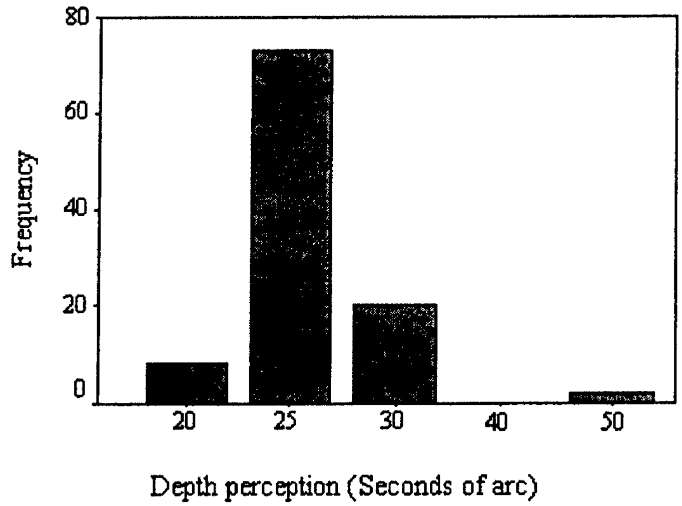

Figure 18. Frequency distribution for depth perception values for control subjects.

Colour perception

The Lanthony desaturated D-15 hue test (Figure 19), adapted from the Farnsworth panel D-15 test was used. This test consisted of 16 colour chips/tabs selected from the Munsell book of colour that are desaturated and appear pale and light. The subject's task was to arrange the colour chips in order according to colour starting with the base/fixed cap. In order to compare small differences in performance, a modified Farnsworth FM-100 test quantitative perception scoring scheme was used. When all caps are correct, the colour perception score is 56.3. Errors in the cap sequencing result in an increase in score. The mean expected score is 64 with a range of normal scores falling between 56.3 (perfect sequence) and 80 (Geller, 2001). This test was conducted monocularly for both left and right eyes. Scoring was performed using VisionScience Software's (Elk City, Oklahoma) Color Vision Analyzer, a software program designed for

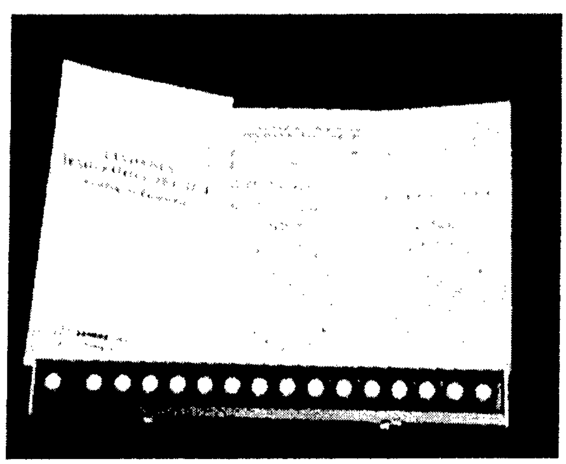

Figure 19. The Lanthony desaturated D-15 hue test.

analyzing the Lanthony desaturated D-15 hue test. One hundred and three control subjects performed this test.

For the right eye, the mean colour score was 64.9 (SD = 12.3; range 56.3 to 144.3); the median score was 62.0. For the left eye, the mean colour score was 64.3 (SD = 12.9; range 56.3 to 144.3); the median score was 60.6. Twelve subjects scored outside the normal range (56.3 – 80). Colour perception scores are presented in Figure 20.

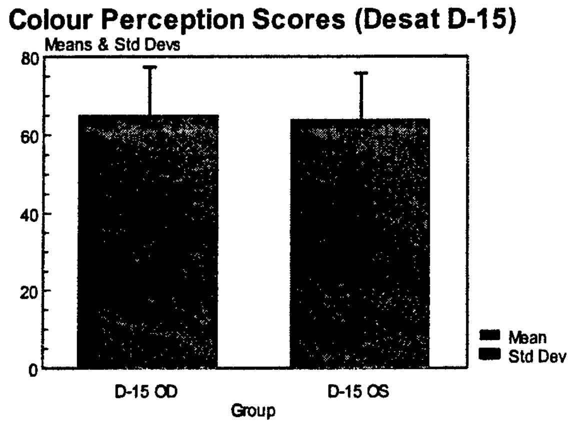

Figure 20. Mean colour perception scores for right (OD) and left (OS) eyes of control subjects.

Accommodation

In the normal aircrew medical examination, accommodation is measured in a binocular fashion, stimulating convergence and accommodation together by maintaining focus and fusion on a target. In this study, accommodation without spectacle correction was tested binocularly and monocularly by moving a small-print target on a Prince Rule (Figure 21) slowly away from each eye in turn, noting when the subject can read the letters on the target. The values recorded were the measured distances, expressed in centimeters (cm). These values were converted into dioptre values (the inverse of the focusing distance in meters). In order to determine true accommodative capability, the uncorrected results were adjusted by the spherical equivalent refractive error.

Figure 21. Accommodation rule test.

One hundred three subjects performed this test. The results are presented based on age (in decade increments); 50 subjects were 20 to 29 years of age (mean 26, range 23 to 29); 45 subjects were 30 to 39 years of age (mean 34; range 30 to 39); and 8 subjects were 40 years of age or older (mean 44, range 40 to 49). Mean binocular accommodation was 8.3 dioptres (SD=1.7) for the youngest group, 6.7 dioptres (SD=1.3) for the 30 to 39 year group, and 4.3 dioptres (SD=1.0) for the oldest group. Monocularly, the mean accommodation for the 20 to 29 year group was 8.5 dioptres (SD=2.1) for the right eye and 8.7 dioptres (SD=2.1) for the left eye. Monocularly, the mean accommodation for the 30 to 39 year group was 6.7 dioptres (SD=1.3) for the right eye and 6.7 (SD=1.5) for the left eye. Monocularly, the mean accommodation for the 40 to 49 year group was 4.1 dioptres (SD=1.0) for the right eye and 4.0 dioptres (SD=1.2) for the left eye. Accommodation values (in dioptres) by age group are presented in Figure 22.

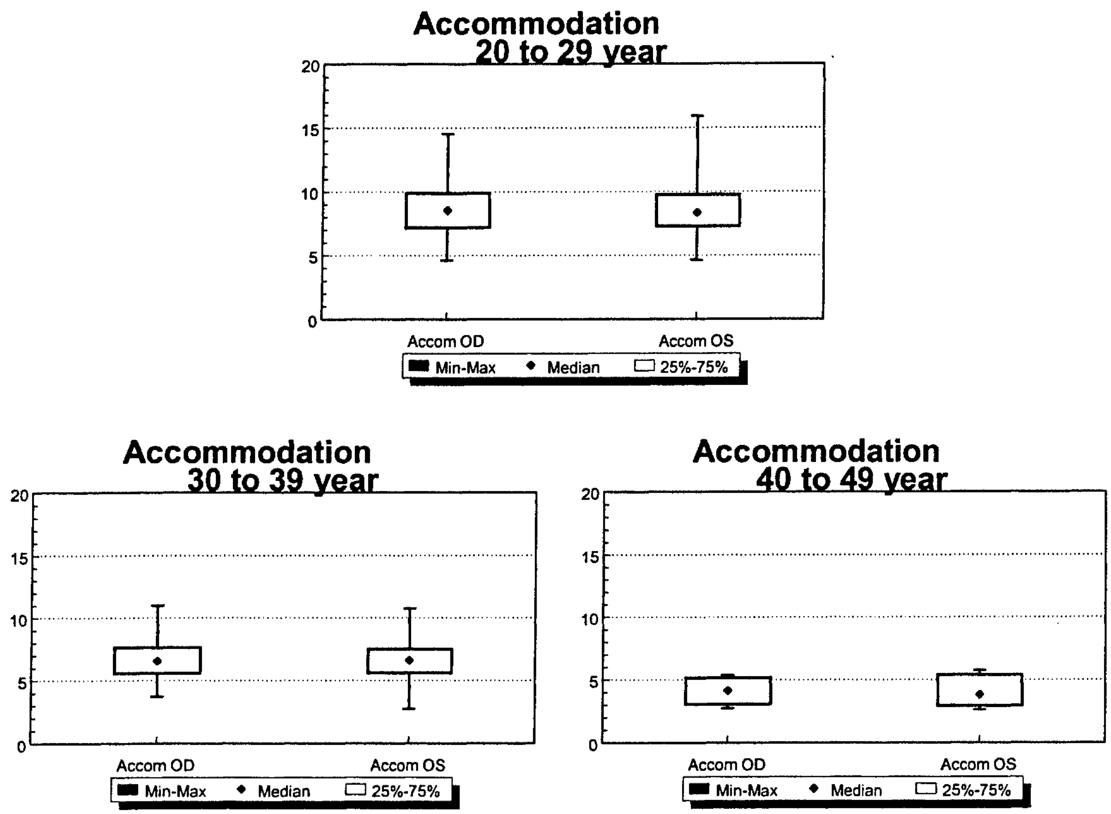

Figure 22. Accommodation by age group (decade) for controls.

Eye muscle balance

The eyes are held in place by three pairs of muscles that constantly balance the pull of the others. These muscles work together to move the eyes in unison, which allow the eyes to track moving objects. Binocular vision is a consequence of the separation of the eyes, which results in two views of the scene. To prevent double vision (diplopia), the eye uses a movement called "vergence." The eyes turn to direct the images directly onto the retina. The brain fuses these two images into one.

Covering one of the eyes and noting the change in the line of sight of the covered eye can test eye muscle balance. If both eyes accurately point toward the target when each eye is covered separately, this normal muscle condition is called orthophoria (Figure 23). If the line of sight departs from the target object, a condition known as heterophoria exists. Such departure can be either lateral or vertical in nature. If the line of sight of the covered eye laterally departs such as to turn outward, a condition called exophoria is present; if the line of sight of the covered eye laterally departs such as to turn inward a condition called esophoria is present (Figure 23). If the line of sight of either covered eye vertically departs from normal vergence, such that one line of sight is directed above the plane of the other, a condition called hyperphoria is present (Figure 24) (Borish, 1949).

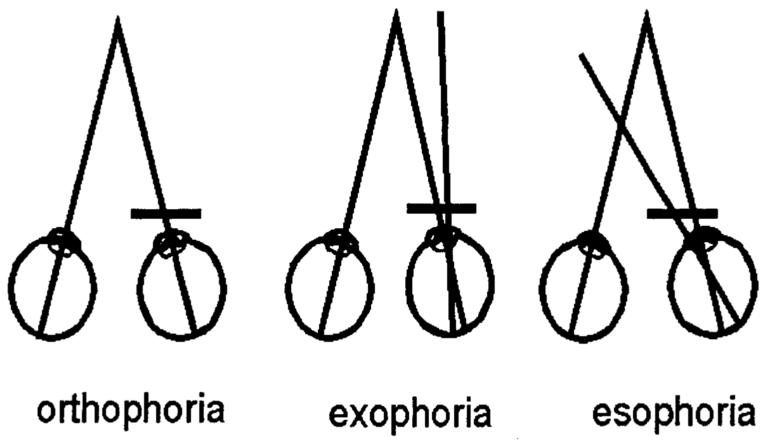

Figure 23. Diagram of orthophoria and lateral heterophorias (adapted from http://spectacle.berkeley.edu/cleere/glossaryNZ.html).

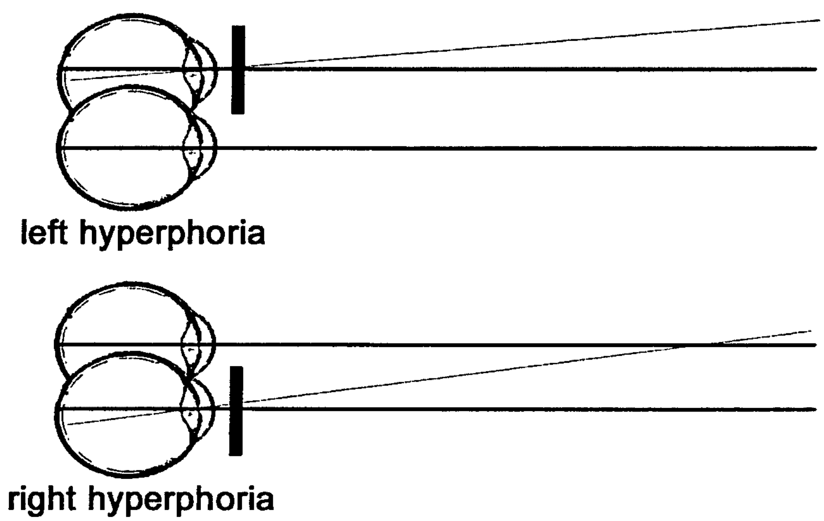

Figure 24. Diagram of hyperphoria.

The Maddox rod test (Figure 25) was used to quantify the presence of any heterophoria. A Maddox rod consists of a series of thin red cylinders placed side by side, usually mounted in a circular holder that can be held before the eye. When a target light is seen through the Maddox rod, its image is a red focal line perpendicular to the axes of the cylinders. Thus, one eye sees the light source directly, while the other eye views its image through the Maddox rod. In orthophoria, the red line appears to run through the light. When the Maddox rod is held so that the cylinders are horizontal, a vertical red line is seen, which, in cases of horizontal deviation, is displaced laterally. A built-in adjustable prism can be rotated until the red line appears to run through the light. The instrument is marked to indicate the angle of deviation. By rotating the Maddox rod 90 degrees, a horizontal line is produced (cylinders of the rod are vertical). The vertical displacement also can be measured by prisms as described above for horizontal deviations.

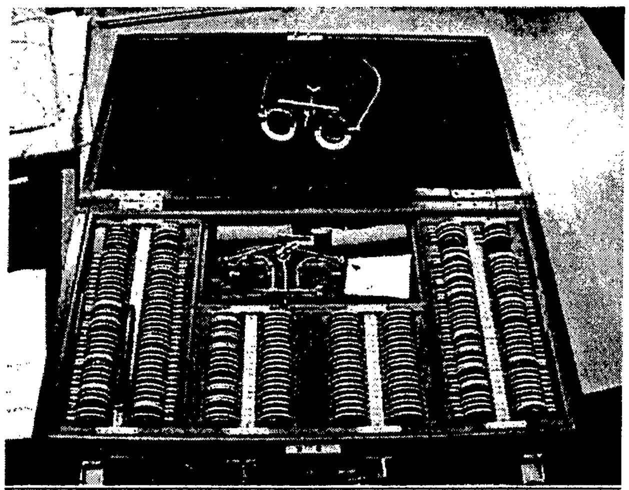

Figure 25. Muscle balance test equipment.

Eye muscle balance was measured for both a near (1/3 meter [1 foot]) and distance (6 meters [20 feet]) condition. If orthophoria was determined, it was so noted. If heterophoria was present, the extent of the esophoria, exophoria or hyperphoria was recorded in prism dioptres. If hyperphoria was present, the eye in which it was found was recorded. Eighty-two subjects were orthophoric at both distance and near. Broken down by the testing distance, 83 subjects were orthophoric at distance, and 98 subjects were orthophoric at near. Of the 21 subjects who had a measurable heterophoria at either distance or near, 12 were esophoric for distance, 1 was esophoric for near, and 4 were esophoric for both near and distance. Three of the remaining 21 subjects were exophoric for distance. One of the remaining 21 subjects was hyperphoric at distance. See Figure 26. For the 21 heterophoric subjects, esophoria ranged from 0.5 to 6 prism dioptres (with one 12-dioptre outlier); exophoria ranged from 0.5 to 3 prism dioptres; the single hyperphoria value was 0.5 prism dioptre.

Eye preference

As a measure of eye preference, a sighting dominance test was used. The test is called the "hole" test, in which the subject views the examiner's head through a hole in a card, then closes each eye alternately allowing the examiner to determine which eye was being used by the subject for sighting. The test was conducted under normal room lighting with the subject and examiner approximately 3 meters (10 feet) apart. The test was repeated four times, and the predominant eye was recorded. One hundred and one control subjects performed this test.

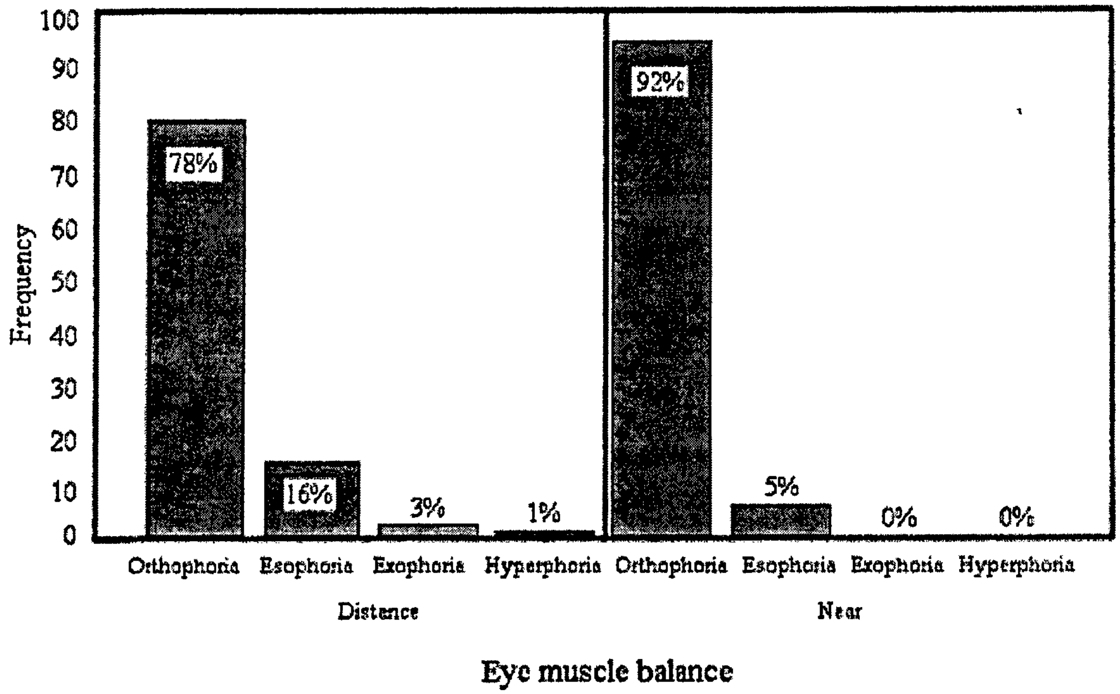

Figure 26. Muscle balance data for control subjects.

The distribution of results for the eye preference test is presented in Figure 27. Eighty-seven percent of measured control subjects were measured to have "right" eye preference.

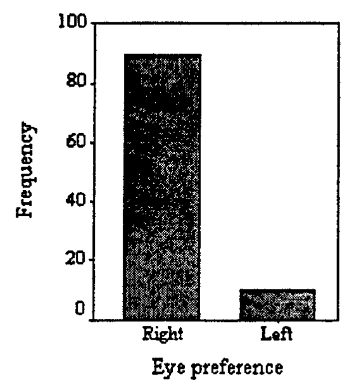

Figure 27. Eye preference distribution for control subjects.

Baseline data for Apache AH Mk 1 (exposed) pilots

The following sections present those issues considered most pertinent to this study, i.e., data for Apache AH Mk 1 (exposed) subjects. A full presentation of all data is provided in the various appendices (A, D-G). Percentages reported in the appendices are based on the total number of subjects, including null responses. Except where noted, percentages in the sections below are based on the proportion of subjects who provided responses to the individual questions or for whom visual test measurements were obtained. There were 14 Apache AH Mk1 (exposed) subjects.

Annual questionnaire

Vision history

Of the 14 exposed subjects, 64% indicated having been prescribed spectacles (Question 10), with distance correction being the most reported reason. Ages for first prescription were extremely variable, ranging from 25 to 47 years with a modal value (n = 3) of 35 years. The period of time since most recent prescription varied greatly from 1 to 87 months, with a median of 10.5 months. Five subjects (36%) indicated they were wearing both contact lenses and spectacles at the time of the study (Question 11). (Note: Additional contact lens data for subjects who currently or recently [within past year] wear contact lenses were collected in a separate questionnaire [Appendix F].)

To accommodate the close fitting design of the IHADSS HDU, specially modified aviation spectacles are used to provide both vision correction and laser protection. These modified spectacles have been a long-standing human factors problem (Rash, Kalich and van de Pol, 2002). No subject reported using the modified spectacles at the time of the study (Question 12). One subject, who was using neither the modified spectacles nor contact lenses, did report experiencing difficulty viewing cockpit instruments (Question 13).

One subject (7%) reported having been treated for an eye disease or injury (Question 14). No subject reported experiencing headaches on a frequent basis (Question 15), but over half (57%) reported routinely experiencing eyestrain (Question 16).

Seventy-nine percent of subjects reported their right eye as their preferred sighting eye; 14% reported left; 1 subject reported no preference (Question 17). For the specific viewing tasks of sighting with a telescope and viewing through a keyhole (Questions 18-19), 93% indicated right eye preference for both tasks. One of the preferred left eye subjects also indicated left eye preference for the telescope and keyhole viewing tasks. However, the other subject indicating left eye preference reported using his right eye for the two specific viewing tasks. When asked if their "preferred eye was the same one (now) as prior to AH Mk 1 training," 13 subjects responded "Yes" (1 no response) (Question 20).

The reporting of visual symptoms by U.S. pilots both *during* and *after* flight has been documented in several studies (Behar et al., 1990; Rash et al., 2001). When U.K. AH Mk 1 subjects were asked to report on presence of specific visual/physiological problems, headache and visual discomfort were the most frequently cited *during* flight (Question 21) and headache was the most frequent *after* flight (Question 22). Tables 8 and 9 summarize the reported symptoms for both *during* and *after* flight, respectively.

Flight imagery and symbology are presented on the HDU. Flight imagery is the picture of the outside world as produced by the nose-mounted FLIR sensor. Symbology is a set of

Table 8.
Reported visual/physiological symptoms *during* flight for exposed subjects.

	Never	Sometimes	Always	No response
Visual discomfort	8(57%)	5(36%)	0(0%)	1(7%)
Headache	7(50%)	6(43%)	0(0%)	1(7%)
Double vision	13(93%)	0(0%)	0(0%)	1(7%)
Blurred vision	13(93%)	0(0%)	0(0%)	1(7%)
After images	12(86%)	1(7%)	0(0%)	1(7%)
Disorientation	9(64%)	4(29%)	0(0%)	1(7%)
Dizziness	13(93%)	1(7%)	0(0%)	0(0%)
Nausea	9(64%)	4(29%)	0(0%)	1(7%)

Table 9.
Reported visual/physiological symptoms *after* flight for exposed subjects.

	Never	Sometimes	Always	No response
Visual discomfort	11(79%)	2(14%)	0(0%)	1(7%)
Headache	7(50%)	6(43%)	0(0%)	1(7%)
Double vision	13(93%)	0(0%)	0(0%)	1(7%)
Blurred vision	13(93%)	0(0%)	0(0%)	1(7%)
After images	12(86%)	0(0%)	1(7%)	1(7%)
Disorientation	13(93%)	0(0%)	0(0%)	1(7%)
Dizziness	12(86%)	1(7%)	0(0%)	1(7%)
Nausea	11(79%)	2(14%)	0(0%)	1(7%)
Unsteadiness or balance problem	13(93%)	0(0%)	0(0%)	1(7%)

alphanumeric and pictograms used to present flight information such as altitude, airspeed, heading, etc. Optically, the HDU imagery is at optical infinity. Approximately a third (38%) of responding subjects indicated having difficulty in seeing or interpreting the IHADSS symbology (Question 23). Over half (58%) of the responding subjects reported having at least a minimal problem focusing on both the outside world and the HDU symbology simultaneously (Question 24); two respondents (17%) reported experiencing such difficulty "50% of the time."

Of the 11 subjects responding, 10 (91%) reported eye fatigue, to some extent, during night flight as a result of using the IHADSS (Question 25). This proportion decreased to 54% (of those responding) for day use of the PNVS/IHADSS system.

Use of the IHADSS visor (in the "down" position) was reported as 77% by responding subjects during day flights but decreases to 40% during night flights (Question 26).

The IHADSS system is dichoptic in nature, i.e., presenting two dissimilar images, one to each eye. The right eye views the HDU presentation, and the left eye views the outside world. This design can lead to a number of undesirable visual responses, including binocular rivalry and suppression (Klymenko and Rash, 1995). During flight, 70% of responding subjects reported experiencing unintentional alternation of visual inputs to some degree (Question 27). Only one subject reported a continuation of alternation symptoms following flight and then only to a minor degree (Question 28).

The IHADSS imagery is considered monochromatic (single colour), presenting a green image at the predominate wavelength of 543 nanometers. Prolonged viewing of such an image can result in colour adaptation that can temporarily affect colour vision immediately following viewing, as experienced with NVGs. One-half (50%) of respondents reported this phenomenon, with most subjects (67%) reporting the effects disappearing in less than 15 minutes postflight (Question 29).

No subjects reported experiencing any dramatic symptoms, e.g., loss of consciousness, graying-out, etc., during "aggressive" flying of the system.

Disorientation

Of responding exposed subjects, 70% reported having experienced SD while flying with the IHADSS; 30% reported they had not (four subjects did not respond to this question) (Question 31). Almost all subjects who reported SD experiences cited the "bag phase" of training as when the experience occurred. The bag phase refers to the period of flight training when the Apache student pilot is learning to use the IHADSS. Flights in this phase occur in daytime, with the student pilot's section of the aircraft (rear seat) fully enclosed (hence the use of the term "bag"), preventing any view of the outside world. When asked about SD episodes following the training period (Question 32), only 2 (20%) reported such episodes.

Previous studies have indicated that while the IHADSS imagery is at optical infinity and of a 1:1 ratio with the outside world, pilots have reported problems with apparent size and distance of objects (targets) as viewed in the IHADSS imagery (Crowley, 1991; Hale and Piccione, 1990). While 58% of responding subjects reported objects to be "about the right size and distance," 25% reported them as "smaller and farther away," and 17% reported them being "larger and closer than reality" (Question 33).

When asked to what extent problems of time lags associated with changes in symbology values and actual aircraft movements existed during flight with the IHADSS (Question 34), only one responding subject (9%) indicated a problem and then only "to a slight extent." Regarding possible similar time lags between head movement and the PNVS image (Question 35), four responding subjects (36%) reported "slight" problems, and one (9%) reported "moderate" problems. Several subjects commented on the slow slew rate of both the PNVS and, especially, the TADS sensors.

Due to the dichoptic viewing design of the IHADSS, pilots must switch attention back and forth between the IHADSS imagery on the HDU (in the right eye) and the view of the outside world (in the left eye). When asked how frequently this switching is needed during flight (Question 36), 18% of responding subjects reported "Always," and 45% reported "50% of the time" or more. Two subjects reported having experienced a "wash out" of right eye HDU imagery as a result of a flash of light into the left, unaided eye (Question 37).

While flight imagery is presented egocentrically in front of the right eye, the imagery actually originates from the PNVS forward looking infrared (FLIR) sensor located approximately 10 feet forward and 3 feet below the pilot's design eye position. It has been suggested that this exocentric positioning of the imagery source can produce problems of apparent motion, parallax, and incorrect distance estimation, among other perceptual problems (Brickner, 1989; Rash, 2000). Of the responding exposed subjects, 64% reported that this exocentric viewing condition created problems with obstacle clearance, mostly during taxiing and ground hover (Question 38). However, one subject reported exocentric viewing as a problem during slow, low-level flights at treetop level.

In anticipation of possible visual fatigue effects of long flights on viewing of symbology, subjects were asked if the symbology ever "disappeared" during such flight (over 2 hours) (Question 39). Only two subjects reported such incidents, but one subject did report this situation as happening "50% of the time."

Neck pain

Neck pain as used in this questionnaire is defined as pain above (but not including) the level of the shoulder blades. There were separate questions on neck pain for *during* and *after* flight. These questions were asked because head-supported mass is an important factor with HMD systems. In addition to the helmet design and materials that must provide for impact and hearing protection, the HMD must have additional components to provide for the HMD optical functions. The IHADSS head-supported mass is 1.8 kilograms (3.96 pounds).

Sixty-nine percent of responding subjects reported having experienced neck pain *during* flight (Question 40), with onset 1 to 60 minutes into flight and an average onset time of 42 minutes. Forty-four percent of subjects reported experiencing more than 10 neck pain episodes during flight (over their flight history); another 44% reported a frequency of 4-10 episodes. A follow-up question asking how many episodes had been experienced in the past year produced an average number of 2.9 episodes. The Gazelle and the Lynx aircraft were cited as most frequently producing pain episodes (but only two subjects for each aircraft).

The main site of neck pain reported was the centre of the neck (56%). This was followed by the left side of the neck (33%), opposite of the HDU mount. The factor most frequently cited as the cause of neck pain episodes was the wearing of NVGs (67%); wearing of the IHADSS helmet with HDU was cited by only 1 subject (7%). (Note: The greater reports of pain with NVGs are attributed to pre-Apache flight experience.)

A similar set of questions was asked regarding neck pain *after* flight. Fifty-four percent of responding subjects reported *after*-flight episodes (Question 41). Such episodes were reported having onsets of 0 to 60 minutes into flight. Forty-three percent of subjects reported a total number of neck pain episodes of more than 10 (over flight history). An equal proportion (43%) reported a total of neck pain episodes of "4-10." However, based on just the previous flight year, 14% of subjects indicated a frequency of 1-3 episodes. Seventy-one percent of subjects reported experiencing no episodes of neck pain in the previous flight year.

Both flight with NVGs and with the IHADSS helmet with HDU were reported as the most frequent causal factors for neck pain *after* flight at 50% and 33%, respectively. Subjects were asked to grade the severity of their worst episode of neck pain (Question 42), both *during* and *after* flight, on a scale of 1 to 9 with 9 being defined as "incapacitating." For *during* flight, the most frequent value was 4 (56%), and the mean and median severity rating was 3.8 and 4, respectively. For *after* flight, the most frequent value was 5, and the mean and median severity rating was 5.3 and 5, respectively.

When asked to indicate the persistence of the worst episode of neck pain (Question 44), most of the responding subjects (33%) chose "during flight only," followed by 22% each for "12-24 hours after flight" and "1-4 days after flight."

Of the two subjects who indicated they "commonly" experienced neck pain (Question 43), again on a scale of 1 to 9 with 9 again being defined as "incapacitating," one subject gave a rating of 3 *during* flight, and the other gave 4. For *after* flight, one subject indicated a rating of 4.

The duration of the "average" episode of neck pain (Question 45) was reported to be 43% for "during flight only," 39% for "2-11 hours after flight," 14% for "12-24 hours after flight," and 14% for "1-4 days after flight." Approximately two-fifths (40%) of subjects reported having sought treatment for flight-related neck pain (Question 46). Of these, three subjects reported having actually received treatment for their neck pain. Twenty-one percent of subjects reported having taken self-initiated actions to minimize or avoid flight-related neck pain. Such actions included physical therapy treatments and use of pain medication.

Twenty-one percent of subjects reported having been grounded as a result of flight-related neck pain (Question 47). All of these subjects reported grounding periods of "<1 week."

Back pain

Back pain as used in this questionnaire is defined as pain at or below the level of the shoulder blades. There were separate questions on back pain for *during* and *after* flight. Poor posture, repeated landing impacts, and constant aircraft vibration are contributing factors to back pain.

Subjects reported a variety of reasons for adjusting seat position (Question 48): To obtain optimum vision (8%), to obtain optimum control position (31%), and a compromise between these two objectives (62%).

Based on their normal seat position and flying posture (Question 49), 62% of subjects reported having no problem in reaching and operating the critical and emergency controls and switches.

However, 31% reported having "slight difficulty," and 8% reported having "moderate difficulty" with this task.

Thirty-eight percent of subjects reported having a previous back injury (Question 50).

Sixty-nine percent of subjects reported having experienced back pain *during* flight (Question 51). Twenty-three percent of subjects reported onset periods of "30 minutes" and of "90 minutes." Thirty-one percent of subjects reported having experienced more than 10 total episodes of back pain (Figure 28). Based on just the preceding year, one subject each reported frequencies of 10, 20 and 30 episodes; 44% of subjects reported not having experienced any back pain in the preceding year. The aircraft type most frequently reported as associated with back pain episodes was the Gazelle (89%), a fact previously documented by Braithwaite and Vyrnwy-Jones (1986).

The lower back (88%) was the most frequently cited "main site" of back pain; the shoulders (13%) were reported by one subject. Unsatisfactory seat position was the most frequently cited factor considered by the subjects to have influenced incidence of back pain *during* flight.

Sixty percent of responding subjects reported having experienced back pain *after* flight (Question 52). Sixty-seven percent of subjects reported having experienced more than 10 total episodes of back pain *after* flight; 33% indicated 1-3 episodes (see Figure 29). Based on just the preceding year, one subject each reported frequencies of 1, 10, 20 and 30 episodes; 33% of subjects reported not having experienced any back pain in the preceding year.

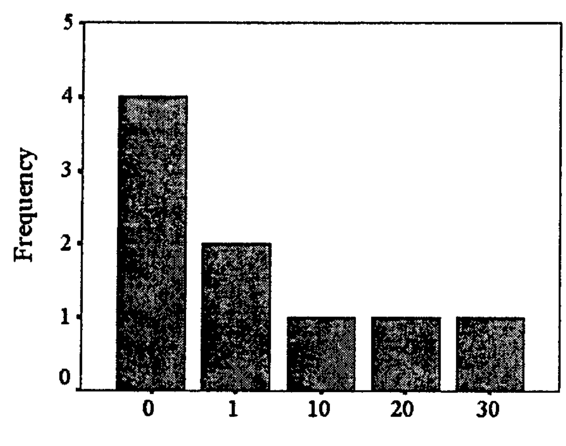

Figure 28. Frequency of exposed back pain episodes *during* flight for previous year.

Subjects were asked to grade the severity of their worst episode of back pain (Question 53), both *during* and *after* flight, on a scale of 1 to 9 with 9 being defined as "incapacitating." For *during* flight, the most frequent values were 3 (22%) and 4 (22%), and the mean and median severity rating were 3.8 and 3.5, respectively. For *after* flight, the mean and median severity ratings were 5 and 4.5, respectively; one subject reported an "incapacitating" rating of 9.

Of the four subjects who indicated they "commonly" experienced back pain (Question 54), again on a scale of 1 to 9 with 9 being defined as "incapacitating," the mean and median ratings during flight were 3.8 and 4, respectively. For *after* flight, the mean and median severity ratings, based on three subjects, were 4.7 and 4, respectively.

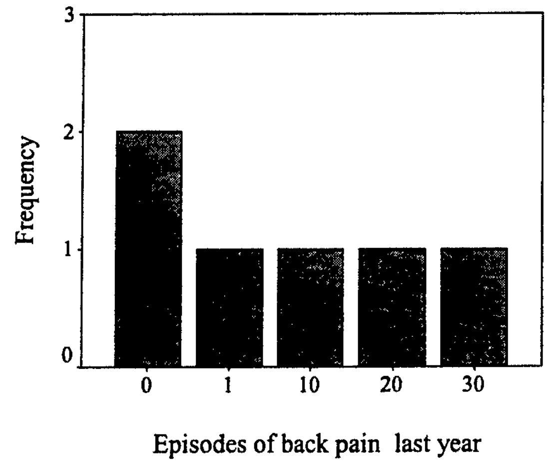

Figure 29. Frequency of exposed back pain episodes *after* flight for previous year.

When asked about duration of symptoms for their worst episode of back pain (Question 55), 38% of subjects reported "1-4 days after flight," 25% reported "during flight only," and 13% each reported "less than 2 hours after flight" and "more than 4 days after flight."

Forty-three percent of subjects reported an average duration of back pain of "less than 2 hrs after flight;" 14% of subjects each reported "during flight only," "12-24 hours after flight," "1-4 days after flight and "more than 4 days after flight" (Question 56).

Sixty-three percent of the subjects citing flight-related back pain reported having sought treatment (Question 57), with all of these having sought initial treatment from their SAM. All of the subjects reported having taken action in order to minimize or avoid flight-related back pain. Actions taken included physical therapy treatments, use of anti-inflammatories, and, in one instance, hospitalization.

Thirty-eight percent of subjects reported having been grounded as a result of flight-related back pain (Question 58), with a grounding period of "<1 week" being the most frequent (67%).

Twenty percent of subjects reported that current seat adjustment procedures and mechanisms did not allow them to achieve "a good flying position" (Question 59). When asked to rate the overall comfort of their aircraft seat on a scale of 1 to 9 (1 = extremely uncomfortable, 5 = adequate, and 9 = extremely comfortable), the mean and median comfort ratings were 5.9 and 6, respectively (Question 60). Sources of discomfort cited included lack of lumbar support and inadequate seat cushions.

IHADSS helmet usage

The IHADSS helmet is a specialized helmet that serves both the protective role of all aviation helmets with the added function of serving as a platform for the display optics (HDU). The AH Mk 1 is the only British aircraft that uses the IHADSS helmet. The helmet is available in three sizes: Medium, large and extra large. Two of the respondents indicated that they had not been issued personal helmets, so data provided in this section are based on only 12 exposed subjects.

More than two-thirds (67%) of subjects use the large sized helmet. See Figure 30 for the helmet size distribution (Question 61) for the exposed subjects.

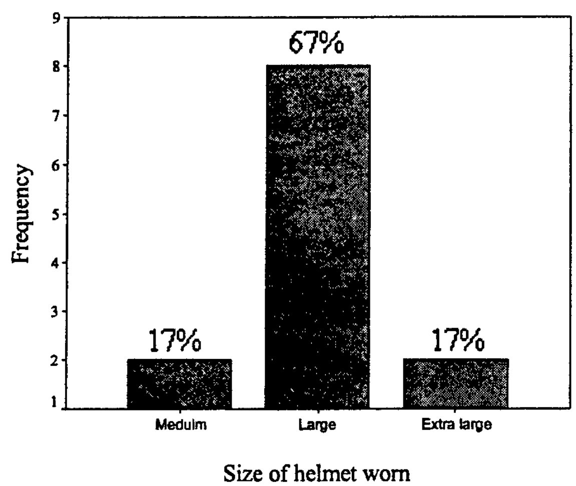

Figure 30. Helmet size distribution for exposed subjects.

When asked to rate the current quality fit of their IHADSS helmet on a scale of 1 to 9 (1 = unsatisfactory, 5 = adequate, and 9 = excellent), the mean and median ratings were 4.5 and 5, respectively (Question 62). The mean statistic was slightly less than the adequate rating of 5. Reasons for a less than adequate mean rating included hot spots, poor quality chinstrap, and a degraded fit following extended wear.

Thirty-six percent of responding subjects reported having fit adjustments made by personnel other than Safety Equipment Section fitters (Question 63). These included the manufacturer's representative and self-adjustment.

Table 10 presents the frequency and relative percentage of reported component breakage, binding, slipping, or other malfunction with IHADSS helmet (Question 65). The microphone and communication cable have the highest reported malfunction rates (33%).

Thirty-six percent of responding subjects reported having experienced HDU-related discomfort (Question 66). Forty-five percent of responding subjects reported having experienced difficulty during installing or removing the HDU from the IHADSS helmet (Question 67). Only one subject (10%) reported having experienced inadvertent release of the HDU during flight (Question 68).

Table 10.
Reported incidents of component breakage, binding, slipping, or other malfunction with IHADSS helmet.

	Yes	No	No response
Microphone	4 (33%)	6 (50%)	2 (17%)
Communication cable	4 (33%)	6 (50%)	2 (17%)
Microphone boom	3 (25%)	7 (58%)	2 (17%)
Helmet internal speakers	3 (25%)	7 (58%)	2 (17%)
Electronics cable	3 (25%)	6 (50%)	3 (25%)
Visor activators	2 (17%)	7 (58%)	3 (25%)
Suspension assembly	2 (17%)	7 (58%)	3 (25%)
HDU mounting bracket	1 (8%)	8 (67%)	3 (25%)
Earcups	1 (8%)	7 (58%)	4 (33%)
Chinstrap	1 (8%)	8 (67%)	3 (25%)
Visors	1 (8%)	8 (67%)	3 (25%)

The IHADSS provides a 30-degree (vertical) by 40-degree (horizontal) FOV. Head and face anthropometry and helmet fit impact the ability of the aviator to achieve the full FOV. Thirty-six percent of the responding subjects reported inability to achieve a full FOV (Question 69).

Due to the unique monocular and close fitting design of the HDU, visors for the IHADSS helmet must be custom trimmed for each aviator. Only one subject (9%) reported being dissatisfied with the adequacy and accuracy of their visor's trim (Question 70). All responding subjects were satisfied with the extent of face coverage provided by the visor (Question 71) and none reported experiencing undesirable contact between the visors and their face (e.g., nose) (Question 73).

One subject (9%) reported having had problems with inadvertent retraction of the visor (Question 72), but three of the responding subjects (30%) reported their visors as easily scratched (Question 74).

When asked to rate the overall comfort of their helmet on a scale of 1 to 9 (1 = extremely uncomfortable, 5 = adequate, and 9 = extremely comfortable), the mean and median comfort ratings were 5.6 and 5.5, respectively (Question 76). The mode was a 5 rating (n = 4). When asked specifically to rate thermal comfort, on the same scale, the mean and median comfort ratings were 6.4 and 6, respectively (Question 75). When helmet stability was rated on a similar scale (1 = extremely unstable, 5 = adequate, and 9 = extremely stable) (Question 78), the mean and median ratings were 6.4 and 6, respectively. The mode was a 5 rating (n = 3). Three subjects (27%) indicated that they felt they needed a smaller sized helmet (Question 77); none of the subjects felt a larger sized helmet was needed.

When asked to rate the overall noise protection of their helmet on a scale of 1 to 9

(1 = extremely noisy, 5 = adequate, and 9 = extremely quiet), the mean and median ratings were 4.5 and 5, respectively (Question 80). The mode was a 5 rating (n = 6). See Figure 31. Using a similar scale (1 = extremely poor, 5 = adequate, and 9 = extremely good), the mean and median ratings for the quality of the radio and intercom audio were 4.9 and 5, respectively (Question 81). Again, the mode was a 5 rating (n = 6).

The final question in the exposed subject questionnaire asked if the capabilities of the IHADSS system were sufficient to allow the aviator to safely meet all mission requirements (Question 82). Seventy-eight percent responded with "Yes;" 22% responded with "No."

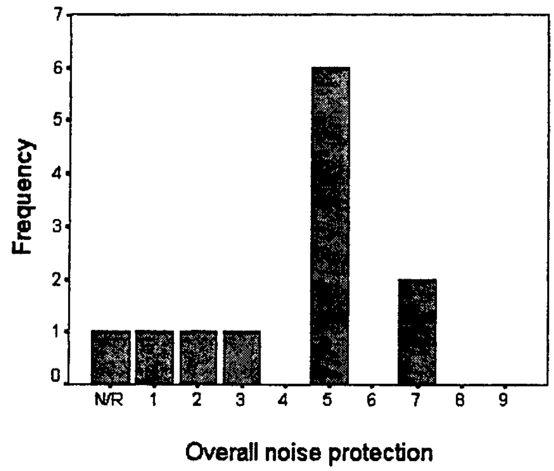

Figure 31. Distribution of noise protection ratings for the IHADSS helmet.

Contact lens usage

The unique design of the IHADSS HMD, with its close fitting monocular optics creates even greater physical compatibility issues between the HDU and the spectacle approach to vision correction. Contact lenses help to overcome this increased incompatibility. However, as mentioned previously, the cockpit can be a dusty and polluted environment, a hostile environment for contact lenses (Rash, Kalich, and van de Pol, 2002).

Appendix F contains the contact lens user survey. The British Army sanctions the use of contact lenses for their aviators. Apache aviators are provided with contact lenses. For these subjects, contact lenses have a greater functional necessity, in that they overcome the compatibility issues of vision correction with the HDU.

There were a total of five exposed subjects who completed the contact lens user survey. When asked to rate the severity of problems they had experienced while inserting contact lenses, using a scale of 1 to 9 (1 = no problem and 9 = severe problems) (Question b), two subjects each gave ratings of 1 and 5, while one subject gave a rating of 2. The mean and median ratings were 2.8 and 2, respectively. When asked to apply the same rating to the removing of contact lenses (Question c), two subjects each gave ratings of 1 and 5, while one subject gave a rating of 3. The mean and median ratings were both 3.

When asked to rate the level of comfort of their contact lenses (1 = very comfortable, 5 = neither comfortable nor uncomfortable, 9 = very uncomfortable) (Question d), responses revealed two subjects gave a rating of 1; one subject gave a rating of 2; and two subjects gave a rating of 5. The mean and median ratings were 2.8 and 2, respectively.

Subjects were asked to compare their vision between contact lenses and spectacles (Question e). Given a scale of 1 to 9 (1 = vision is better with contact lenses, 5 = no difference in vision between contact lenses and glasses, and 9 = vision is better with glasses), two subjects (40%) gave a rating of 1, one subject gave a rating of 2, and one gave a rating of 8. There was one subject who did not respond. The mean and median scores were and 3 and 1.5, respectively.

None of the subjects reported having experienced difficulty in maintaining their contact lenses, either in a benign environment such as at home or in the barracks, nor in the more hostile field environment (Question f). When asked to indicate the types of weather conditions that made wearing of contact lenses difficult (Question g), only one subject provided a response, citing the condition of dry weather.

Table 11 provides a summary of responses given by subjects when asked to report problems experienced *while* flying with contact lenses (Question h). "Eye irritation" and "Dry eye" were the two most commonly reported symptoms.

Table 11.
Problems with contact lenses reported while flying.

	Never	Rarely	Occasionally	Often	N/R
Eye irritation	2 (40%)	1 (20%)	1 (20%)	0 (0%)	1 (20%)
Eye pain	4 (80%)	0 (0%)	0 (0%)	0 (0%)	1 (20%)
Blurred vision	3 (60%)	0 (0%)	1 (20%)	0 (0%)	1 (20%)
Dry eye	1 (20%)	2 (40%)	0 (0%)	1 (20%)	1 (20%)
Light sensitivity	4 (80%)	0 (0%)	0 (0%)	0 (0%)	1 (20%)

The one subject who indicated blurred vision rated the problem as "Severe." Both dry eye and eye irritation were each rated as "Moderate" by one subject. Eye irritation (one subject) and dry eye (two subjects) were rated as "Minor" (Question i).

Table 12 provides a summary of responses given by subjects when asked to indicate if these same problems were experienced *while on the ground* (Question j). Dry eye was the most common problem reported, with three subjects (60%) indicating that it occurred "Rarely."

The one subject who reported blurred vision rated it as "Severe." Three of the four subjects who indicated experiencing dry eye while on the ground rated the discomfort as "Minor;" the fourth subject rated it as "Moderate" (Question k).

Of those subjects who reported using contact lenses *during* flight, the majority (80%) rated comfort as "Adequate" or better, with a mean and median of 6 and 7, respectively (Question l).

Table 12.
Problems with contact lenses reported while on the ground.

	Never	Rarely	Occasionally	Often
Eye irritation	3 (60%)	1 (20%)	1 (20%)	0 (0%)
Eye pain	5 (100%)	0 (0%)	0 (0%)	0 (0%)
Blurred vision	4 (80%)	0 (0%)	1 (20%)	0 (0%)
Dry eye	1 (20%)	3 (60%)	0 (0%)	1 (20%)
Light sensitivity	5 (100%)	0 (0%)	0 (0%)	0 (0%)

When asked about any difficulties the wearing of contact lenses may have caused with respect to any specific flight, one incident of having to "hand over controls in flight" was reported (Question m).

Of the three subjects who indicated that they had begun wearing contact lenses within the past year, all evaluated their training in the application and removal of their contacts as "Good" or better (Question n). Eighty percent of subjects rated the Army Aviation Medicine support of the Apache contact lens programme as "Excellent" (Question o). Two subjects, commenting on possible improvements to the Apache contact lens programme, suggested the use of more state-of-the-art contact lenses (Question p).

Handedness inventory

The IHADSS system is monocular in design, providing imagery to the right eye only. It has been suspected that pilots who are left-eye dominant may have increased difficulty learning and using the right-eyed IHADSS (Rash, 2000). While eye dominance only weakly correlates with handedness (Coren, 1993), it was deemed potentially useful to measure handedness; therefore, this property was measured during the physical eye exam. Subject handedness was assessed using the EHI, a 10-item self-reporting questionnaire (Appendix G) adapted from Oldfield (1971). Subjects were asked to indicate their preference in use of hands for various activities, e.g., writing, drawing, using a toothbrush, etc. Both absolute and relatives scores were computed for each subject.

Thirteen exposed subjects completed this questionnaire. The absolute handedness scores were predominately "right' with 11 (85%) responding subjects indicating a preference for right-handedness and 2 (15%) indicating left-handedness. The EHI relative scores confirmed this finding with the same distribution: 85% indicating right-handedness and 15% indicating left-handedness (Figure 32). The median EHI relative score was +73, with six subjects (46%) indicating an overwhelming preference (+100) for right-handedness. See Appendix G for a full presentation of data responses to this questionnaire.

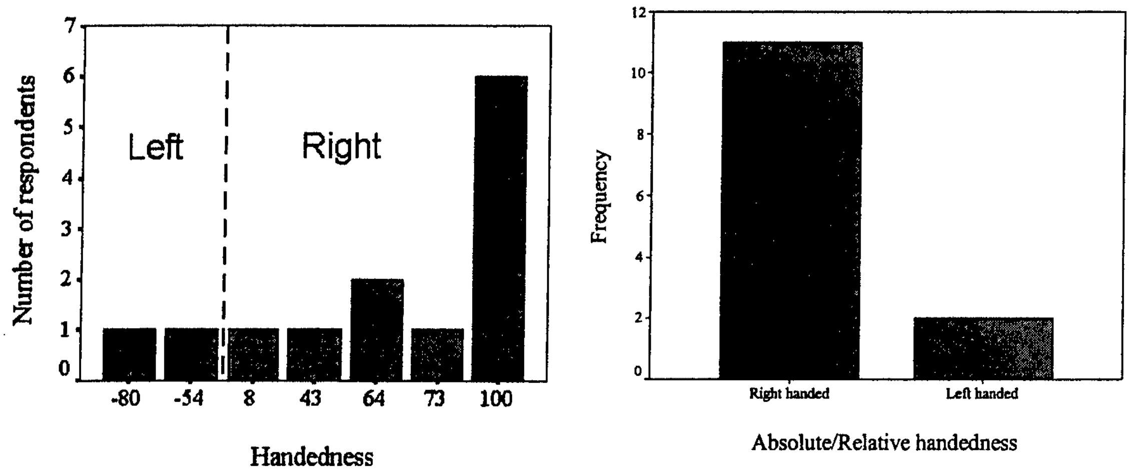

Figure 32. Absolute and relative handedness for exposed Apache subjects.

Eye examination

A series of nine visual tests were administered as an extended eye examination component of the regular annual flight physical. Tests of visual performance were conducted monocularly and/or binocularly, as required, except where inapplicable (e.g., in eye dominance testing). Visual acuity and contrast sensitivity were measured with vision correction (spectacles or contact lenses), if used by subjects. Full eye examination data for exposed subjects are presented in Appendix E. A total of 13 (out of 14) exposed subjects had completed eye examinations at the time of this review.

Refractive error

Each subject's refractive error was measured monocularly using an autorefractor (Model AR-600, Nidek Co., LTD., Tokyo, Japan). A single reading was taken for each eye. Each recorded measurement consisted of a sphere, cylinder and axis value, recorded in minus cylinder form.

Thirteen exposed subjects were measured. The range for spherical and cylindrical refractive error (across both eyes) was –2.00 to +0.75 dioptres and –2.00 to 0.00 (plano) dioptres, respectively. The mean spherical refractive error was -0.19 (SD=0.94), -0.06 (SD=0.89), and -0.13 (SD=0.90) dioptres for right eye, left eye and both eyes, respectively. The mean cylindrical refractive error was –0.52 (SD=0.58), -0.63 (SD=0.46), and –0.58 (SD=0.52) dioptres for right eye, left eye and both eyes, respectively. The spherical equivalent (average power) was –0.45 (SD=0.91), -0.38 (SD=0.98) and –0.41 (SD=0.93) dioptres for right, left and both eyes, respectively. Box plots of the spherical equivalent refractive error for the right and left eyes for exposed subjects are presented in Figure 33.

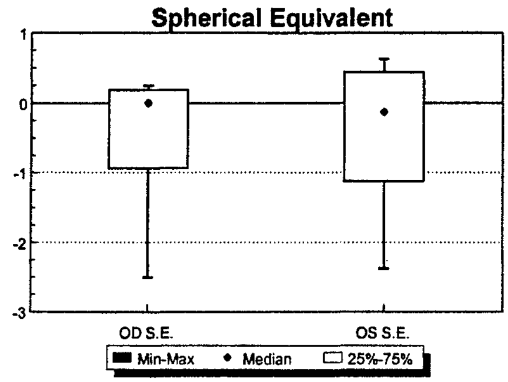

Figure 33. Box plot of spherical equivalent refractive error for the right (OD) and left (OS) eyes for exposed subjects.

Bailey-Lovie high contrast visual acuity

High contrast visual acuity was measured using the Bailey-Lovie visual acuity chart (Figure 12) at a chart luminance of 100 cd/m^2. Subjects were measured monocularly for both the right and left eye using their habitual correction (either glasses or no glasses). Due to circumstances associated with the very first subjects examined, four subjects did not have their spectacles available for this test. Therefore, their high contrast visual acuity results were obtained without spectacle correction and are not included. All statistics are based on the remaining nine exposed subjects.

For the right eye, the mean visual acuity was 0.16 logMAR (Snellen equivalent of 6/9 [20/29]) with a standard deviation of 0.10 logMAR. For the left eye, the mean visual acuity was 0.12 logMAR (Snellen equivalent of 6/8 [20/27]) with a standard deviation of 0.09 logMAR. Included in this sample are two subjects that presented without spectacles and were found to have uncorrected refractive error less than 0.5 dioptre of myopia (spherical equivalent) and no more than 0.75 dioptre of astigmatism on autorefraction. Since this is their natural flying condition, their results are included. The mean visual acuity in logMAR, based on the Bailey-Lovie high contrast chart, for the right and left eyes are presented in Figure 34.

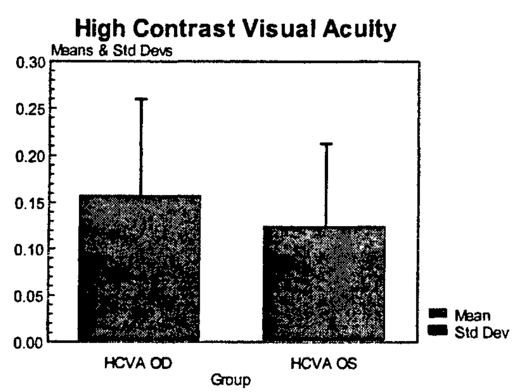

Figure 34. Mean Bailey-Lovie high contrast logMAR acuity for right (OD) and left (OS) eyes.

Bailey-Lovie low contrast visual acuity

The Bailey-Lovie low contrast chart was designed to measure static visual acuity under low contrast conditions. All criteria of the high contrast test above were applied to this test.

At the very beginning of the study, acuity was measured only via the high contrast chart. It was later decided to add the low contrast chart as an additional measure. Therefore, only six exposed subjects have measured data for the Bailey-Lovie low contrast acuity test. One of these subjects presented without spectacles, therefore his uncorrected low contrast visual acuity was not included in the analysis. All statistics for this test are based on the five exposed subjects.

For the right eye, the mean low contrast acuity was 0.37 logMAR (Snellen equivalent of 6/14 [20/48]) with a standard deviation of 0.11 logMAR. For the left eye, the mean low contrast acuity was 0.41 logMAR (Snellen equivalent of 6/16 [20/54]) with a standard deviation of 0.14 logMAR. The mean 10% low contrast visual acuities in terms of logMAR for the right and left eyes are presented in Figure 35.

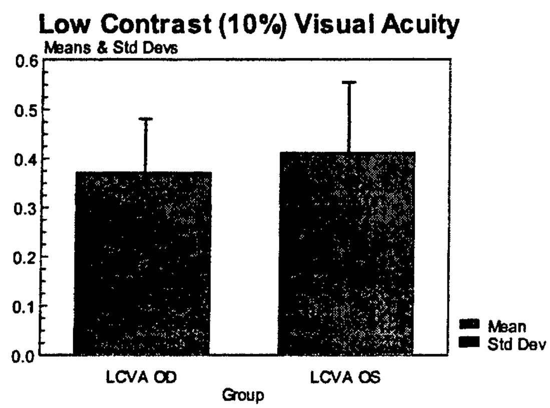

Figure 35. Mean Bailey-Lovie low contrast logMAR acuity for right (OD) and left (OS) eyes.

Small letter contrast sensitivity

Small letter contrast sensitivity was tested using the SLCT (Figure 15). Testing was completed monocularly with the subject's habitual correction (glasses or no correction) in place. Four subjects did not have their spectacles available for this test. Therefore, their small letter contrast results are not presented, and all statistics are based on the remaining nine exposed subjects.

For the right eye, the mean contrast sensitivity was 0.90 logCS (SD = 0.3; range = 0.31 to 1.16 logCS). For the left eye, the mean was 0.91 logCS (SD = 0.23; range = 0.38 to 1.13 logCS). The mean small letter contrast sensitivity is shown in Figure 36.

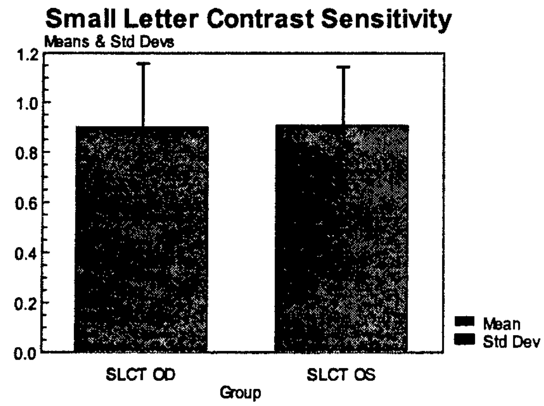

Figure 36. LogCS scores for the right (OD) and left (OS) eye.

Depth perception

Depth perception (stereopsis) was measured using the Stereotest-Circles test (Figure 17). Subjects viewed arrangements of three circles through polarized spectacles and reported which circle in each group of three appeared closer than the others. The recorded data point was the angular disparity measure of the last correct answer, expressed in seconds of arc. Thirteen out of the 14 exposed subjects were measured.

All subjects had measured values of either 25 or 30 seconds of arc. The distribution of values is presented in Figure 37. The mean, median and standard deviation of these values are 26.5, 25 and 2.4 seconds of arc, respectively.

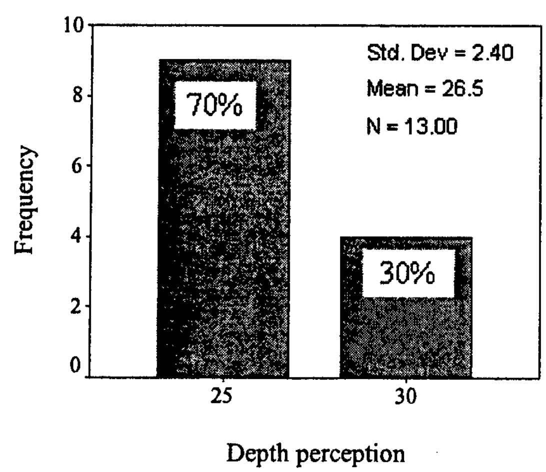

Figure 37. Frequency distribution for depth perception values for exposed subjects.

Colour perception

Colour perception was determined using the Lanthony desaturated D-15 hue test (Figure 19). The subject's task was to arrange sixteen desaturated colour chips in order according to colour.

A colour perception score was calculated for each eye. Thirteen exposed subjects performed this test.

A modified Farnsworth FM-100 test quantitative perception scoring scheme was used to compare small differences in performance. When all caps are correct, the colour perception score is 56.3. Errors in the cap sequencing result in an increase in score. The mean expected score is 64 with a range of normal scores falling between 56.3 (perfect sequence) and 80 (Geller, 2001).

For the right eye, the mean colour score was 66.7 (SD=7.4; range 56.3 to 81.6). For the left eye, the mean colour score was 67.9 (SD=13.9; range 56.3 to 107.0). Two subjects scored outside the normal range in one of their eyes; possibly indicative of mild to moderate colour deficiency. Colour perception scores are presented in Figure 38.

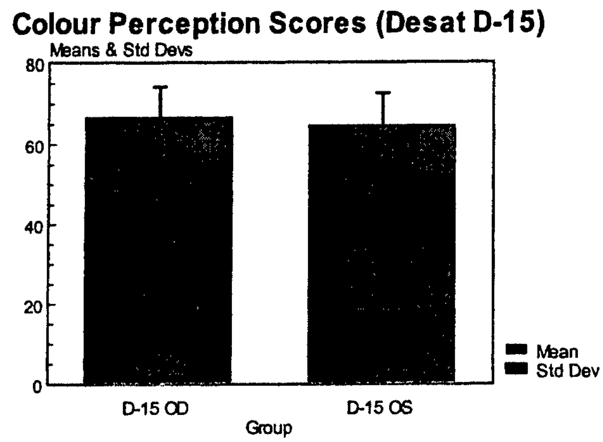

Figure 38. Mean colour perception scores for right (OD) and left (OS) eyes of exposed subjects.

<u>Accommodation</u>

In the normal aircrew medical examination, accommodation is measured in a binocular fashion, stimulating convergence and accommodation together by maintaining focus and fusion on a target. In this study, accommodation without spectacle correction was tested binocularly and monocularly by moving a small print target on a Prince Rule (Figure 21) slowly away from each eye in turn, noting when the subject <u>can</u> read the letters on the target. The values recorded were the measured distances, expressed in centimeters (cm). These values were converted into dioptre values (the inverse of the focusing distance in meters). In order to determine true accommodative capability, the uncorrected results were adjusted by the spherical equivalent refractive error.

Thirteen subjects performed this test. The results are presented based on age; seven subjects were less than 40 years of age (mean 35, range 34 to 36), and six subjects were 40 years of age or older (mean 43, range 40 to 47). Mean binocular accommodation was 8.5 dioptres (SD=3.5) for the younger group and 6.5 dioptres (SD=4.4) for the older group. Monocularly, the mean accommodation for the younger group was 8.0 dioptres (SD=3.1) for the right eye and 8.2 dioptres (SD=3.5) for the left eye. For the older group, the mean monocular accommodation was 6.8 dioptres (SD=5.0) for the right eye and 6.7 dioptres (SD=4.8) for the left eye. Accommodation values (in dioptres) by age group are presented in Figure 39.

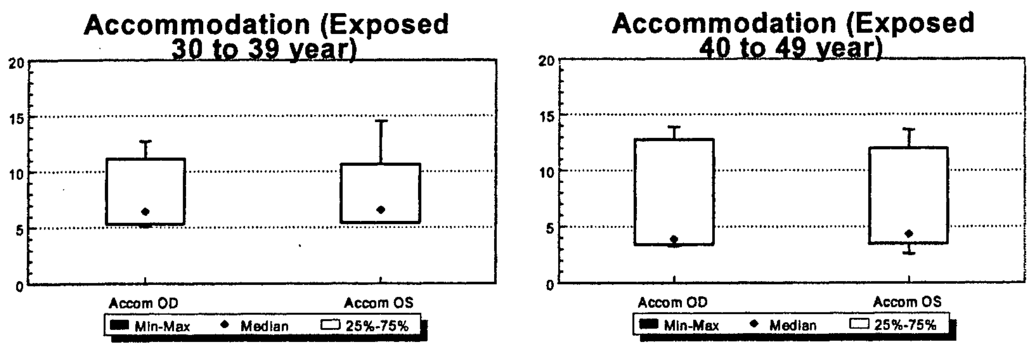

Figure 39. Accommodation by age group (decade) for exposed subjects.

<u>Eye muscle balance</u>

Eye muscle balance was measured using a Maddox Rod for both a <u>near</u> (1/3 meter/1 foot) and <u>distance</u> (6 meters/20 feet) condition (Figure 25). If orthophoria was determined, it was so noted. If heterophoria was present, the extent of esophoria or exophoria was recorded in prism dioptres. If hyperphoria was present, the results were noted based on the hyperphoric eye (e.g. 1 dioptre of right hyperphoria is equivalent to 1 dioptre of left hyperphoria).

Eye muscle balance was measured for 13 exposed subjects. Ten of these subjects (77%) were found to be orthophoric for both the distance and near tests. Of the remaining three subjects, two were orthophoric for the near test, but both were found to have esophoric heterophoria for the distance test, with prism dioptre values of +3 and +4, respectively. The third non-orthophoric subject was esophoric (+0.5 prism dioptre) for both the near and distance tests. See Figure 40.

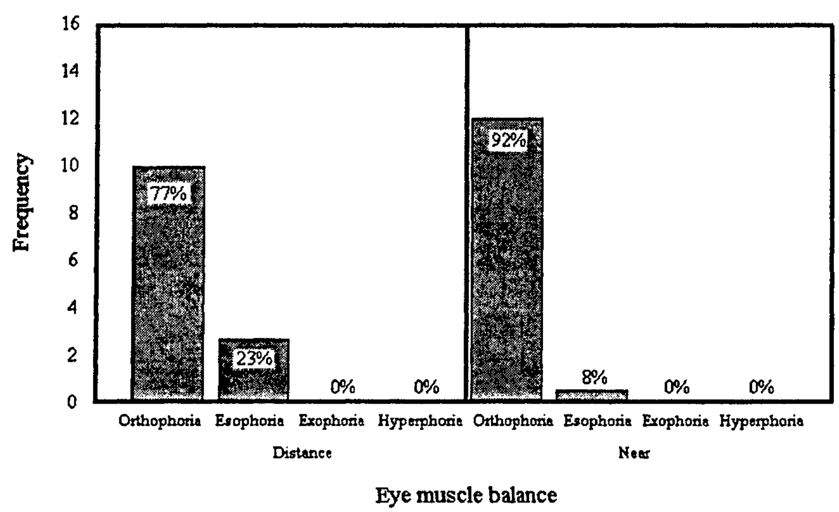

Figure 40. Eye muscle balance for exposed subjects.

Eye preference

As a measure of eye preference, a sighting dominance test was used. The test is called the "hole" test, in which the subject views the examiner's head through a hole in a card held at approximately arms' length in front of the subject's eyes. The subject then closes each eye alternately to determine which eye was being used for sighting. The test was conducted under normal room lighting with the subject and examiner approximately 3 meters (10 feet) apart. The test was repeated four times, and the predominant eye was recorded. Thirteen exposed subjects performed this test.

The distribution of results for the eye preference test is presented in Figure 41. Seventy-seven percent of exposed subjects indicated "right" eye preference.

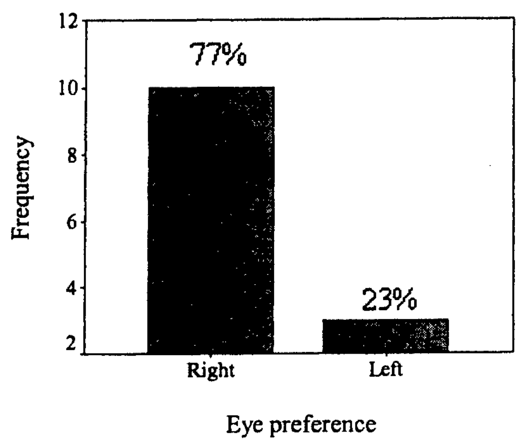

Figure 41. Eye preference distribution for exposed subjects.

Discussion

Sample demographics

It is always desirable to compare samples of as nearly equal characteristics as possible. Real world military scenarios do not always allow this. In this study, we are comparing a sample of aviators drawn from what is currently a very small population (AH Mk1 Apache aviators), members of which, by design, are older and more experienced aviators. Currently, all U.K. Apache aviators are male in gender; less than 1% of all U.K. aviators are female.

The two samples are similar in being predominately male and consisting of rated aviators flying in the same general time frame. The major differences between the two samples are: a) the exposed group is older (mean age of 39 years versus 31 for the control group, $p = 0.000$) and b) the exposed group has considerably more overall flight experience (mean 3720 hours versus 805 hours for control group, $p = 0.001$).

The greater age and experience of the exposed AH Mk1 Apache aviators is due to the selection process for this aircraft. It is accepted practice to man new aircraft with the most experienced aviators available, resulting in a population that is older and has greater flight experience. This was true for the U.S. fielding of the AH-64 Apache, where initially selected aviators were experienced AH-1 Cobra aviators.

It is a well-documented phenomenon that vision status changes with age, e.g., decreases in visual acuity and accommodation range. Therefore, due to the age difference between the two samples, the reader is cautioned in how reported differences of some visual parameters are interpreted in the data presented in this first review. As the study progresses, changes in the demographics of the exposed group are expected, as younger, less experienced aviators transition into the Apache and are recruited into the exposed group. Of real interest in this study will be the data obtained in future years, following long-term use of the monocular HMD.

This study is concerned with differences in both binocular and monocular visual parameters that could be associated with long-term utilization of the Apache's monocular HMD. Binocular parameters include muscle balance, depth perception and eye preference. Monocular parameters include refractive error, visual acuity, contrast sensitivity, colour perception and accommodation.

Finally, the reader is cautioned in the interpretation of data and statistical tests associated with the small sample size (n = 14) for exposed subjects at this early stage of the 10-year study. Until this sample size increases, each response has an inflated effect on data proportions and statistical tests.

Annual questionnaire data

Vision history

Due to the difference in sample mean age, it is not surprising that the proportion of exposed respondents (mean age = 39) using some type of vision correction (64%) is greater than for the control respondents (26%) (mean age = 31). It is equally predictable that there is a higher percentage of contact lens wearers among those requiring vision correction for the exposed respondents (55%) versus control respondents (22%). This higher usage is driven by the incompatibility of spectacles with the HDU and contacts being provided at no cost to the Apache aviators (exposed group).

Since the main purpose of this study is to look for changes in visual performance associated with the long-term use of the monocular IHADSS, one parameter deserving of close scrutiny is eye dominance. Seventy-nine percent of exposed respondents reported a preference for the right eye; 64% of control respondents indicated a similar preference. Estimates of right eye dominance range from 50% to 90% of the general population (Crider, 1944). This variability is attributed to the many types of dominant tasks. Therefore, it is most probable that there is no difference in eye dominance between the two groups, especially since both groups report a somewhat similar right eye preference for the two specific viewing tasks, telescope and keyhole viewing.

All responding exposed subjects reported no change in preferred eye following IHADSS training.

Flight-related visual symptoms

Headache was the most commonly reported symptom by both exposed and control subjects. For exposed subjects, headache was reported by nearly half of the subjects both *during* and *after* flight. For control subjects, disorientation was the most frequently reported symptom *during* flight, with headache rated second; headache was the most frequently reported symptom *after* flight. A two-way contingency table analysis was conducted to evaluate whether exposed subjects had a different headache frequency than control subjects, either *during* or *after* flight. No difference (exposed – 43%; control - 29%) was found *during* flight ($\chi^2 = 1.56$; $p = 0.21$); a significant difference (exposed – 43%; control – 17%) was found *after* flight ($\chi^2 = 6.38$; $p = 0.01$). Visual demand may be increased by the presence of alternating images and the need to interpret the IHADSS symbology and infrared imagery.

Eye fatigue

Viewing natural scenes is easy on the human visual system. However, prolonged viewing of displays, such as computer monitors, has resulted in reports of eye fatigue (McCown, 1999). Viewing imagery on HMDs is quite different from viewing the natural environment because an HMD is a display (Meltzer and Moffitt, 1997).

Viewing natural scenes with both eyes is an effortless and comfortable experience. This is because natural scenes have perfect alignment. Viewing imagery on binocular HMDs, e.g. NVGs, can result in the images seen by the two eyes having differences in magnification, brightness, distortion and vertical, horizontal, or rotational alignment. As a result, the left- and right-eye images can be different in multiple ways (Melzer and Moffitt, 1997).

With monocular HMDs, i.e., the IHADSS, a more complex visual situation is presented. Since only one eye views the display, the brightness difference between the images presented to the two eyes can be quite large. While the other binocular alignment problems are not present, perceptual issues relating to conflicting left-and right-eye images can cause eye fatigue. The major of these issues is binocular rivalry (Rash, Verona and Crowley, 1990). The response to one eye viewing the monochromatic green video image and the other eye viewing a dark cockpit and the outside world can be suppression of the eye viewing the dimmer cockpit and outside world. Viewing these dissimilar images has proven to be especially fatiguing during lengthy missions. Voluntary switching between the two images has been reported as difficult by some aviators. In addition, these competing images can lead to involuntary switching of attention, due to binocular rivalry (Melzer and Moffitt, 1997).

A two-way contingency table analysis was conducted to evaluate whether exposed subjects had a different proportion of eye fatigue (91%) than control subjects (73%). No significant difference was found ($\chi^2 = 1.5273$, $p = 0.217$).

Colour perception

The problem of colour aftereffects after using HMDs was raised in the early 1970s (Glick and Moser, 1974). This phenomenon was reported by U.S. Army aviators using NVGs for night flights. It was initially, and incorrectly, called "brown eye syndrome." The reported visual problem was that aviators experienced only brown and white colour vision for a few minutes following NVG flight. Glick and Moser (1974) investigated this phenomenon and concluded that the aviators' eyes were adapting to the monochromatic green output of the NVGs, i.e., cone saturation being responsible for this effect. The final conclusion was that this phenomenon was a normal physiological response and was not a concern (Rash, 2000).

A two-way contingency table analysis was conducted to evaluate whether exposed subjects had a different proportion (50%) of colour episodes than control subjects (58%). No significant difference was found ($\chi^2 = 4.7376$, $p = 0.030$). This finding might be expected since both NVG and IHADSS stimuli are provided by a monochromatic phosphor dominant in the green part of the visible spectrum.

Disorientation

All exposed subjects who reported episodes of SD indicated these episodes as having been experienced during the "bag phase" of initial IHADSS training. Flights in this phase occur in daytime, with the student pilot's section of the aircraft (rear seat) fully enclosed (hence the use of the term "bag"), preventing any view of the outside world. For control subjects, most SD episodes occurred during periods of degraded NVG flight, e.g., "white-out."

A two-way contingency table analysis was conducted to evaluate whether exposed subjects have a different proportion (70%) of SD episodes than control subjects (29%). The greater proportion for exposed subjects was found to be significant ($\chi^2 = 6.5778$, $p = 0.010$). This difference is based primarily on the high frequency of SD episodes for exposed aviators during the "bag" phase, which is totally lacking of peripheral cues. Following the completion of the "bag" phase of training, the percentage of exposed subjects reporting SD episodes decreased to 20%. A two-way contingency table analysis continued to find a statistical difference between the two proportions ($\chi^2 = 0.35$, $p = 0.554$).

Neck pain

Neck (and back) pain is well associated with the rotary-wing environment (Hiatt, 2000; Bowden, 1987). Army medical experts have noted the complaints of aviators for years. However, the recent trend in using more complex and heavier HMDs have resulted in increased complaints (Hiatt, 2000).

Sixty-nine percent of exposed subjects reported neck pain *during* flight, as compared to 26% for control subjects. The greater proportion for exposed subjects was found to be significant using a two-way contingency analysis ($\chi^2 = 9.9800$, $p = 0.002$). For neck pain *after* flight, a 54% proportion of exposed subjects reporting neck pain, as compared to 19% of control subjects, was also found to be significantly different ($\chi^2 = 7.5978$, $p = 0.006$). The higher proportions for the exposed subjects may be due to the center of mass shift of the IHADSS, as well as to their higher mean age and flight experience.

The ranking of the sites for reported neck pain was the same for both exposed and control groups. The centre of the neck was the predominant site, followed by the left side and then the right side of the neck. For the control group, the "average" severity ratings for neck pain episodes were 3.3 and 2.9 for *during* and *after* flight, respectively. Only 1 exposed subject responded to this question; therefore, no comparison between groups is possible, and there is no ability to assess the lower head supported mass but increased centre of mass shift of the IHADSS.

Back pain

There are a number of factors in the rotary-wing flight environment that contribute to the presence of back pain. These factors include seat design, posture and vibration (Bowden, 1987; Bongers, Hulsof, and Dijstra, 1990).

A two-way contingency table analysis was conducted to determine whether exposed subjects had a different proportion (69%) of back pain *during* flight than control subjects (61%). The difference in proportions was found not to be significant (p = 0.576). For *after* flight, a two-way contingency analysis also found the difference in proportions (exposed – 60%; control – 39%) not to be significantly different (p = 0.208).

The most prevalent site of reported back pain was the same for both exposed and control groups, the lower back. For the control group, the "average" severity ratings for back pain episodes were 2.8 and 2.7 for *during* and *after* flight, respectively. Only four exposed subjects responded to this question. The "average" severity ratings for back pain episodes were 3.8 and 4.7 for *during* and *after* flight, respectively. However, because of the small number of exposed responses, no comparison between groups is meaningful.

Helmet usage

The most prevalent sized helmet was a medium version (79%) for control subjects and the large (67%) for exposed subjects. The mean rating of helmet quality fit (based on a scale of 1-9) was 6.9 and 4.5 for control and exposed subjects, respectively. For both groups, the presence of hot spots was the most frequently cited reason for a low quality rating. A Mann-Whitney U-test comparing the distributions of fit ratings found the distributions to be statistically different (U = 209, p = 0.000). Overall comfort also was found to be statistically lower for the IHADSS helmet (mean rating = 5.6 versus 6.7 for standard aviation helmets [p = 0.033]). This implies a lesser overall degree of satisfaction with the fit and comfort of the IHADSS helmet.

A more recent survey of helmet fit satisfaction for the IHADSS helmet used by U.S. and U.K. Apache aviators reported an adjusted mean quality of fit rating of 6.3 (Rash et al., 2003). This higher satisfaction rating is most likely attributable to the increased number of flight hours with the IHADSS helmet (median of 160 hours for the more recent study versus 43 hours for the COHORT study).

Contact lens usage

The objective of the contact lens usage questionnaire was to determine if the use of contact lenses has been an advantage as a solution to vision correction in the cockpit. Approximately one out of every four (26%) control subjects reported requiring vision correction. Of these, only six indicated that they were wearing contact lenses during the time of the study, representing 6% of the control sample, but 23% of those requiring vision correction. The percentage of exposed subjects requiring vision correction was more than doubled (64%); contact lens usage was also higher, 36% of the exposed sample, but 56% of those requiring vision correction. The increase in the need for vision correction by the exposed subjects is most likely due to the higher median age for these subjects. The two-fold increase in contact lens usage is most likely explained by the need to solve the incompatibility issue between spectacles and the HDU, and the fact that contact lenses have been designated as mission essential and therefore were provided to the exposed subjects free of charge.

The use of contact lenses by the exposed subjects has been an advantage in overcoming the vision correction compatibility issue. For the control pilots, the use of contact lenses was most likely an issue of convenience or preference for the unencumbered vision provided by contact lenses. Possibly the contacts also may have provided an advantage over the wearing of spectacles because spectacle temples break the ear cup seal and therefore may interfere with the effectiveness of hearing protection.

Overall, the comfort rating for contact lens usage was high, and the frequency of associated problems was low. In comparing the comfort and logistical problems, there were no significant differences between the exposed and control groups. All subjects, exposed and control, indicated that vision with contact lenses as compared to vision with spectacles was an improvement.

Handedness

Both exposed and control subject groups indicated a predominate preference for right-handedness, with 85% for the exposed group and 91% for the control group. A Chi-square test showed no difference between the two groups ($p = 0.509$).

The mean EHI relative score for the exposed group was +55; the mean EHI relative score for the control group was +62. The difference between the two groups was not statistically significant ($p = 0.703$). The exposed group had a larger proportion (46% to 37% for the control group) of overwhelming right-handedness relative scores (+100), but there was no statistically significant difference between the two groups ($p = 0.335$).

Of the two exposed subjects who indicated left eye preference, one did not complete the handedness survey, and the other had both absolute and relative (+65) right-handedness scores. Of the control group, 12 subjects had indicated left-eye preference. Four of these did not complete the handedness survey; five had right-handedness absolute and relative scores; and three had left-handedness absolute and relative scores.

In the general population, the proportion of right-handed people ranges from 90-95% (Augustyn and Peters, 1986; Brown and Taylor, 1988), therefore the proportions cited here for the exposed and control groups are similar to those reported in the general population.

Eye examination data

For the measures of visual performance within the eye examination test battery where monocular measurements were possible, there was no statistically significant difference between right eye and left eye measurements in either the control or the exposed group.

Refractive error

Aviators tend to have a low level of refractive error as a result of limits set during selection for aviation. In the U.K., for aviators entering flight school, vision unaided in each eye must not be less than 6/12 (20/40), and each eye correctable to 6/6 (20/20). The strength of the required correction cannot exceed –0.75 to +1.75 dioptres (spherical) and the astigmatic element must not be greater than +/-0.75 dioptres (cylindrical). There is a tendency for refractive error to increase with age, especially in the mid to late twenties, and for individuals to develop presbyopia in their early forties. Both of these factors lead to an increased prevalence of spectacle wear with age, where individuals who did not previously need spectacles develop the need for refractive correction.

The mean refractive error for controls was essentially zero, or emmetropia, while the exposed group had a mean spherical equivalent refractive error in the myopia range; -0.45 for the right eyes and -0.38 for left eyes. This difference was statistically significant (right eyes, $p = 0.02$; left eyes, $p = 0.03$). The difference is most likely due to the difference in age of the two groups, in keeping with a trend toward increasing myopia with age.

High contrast visual acuity

Visual acuity is an important measure of visual capability of pilots. While visual acuity was expected to be 6/6 (20/20) or better (0.00 logMAR) for this population, the actual measures were closer to 6/8 (20/27 or 0.12 logMAR) for both groups. This reduced acuity was a consequence of measurements of acuity using each pilot's own eyeglasses, which may or may not be current, or for those subjects without glasses, low amounts of uncorrected refractive error. There was not a statistically significant difference in the high contrast visual acuity of the two groups (right eyes, $p = 0.11$; left eyes, $p = 0.35$).

Low contrast visual acuity and Small Letter Contrast Sensitivity

The ability to see low contrast letters is affected by the optics of the eye and/or the sensitivity of the retina. Optics of the eye includes clarity of the media, cornea and lens, and pupil size; both tend to decrease with age. However, the mean age difference between the two groups was only 8 years, the two groups are still relatively young, and changes are generally not evident until the 5^{th} or 6^{th} decade of life. Retinal sensitivity also declines with age; however, the same general trends apply as seen with optical changes with age. Fewer subjects in each group were measured on this test than for the high contrast visual acuity test, as previously explained. The mean performance across eyes for the control subjects was 6/14 (20/48 or 0.36 logMAR) for the low contrast acuity test and 0.98 logCS for the SLCT. The mean performance across eyes for the exposed subjects was just slightly worse at 6/15 (20/50 or 0.39 logMAR) on the low contrast test and 0.91 logCS for the SLCT. There was not a statistically significant difference between groups for low contrast visual acuity (right eyes, $p = 0.43$; left eyes, $p = 0.22$). The same was true for the SLCT results (right eyes, $p = 0.13$; left eyes, $p = 0.18$).

Depth perception

The mean depth perception score for the control group was 26.1 seconds of arc and for the exposed group was 26.5 seconds of arc. This represents excellent depth perception, 40 seconds of arc or better is the standard for U.S. Army aviators. Only one control subject performed worse than this standard. There was not a statistically significant difference between the groups ($p = 0.62$).

Colour perception

Control subjects, on average, had a colour perception score of 64.9 for the right eyes and 64.3 for the left eyes. Exposed subjects had only a slightly higher colour perception score of 66.7 for right eyes and 67.9 for left eyes, on average. The twelve control subjects who were outside the norms for colour perception may have mild to moderate levels of colour deficiency; one of these subjects had the maximum error score and appears to have severe colour deficiency or failed to complete the test appropriately. Among the exposed subjects, two were outside the norms for colour perception and may have a mild level of colour deficiency. There was not a statistically significant difference between the groups (right eyes, $p = 0.31$; left eyes, $p = 0.17$).

Accommodation

The results of the accommodation test were broken down according to age, since accommodative capability naturally decreases with age (Borish, 1954). The control group included younger subjects between the ages of 20 and 29; there were no subjects in this age range for the exposed group. The mean accommodation for the 30 to 39 year olds in the control group was statistically significantly lower than that measured for the same age range in the exposed group (1.3 dioptres less for right eyes, $p = 0.04$; 1.5 dioptres less for left eyes, $p = 0.02$). While these differences are statistically significant, they are not clinically significant. For the 40 to 49 year age groups, controls again had a lower mean accommodation than exposed subjects. However, this difference was not statistically significant (2.7 dioptres less for both eyes, $p = 0.14$). These differences are more clinically significant; however, these differences were driven by two of the exposed subjects performing significantly better than predicted for their age. Predicted accommodation for these two subjects, aged 40 and 41, is around 6 dioptres as opposed to their performance level of 12 dioptres in each eye. The rest of the exposed group had a mean performance level of 3.7 dioptres (SD 0.67), which is more in keeping with the measured mean performance of the control group.

Eye muscle balance

Heterophoria is a measure of the solidness of ocular alignment and binocular fusion to a target at a given distance. Individuals who are orthophoric maintain ocular alignment on the target even when one eye is covered, breaking binocular fusion. For both groups, orthophoria was the most common condition for both distant and near targets. The pilot selection process favors this finding of excellent eye muscle balance. Esophoria, the tendency for convergence of the eyes when fusion is broken, was the next most common finding, especially for distant targets. Only three control subjects had exophoria, a divergence tendency, and one control subject had hyperphoria, a vertical misalignment tendency, for distance viewing. The distribution of heterophorias was very similar for both groups and was not statistically different between groups (distance, $p = 0.77$; near, $p = 0.80$).

Eye preference (dominance test)

Both groups demonstrated a right-eye preference when tested using the "hole" dominance test. The control group proportion was 87%; the exposed group proportion was 77%. However, the difference in proportions was not statistically significant ($p = 0.521$). The right-eye trend in these proportions agreed with the eye preference question in the vision history section (Question 17) of the annual questionnaire, where 64% of control subjects and 79% of exposed subjects reported a right-eye preference. Both exposed subjects who previously indicated left-eye preference were found to be left eye dominant using the "hole" test.

Conclusions

At this early stage of the study, the constrained selection process for exposed subjects has resulted in an older and more experienced exposed group. This is a result of the current Apache aviator population consisting of entirely experienced aviators. An additional consequence of this selection process is a higher proportion of exposed subjects requiring vision correction. In turn, the higher proportion of exposed subjects requiring vision correction resulted in a higher proportion of contact lens usage, which is also driven by incompatibility issues between the IHADSS and use of spectacles.

The exposed group reported significantly higher incidences of headache, neck pain *during* and *after* flight, and SD. The use of the specialized IHADSS helmet by exposed subjects resulted in a lower acceptance rating for both quality and comfort of helmet fit.

At this 2-year stage of the study, there are only minor differences between the two groups in terms of refractive status and visual performance. The exposed group is more myopic than the control group, which is in keeping with the age differences between the two groups, as the exposed group is older. The control group has a lower level of accommodative range by age, which was not an expected finding; however this difference is probably due to the greater accommodative capability of a few exposed subjects within a much smaller sample size than the control subject pool. For all other visual measures, there is not a significant difference.

One of the primary concerns with prolonged use of the IHADSS system is the potential for differential vision changes between eyes. The vision test battery was specifically designed to include monocular measurements, such as refractive error, accommodation and visual acuity, to be able to assess differences between pilots who fly standard aircraft and those who fly with the monocular head-up display used in the Apache. To date, the only evidence of the impact of the IHADSS system on one eye versus the other has come from pilot reports on surveys or anecdotal reports. As the study progresses, we will be looking for any trends in visual performance or refractive error between eyes that may support or refute the presence of these differential changes.

Recommendations

As the study progresses, it is recommended that the following issues be addressed:

- The current small sample size for the exposed group can result in each response having an inflated effect on data means and proportions and statistical tests. Study administrators must take appropriate actions to increase exposed sample size.
- A common problem associated with the initial phase of cohort studies is developing stringent oversight of data collection. A small percentage of study questionnaires were not completed, resulting in missing data values. A tighter oversight of questionnaire completion is recommended.
- There is concern that study subjects having minimal flight experience may adversely affect study results. It is recommended that student pilots not be recruited for this study.
- A high percentage of exposed subjects require vision correction. It is recommended, where appropriate, that vision tests be conducted with and without vision correction.
- The current muscle balance test is complicated and difficult to administer by non-optometric medical personal, which can result in problems with accuracy and repeatability. It is recommended that some form of automated testing for this function be investigated.

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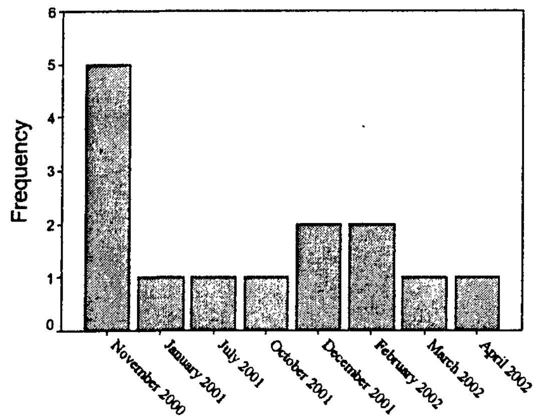
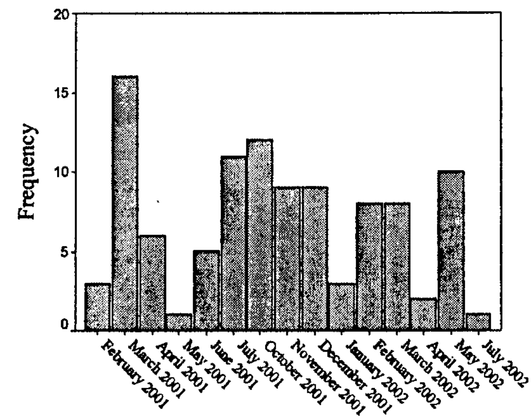
Appendix A.

Demographics questionnaire.

1. Date questionnaire completed: _____ (YYMMDD)

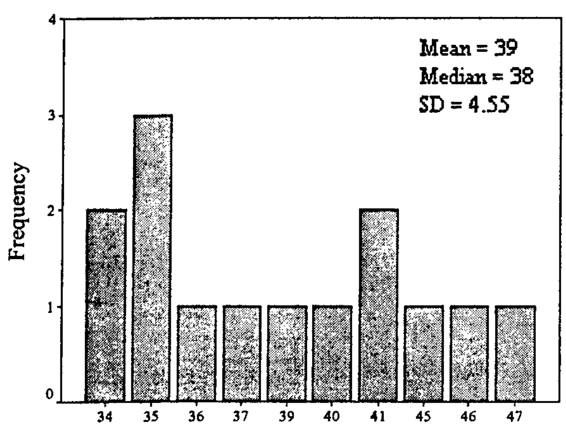


Completion of Questionnaire (exposed)

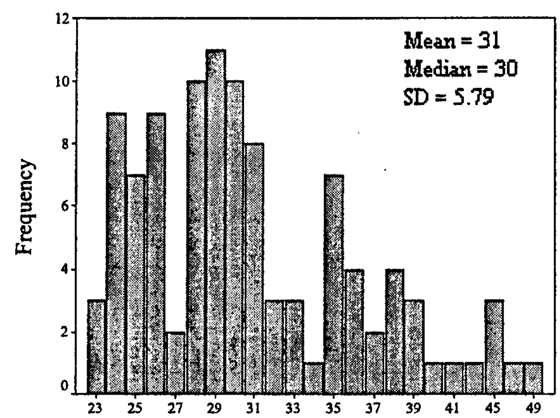


Completion of Questionnaire (control)

2. Present age: _____ yrs

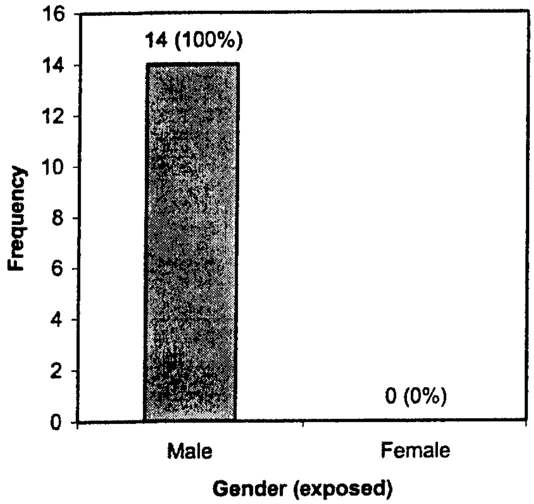


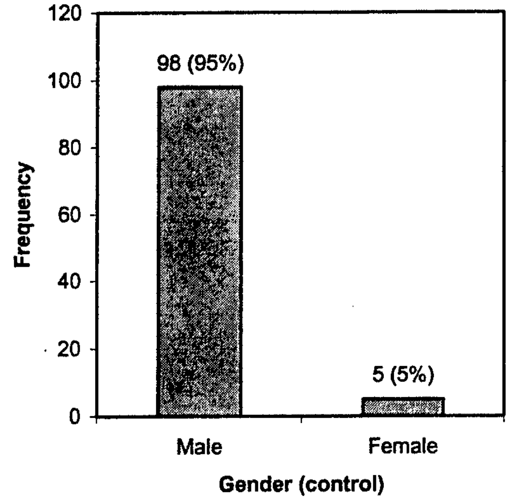
Age (exposed)



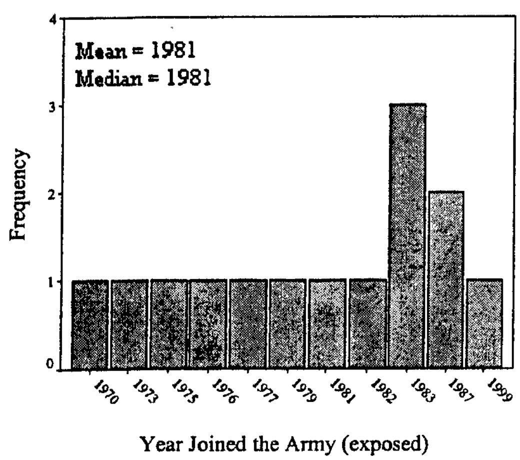
Age (control)

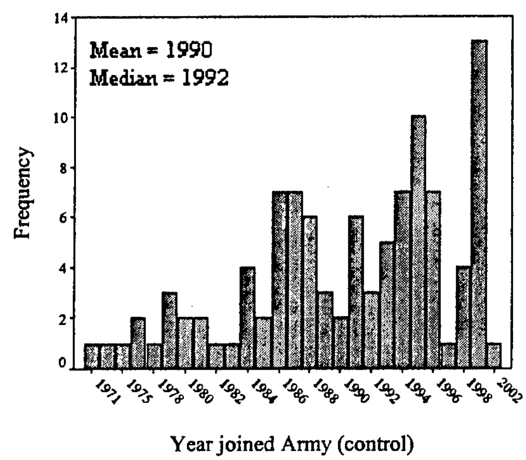
3. Gender: [ ] male [ ] female



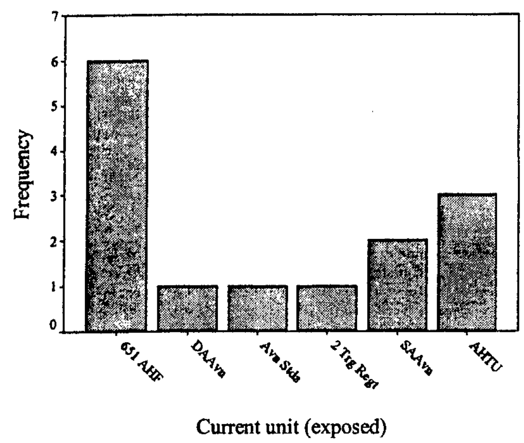


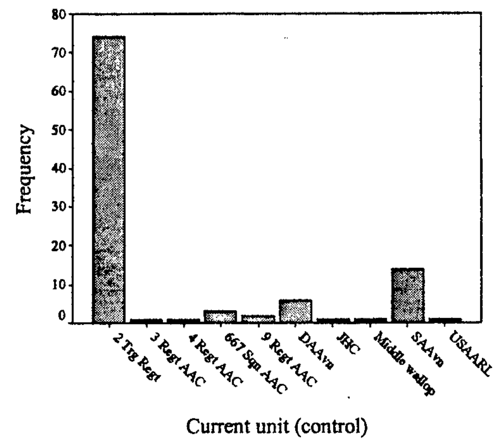
4. When did you join the Army?: _____





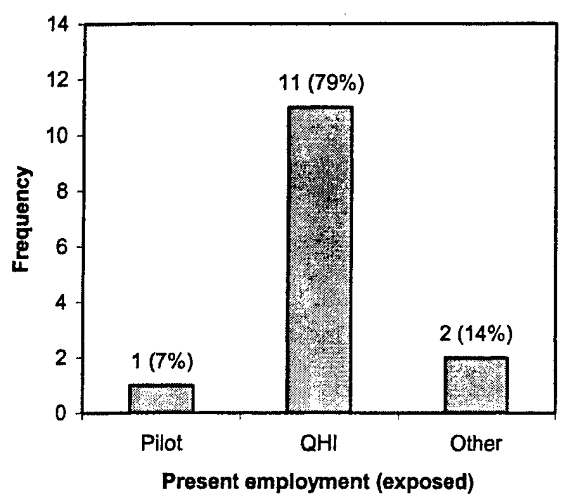
5. Current Unit: _____





6. Present employment (status):

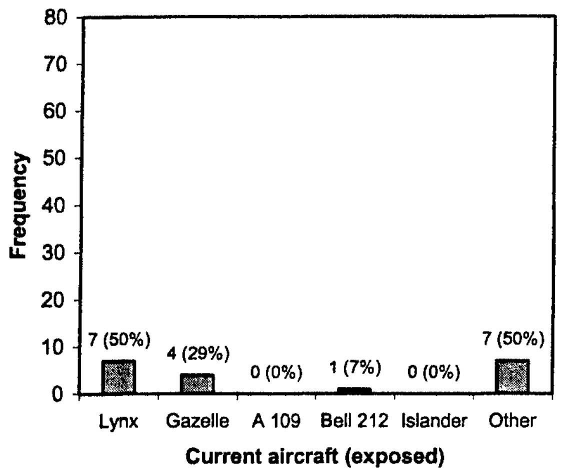
Pilot QHI Other (please specify)

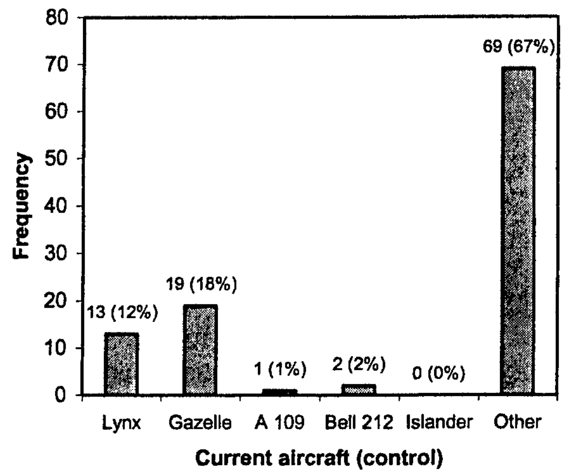


7. Aircraft currently flown (circle 1 or more):

Lynx Gazelle A109 Bell 212 Islander

Other (please specify) _____

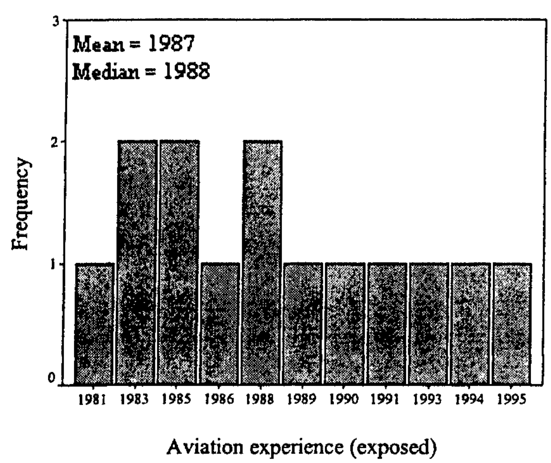


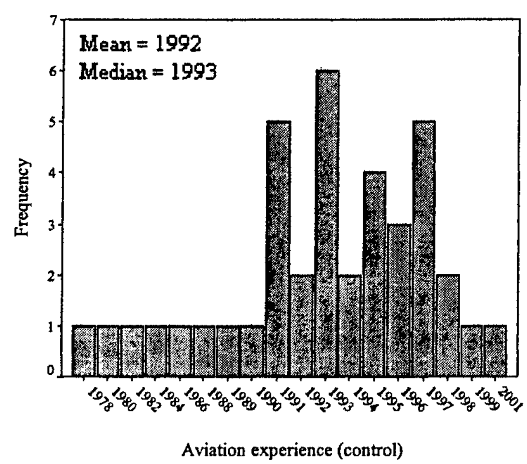


NOTE: Percentages may exceed 100 because subjects indicated multiple choices.

8. Aviation experience

Which year did you gain your wings? : _____





Appendix B.

Non-Apache (control) pilot questionnaire.

(some question numbers have been deliberately omitted in this questionnaire)

Date questionnaire completed: __________ **See Appendix A.**

Current Unit: __________ **See Appendix A.**

1. Present employment: Tick one only **See Appendix A.**

Line Pilot	[ ]
QHI	[ ]
Other (please specify)	[ ] __________

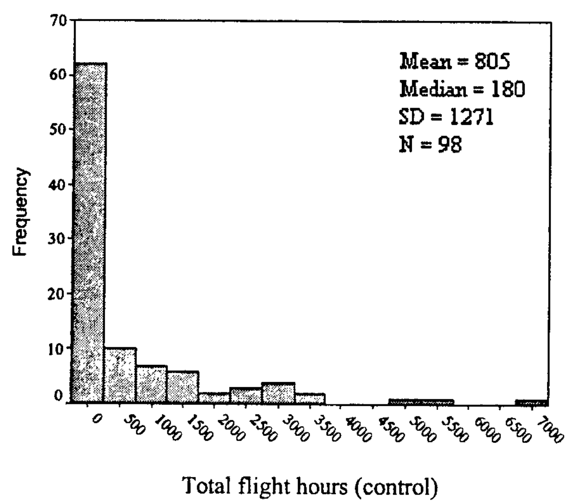
5b. Aircraft currently flown (circle 1 or more) **See Appendix A.**

Lynx Gazelle A109 Bell 212 Islander

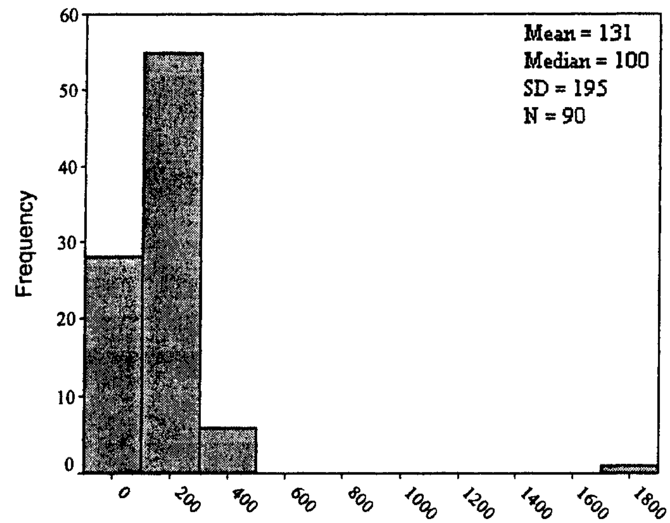
Other (please specify) __________

FLYING HOURS

6a. Total flight hours (rounded to nearest 10): _____

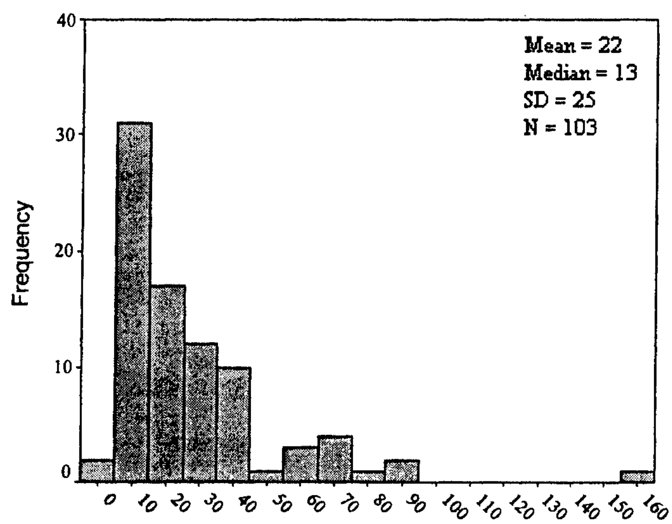


6b. Total flight hours in last year (rounded to nearest 10): _____



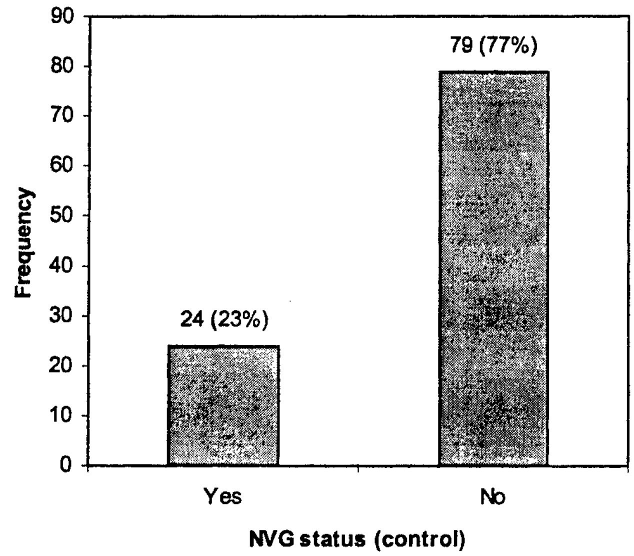
Total flight hours in last year (control)

6c. Total flight hours in last 8 weeks (exact): _____

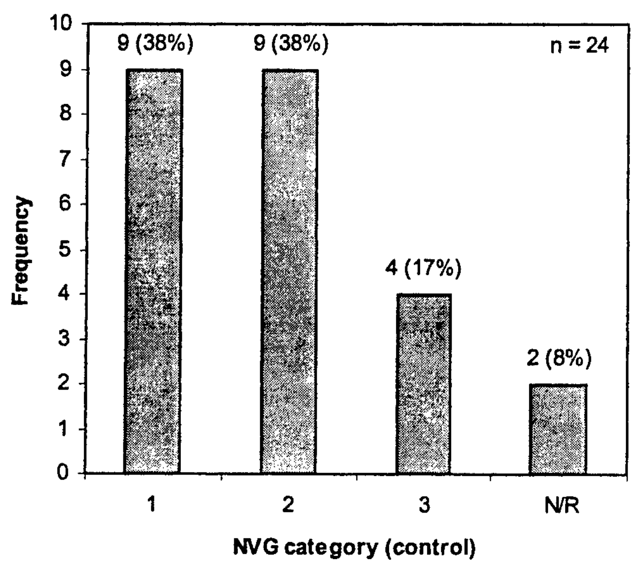


Total flight hours in last 8 weeks

8a. Are you NVG current? (Tick one only)

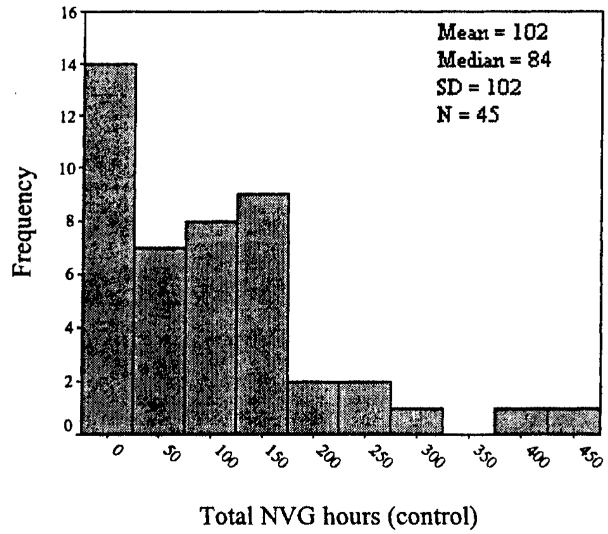


8b. If yes, what category? (Circle one only) 1 2 3

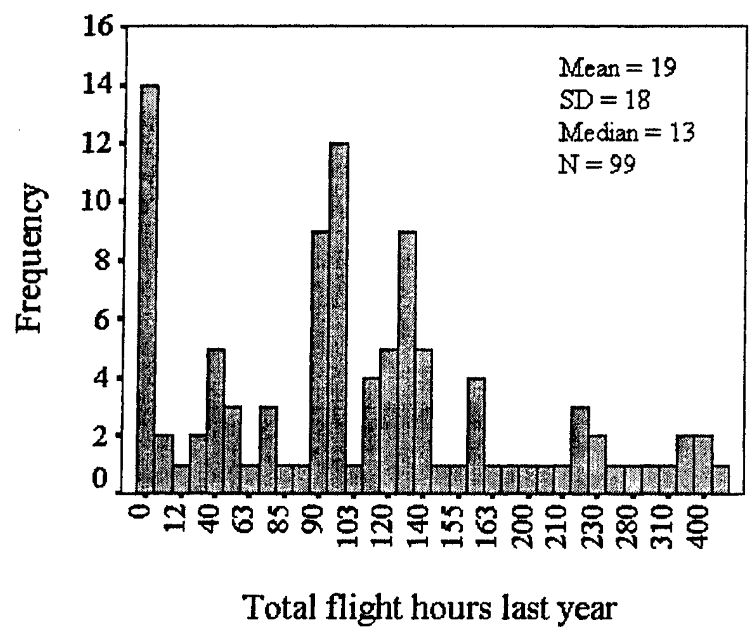


9. Please give approximate number of NVG hours

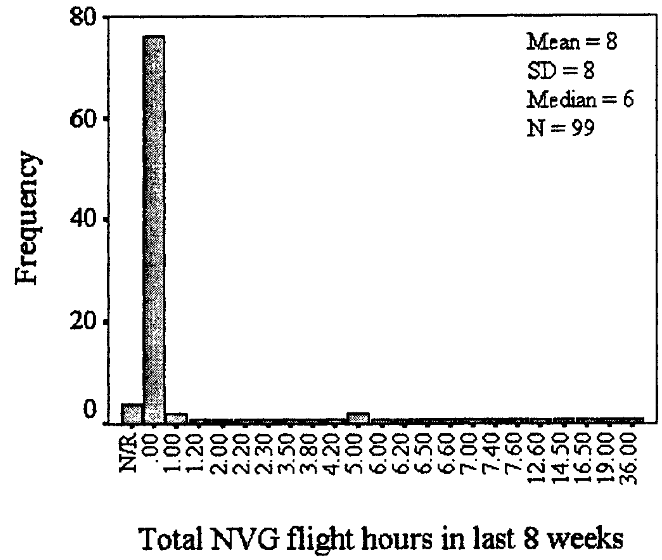
9a. Total NVG hours _____



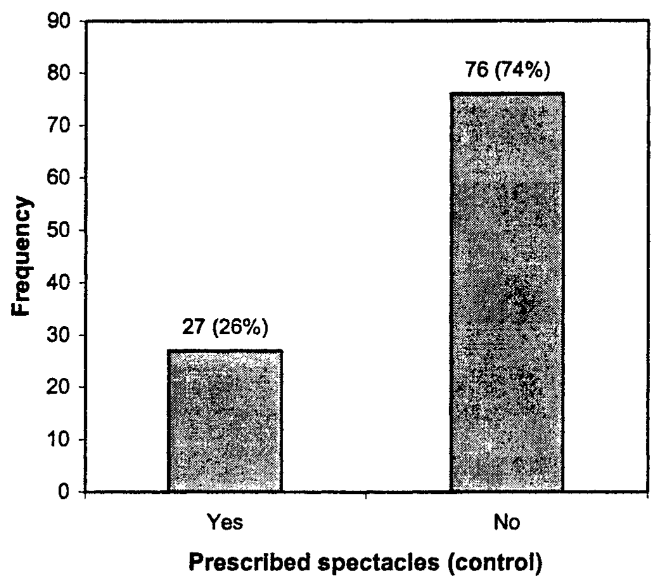
9b. In the last year: _____



9c. In last 8 weeks _____



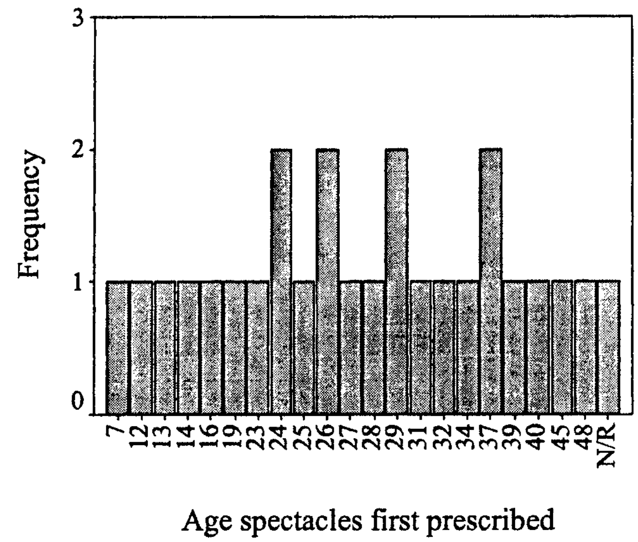
10a. Have you ever been prescribed spectacles? (Tick one only)



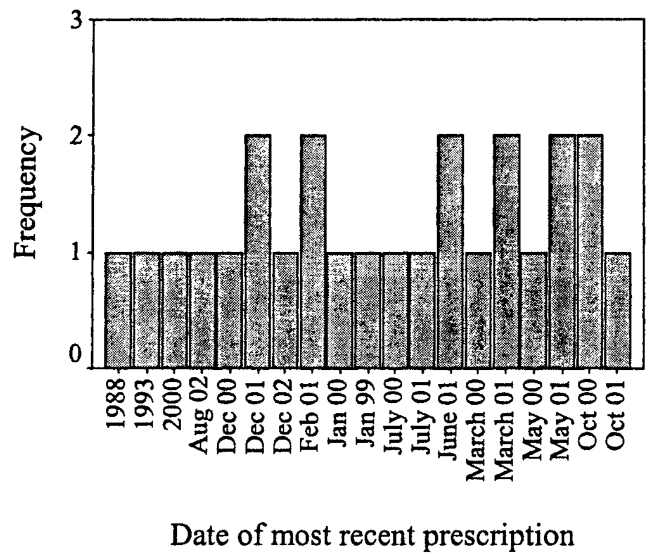
10b. If yes, please give reason for spectacles (For example, for distance, for reading/close work, all the time, flying only):

- Night driving.
- Reading, driving, flying.
- Night flying only.
- I was prescribed spectacles in 1993 for flying duties but I was told at my next ACM that they were not required.
- Initially flying only then driving, television, cinema etc.
- Close work.
- Myopia.
- Reading.
- Mild shortsightedness.
- Lazy left eye.
- Distance and night tired eyes etc.
- Computers reading close work
- Distance.
- For flying only.
- Reading close work.
- Computer use.
- Short sighted.
- Flying only.
- For distance and flying.
- Distance flying and driving.
- For distance.
- Presbyopia 2.00, + 1.00 both eyes.
- Reading, flying and close work.
- Reading or working with computers.
- Distance.
- Slight astigmatism. Proved useless not worn for 12 years.
- Distance.
- Flying only.

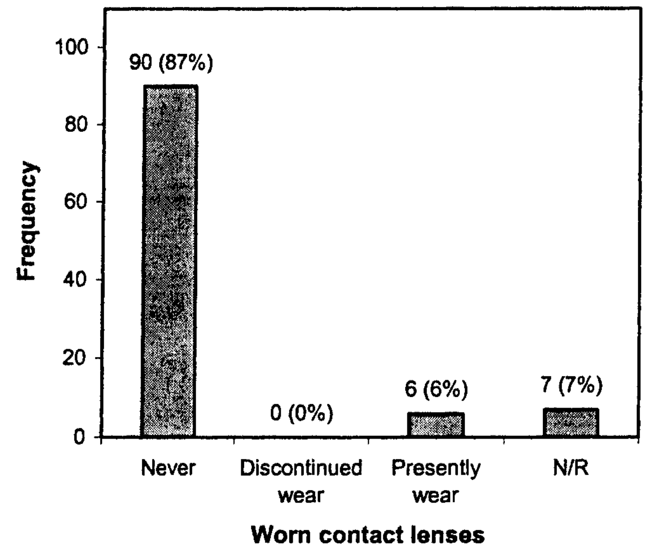
10c. Age when spectacles were first prescribed: ____________



10d. Date of most recent prescription: ________________

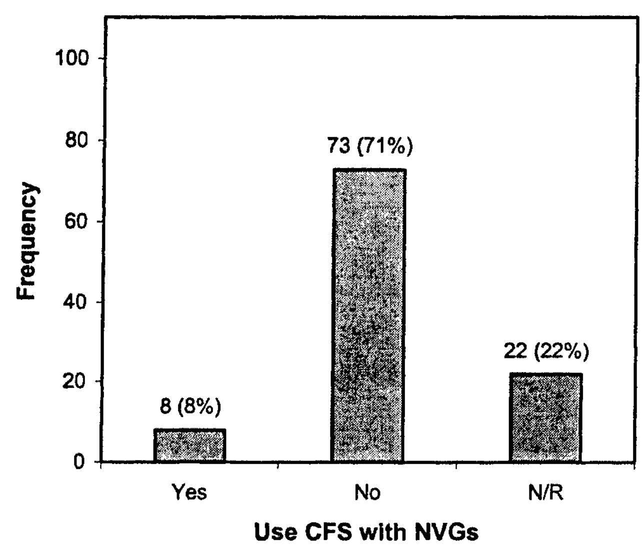


11. Have you ever worn contact lenses? (Tick one only)

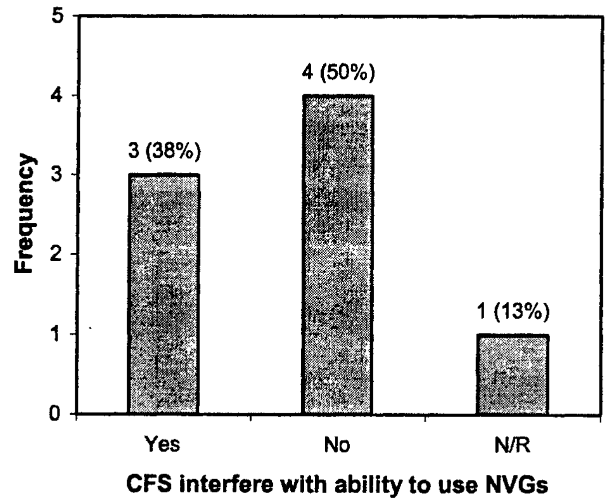


If discontinued contact lenses within last year or presently using, please fill out the supplemental form (Appendix F) for contact lens users.

12a. Do you use the corrective flying spectacles (CFS) with NVGs? (Tick one only)



12b. If yes, do the CFS interfere with your ability to use the NVG?

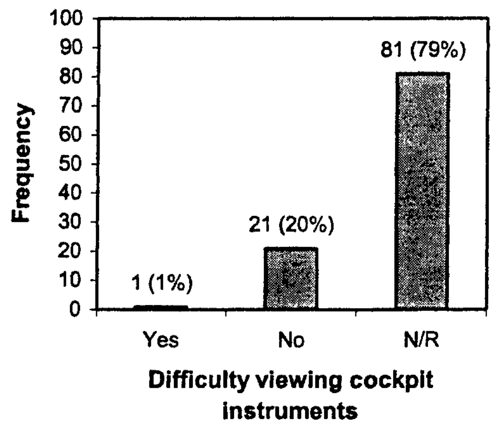


12c. If yes, please explain:

- No NVG .
- I cannot wear the FPV with glasses. The two do not fit together.
- Only with FPV fitted.
- Headache.
- Steam up or mist up badly in summer and winter.

13. If you do require spectacles for flying, but do NOT use the CSF or contact lenses, do you experience any difficulty:

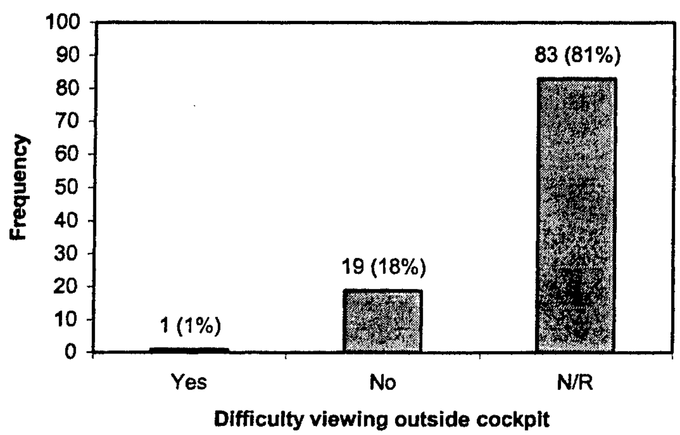
a. When viewing cockpit instruments?



b. If yes, please explain:

a. I always use the CFS, otherwise I may have difficulties.
b. Spectacles slope down on my nose and require repositioning every few minutes.

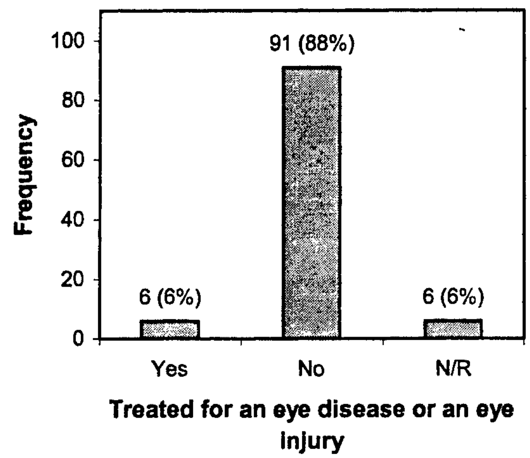
c. When viewing outside the cockpit?



d. If yes, please explain:

- No explanation provided.

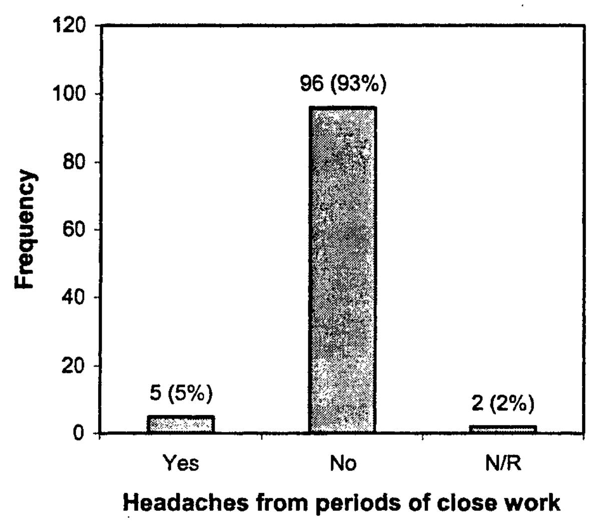
14a. Have you ever been treated for an eye disease or an eye injury?



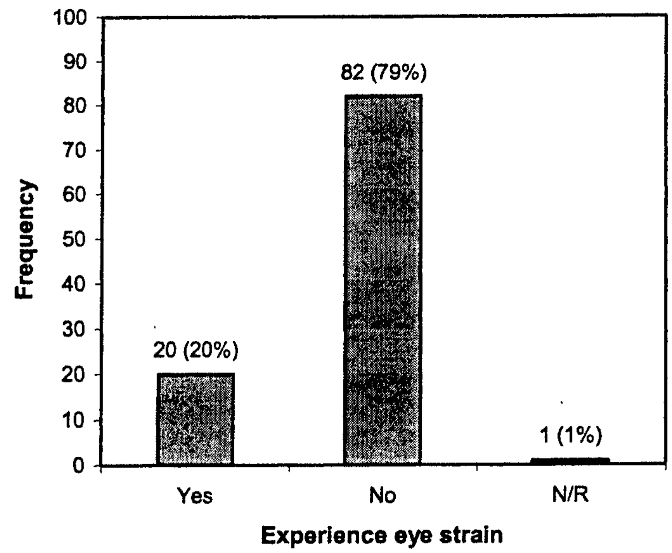
14b. If yes, please state when, for what reason, and do you have any continuing problems?

- Right eye socket damaged due to a heavy blow. Two plates fitted to aid recovery.
- In 1997 I was hit in my right eye by a chip of wood. I was grounded for 2 weeks. I have not had any problems to date.
- Conjunctivitis in childhood. No sequelae.
- Conjunctivitis dates unknown. No problem.
- Blocked tear duct.

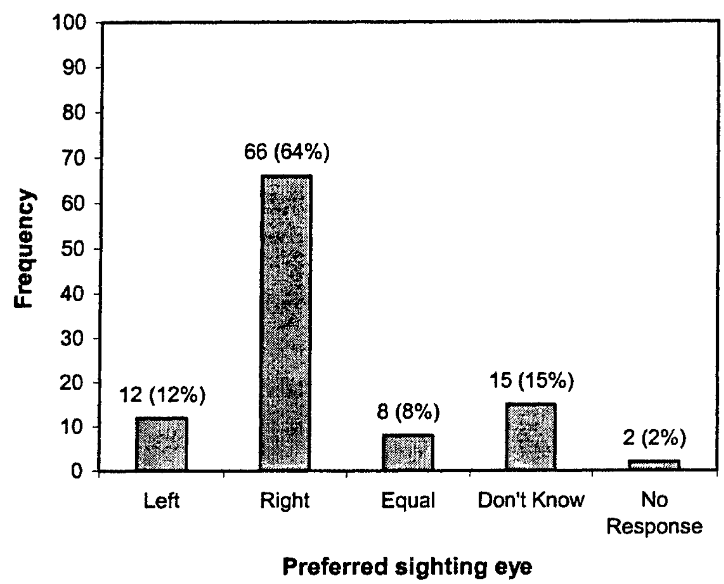
15. Do you get headaches from extended periods of close work e.g., reading small print?



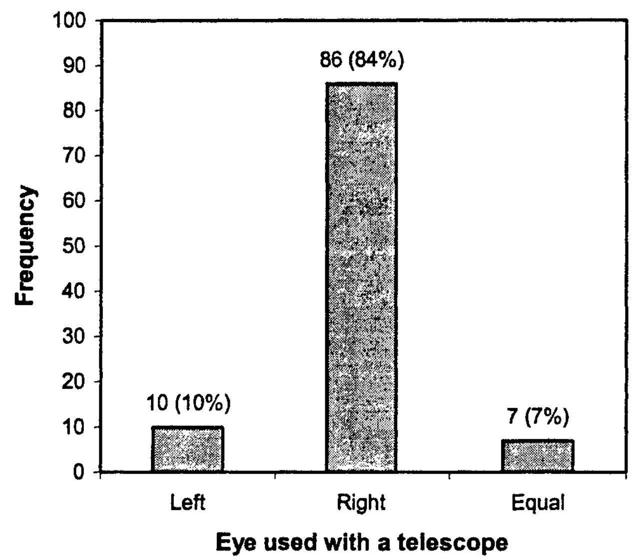
16. Do you ever experience eye-strain?



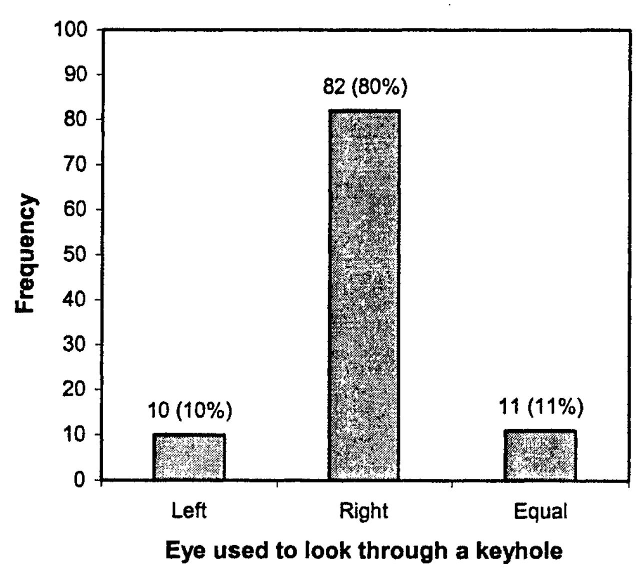
17. Which is your preferred sighting eye? (Tick one only)



18. Which eye would you use with a telescope?



19. Which eye would you use to see through a keyhole?



21. <u>While flying</u>, have you experienced (tick one box on each row only):

If other than never, please comment on how often, duration of symptoms, severity of symptoms and impact on that flight.

a. Visual discomfort:

Never [ ] Sometimes [ ] Always [ ]

Comment:

- Poor set of NVG 1992/3 NVG flying post use of goggles, minor discomfort.
- Night or poor weather conditions (clouds). Very low occurrence.
- During prolonged use of NVG less than 3 hours.
- Rarely after several hours of NVG.
- Very infrequently when on NVG for long period. Nil impact.

b. Headache:

Never [ ] Sometimes [ ] Always [ ]

Comment:

- A poorly fitted helmet.
- Helmet feels tight.
- Always been due to helmet.
- Helmet too tight just after refit.
- With CFS. Rare because I normally used contact lens.
- Post helmet refit only duration- duration of sortie minus 20 minutes. Impact discomfort until sortie complete. Severity varies.
- Probably dehydration.
- Due to poor helmet fitting, corrected after sortie.
- New glasses on NVG.
- Hot days.
- Helmet was too tight, corrected after flight.
- Rarely usually when dehydrated.
- During periods of long hours and reduced sleep.
- Poor helmet fit.
- A couple of times when very tired. No effect.
- Effect of helmet pulling hair on scalp.
- Rarely if a little dehydrated preflight.
- Slight headache from helmet following long periods of flying.
- Minor.
- If only really bright and I squint.
- After long working day ending with NVG.
- Helmet too tight, nil impact.
- Whilst using NVG or instrument flying (IF).
- Frontal (headaches) generally due to the helmet.

- Rarely occasionally > 4 hrs NVG.
- Very occasional, not severe.

c. Double vision:
Never [ ] Sometimes [ ] Always [ ]

Comment:
- Vibrations.

d. Blurred vision:
Never [ ] Sometimes [ ] Always [ ]

Comment:
- I use CFS all the time at night. Otherwise it would be blurred.
- 1992/3 NVG flying post use of goggles, minor discomfort.
- During prolonged use of NVG less than 3 hours.
- When very tired.

	Never	Sometimes	Always	No response
Visual Discomfort	95(92%)	8(8%)	0(0%)	0(0%)
Headache	73(71%)	30(29%)	0(0%)	0(0%)
Double vision	102(99%)	1(1%)	0(0%)	0(0%)
Blurred vision	100(97%)	3(3%)	0(0%)	0(0%)

e. After Images:
Never [ ] Sometimes [ ] Always [ ]

Comments: move over
- Flying near other A/C (aircrafts) with their strobes on.
- Bright lights.
- Pink/brown colorcast after NVG use.
- After NVG flight.
- After map study- often see map image when I blink.

f. Disorientation:
Never [ ] Sometimes [ ] Always [ ]

Comment:
- I.F. disorientation exercises.
- See grading history.
- Only when demonstrated.
- Leans.
- At night.

- Once solo IMC (Instrument Meteorological Condition) after long night duty in NI (Northern Ireland).
- The lens in early days of I.F.
- Leans with IF usual in actual (i.e. in clouds) 30 seconds no impact.
- Once on I.F. training.
- During I.F. but who doesn't.
- Occasionally leans during I.F. training infrequent duration less than 1 minute. Severity varies impact.
- In confined area on NVG /once/instructor took control.
- During flying. Mild symptoms, no impact.
- Poor weather conditions. Not often but can be severe.
- I.F. leans mild.
- Leans.
- Had leans after a 'UP' on an I.F. sortie. Subdued after regaining visual cues (2-3 minutes).
- Leans on instrument flying approximately 1 minute, no impact on flight.
- I.F flying.
- Leans on entry into IMC on occasion.
- Occasional leans during I.F.
- Instrument flying.
- Rarely on instruments.
- Instrument flying.
- IF at night on the odd occasion.
- Instrument flying.
- Leans – I.F. training occasional in actual has no effect on flight.
- Leans.
- After spinning exercise on fixed wing phase.
- I.F. the leans.
- Leans.
- In particularly marsh control inputs.
- Specific disorientation i.e. I.F. flying.
- Rarely and self-induced by occasional lapse in concentration.

g. Dizziness:
Never [ ] Sometimes [ ] Always [ ]
Comments:

- Twice in early stages of fixed-wing part of course.

h. Nausea:

Never [ ] Sometimes [ ] Always [ ]

Comment:

- Mild airsickness on occasion.
- Mountain flying in strong winds.
- If hungry/helmet tight.
- Initial airsickness.
- Only in the rear.
- I.F. trips if not actually flying.
- During ACT training. Duration until 10 minutes after cessation of ACT. Severity very close to being physically ill. Impact, cessation of aviation combat tactics (ACTS) maneuvering until symptoms reduced.
- Occasionally when carrying out a lot of "heads in" work.
- After confined area lessons.
- Spinning sortie in firefly; symptoms cleared once landed.
- On NVG only mild to moderate symptoms flight has continued after vomiting.
- When first flying fixed wing.
- Once a 'spinning sortie at jefts.
- Twice early stages of fixed wing part of course.
- Aerobatics on fixed wing rarely occurs.
- Aeros [Aerobatics] fixed wing.
- Very rarely if once or twice.
- On warm days during turbulence.
- Reading map in back, only last while head in cockpit.
- When first flying.
- FT (Flight training) aerobatics or FT low level turbulence never in rotary.
- Only briefly during prolonged aerobatics maneuvers.
- During prolonged aerobatics on fixed wing.
- Depends on the way I feel, sleep, and tiredness.
- Occasionally too hot but rarely.
- PFL (Practice False Landing) training "wingover."

	Never	Sometimes	Always	No response
After images	95(92%)	8(8)	0(0%)	0(0%)
Disorientation	65(63%)	37(36%)	1(1%)	1(1%)
Dizziness	101(98)	2(2%)	0(0%)	0(0%)
Nausea	73(74%)	26(25%)	1(1%)	0(0%)

22. After flying, have you experienced (tick one box on each row only):

If other than never, please comment on how often, how long post flight before symptoms began, duration of symptoms, and severity of symptoms:

a. Visual discomfort:

Never [ ] Sometimes [ ] Always [ ]

Comment:

- Itchy eyes post NVG (fire after sleep).
- Directly after removal of NVG. Up to 2 hours- minor.
- During prolonged use of NVG less than 3 hours.
- Adjusting afterwards.
- Poor focusing NVG.

b. Headache:

Never [ ] Sometimes [ ] Always [ ]

Comment

- Tight helmet.
- Occasionally area prolonged NVG flight in NI/ for few minutes, minor.
- Rarely when workload has been high 1-3 hours.
- Probably dehydration.
- During prolonged use of NVG less than 3 hours.
- On hot days drinking water helps.
- Due to possible eyestrain.
- Dehydration headache very occasional.
- If dehydrated.
- Helmet discomfort front of head.
- Post NVG.
- Short period after long working day ending with NVG.
- After NVG.
- Small headache after concentrating on flight.
- After NVG or instrument flying.
- Occasionally due to concentration example after I.F.

c. Double vision:

Never [ ] Sometimes [ ] Always [ ]

Comment:

- None

d. Blurred vision:

Never [ ] Sometimes [ ] Always [ ]

Comment:

- For a small amount of time.
- During prolonged use of NVG less than 3 hours.
- Hour after NVG but only infrequently.

	Never	Sometimes	Always	N/R
Visual discomfort	98(94%)	5(5%)	0(0%)	0(0%)
Headache	86(83%)	17(17%)	0(0%)	0(0%)
Double vision	103(100%)	0(0%)	0(0%)	0(0%)
Blurred vision	100(97%)	3(3%)	0(0%)	0(0%)

e. After Images:

Never [ ] Sometimes [ ] Always [ ]

Comment:

- Bright lights.
- Pink/Brown colorcast after NVG use.
- Post NVG.
- After NVG flight.
- Again map images sometimes.

f. Disorientation:

Never [ ] Sometimes [ ] Always [ ]

Comment:

- None.

g. Dizziness:

Never [ ] Sometimes [ ] Always [ ]

Comment:

- None.

h. Nausea:

Never [ ] Sometimes [ ] Always [ ]

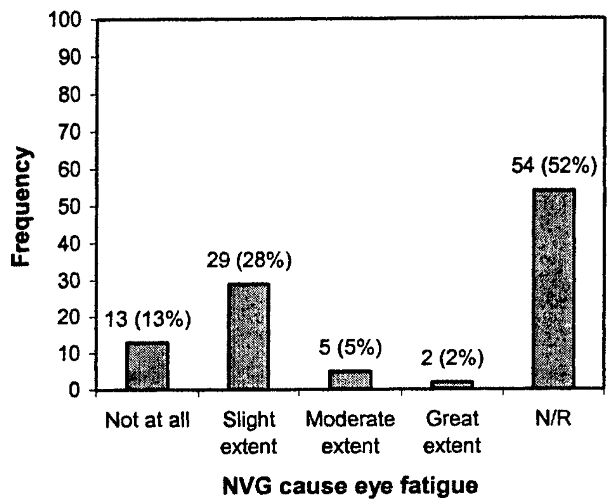
Comment:

- Once only.
- During prolonged use of NVG less than 3 hours.
- When first flying.
- Stress levels with flight.

	Never	Sometimes	Always	N/R
After images	95(94%)	6(6%)	0(0%)	0(0%)
Disorientation	103(100%)	0(0%)	0(0%)	0(0%)
Dizziness	103(100%)	0(0%)	0(0%)	0(0%)
Nausea	99(96%)	4(4%)	0(0%)	0(0%)
Unsteadiness	102(99%)	1(1%)	0(0%)	0(0%)

i. Unsteadiness or trouble with balance:
Never [ ] Sometimes [ ] Always [ ]

25a. To what extent does flying using NVG cause eye fatigue?



26. How do you use your visor? (not the Face Protective Visor) (tick one on each row ONLY)

a. Day:
UP [ ] DOWN [ ]

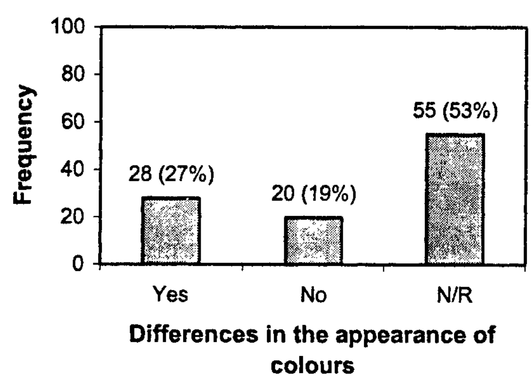
b. Night:
UP [ ] DOWN [ ]

Use of visor	Up	Down	N/R
Day	3(3%)	93(90%)	7(7%)
Night	31(30%)	58(56%)	14(14%)

26a. If either answer is "UP", please explain why.

- I.F flying on NVG cannot have it down?
- I use the FPV compatible for NVG (nightop).
- Only in bright sunlight.
- I feel safer at night due to higher altitude.
- Cannot lower visor with NVG fitted.
- When using NVG, down for reversionary.
- Looking through two sets of perplex often causes twin images and birds don't fly at night.
- Goggles stand too far off eyes. Problem with misting.
- Either using NVG or flying high.
- Cannot be put down when wearing NVG goggles.
- Because it interferes with the NVG goggle.
- Interacts with NVG position.
- Birds do not fly at night - little need for protection.
- Slight improvement in vision.
- Dark visor down at night stops you from seeing.
- Visor down at night causes reflection and bird strikes unlikely at night.
- Dark visor up at night only.
- No requirement to have visor down during night flying.
- NVG.
- I find the FPV with NVG very restrictive.
- Glint effect.
- I use an FPV.
- Use FPV at night NVG. Flew down at night unaided.
- Following instructor's advice.
- Would cause restrictive vision.
- Up using NVG. EPV issued but unsatisfactory. Visor down for reversionary night.
- It would be too dark.

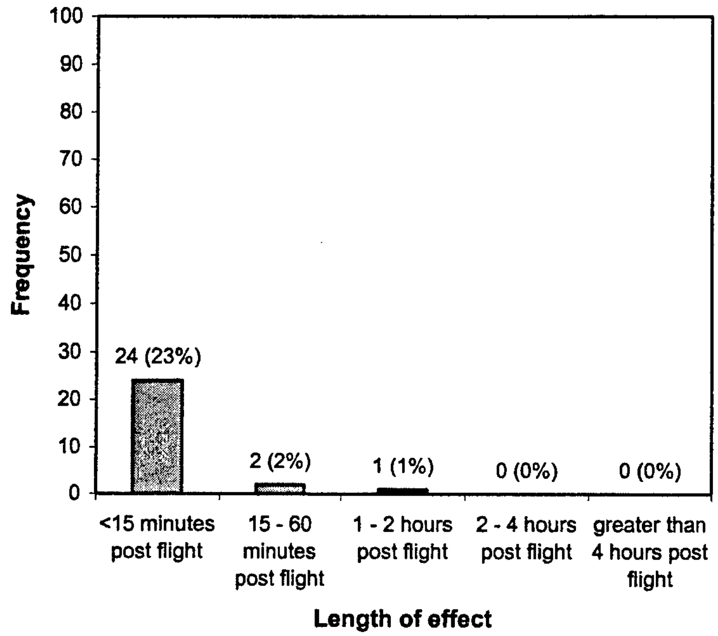
29a. After using the NVG, do you experience a difference in the appearance of colours?



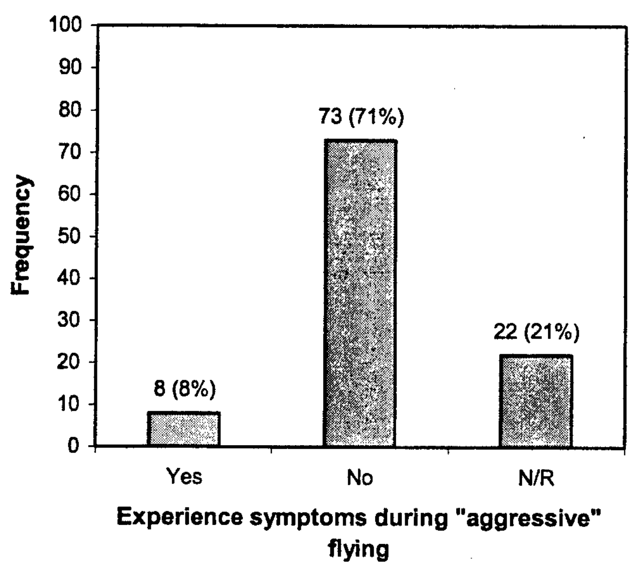
29b. If 'YES', please describe what seems different:

- Brown eye.
- A general brownish tinge for a short period.
- Brown eye.
- Everything goes brown.
- After prolonged use there is a short period of brown eye.
- Brown vision for up to 5 minutes.
- Magenta eye for up to 5 minutes.
- Only brown eye.
- Browning of lights for about 1 minute.
- Brown appearance.
- Green brown shading.
- Green obstacles become brownish.
- Everything a shade of red.
- Brown eye only on white light maximum 1 minute.
- Brown tinge to objects.
- Brown/pink color on instrument lights and clear lights.
- Discoloring, sometimes browning of image.
- Pink/brown colorcast after use.
- As 2 door gunner, browning of color.
- Brown eye for a few seconds.
- Brown out.
- Red blur.
- Only for limited period and immediately after removing NVG ' brown out'.
- Brown eye only after long periods.
- Area illuminated by white light looks brown or brown tinge.
- All colors appear brown for small amount of time.
- Brown eye.
- Brown out for 1/2hours after 1 hour of NVG.
- Browning for about 10 minutes.
- Pink and brown hues for a short period.

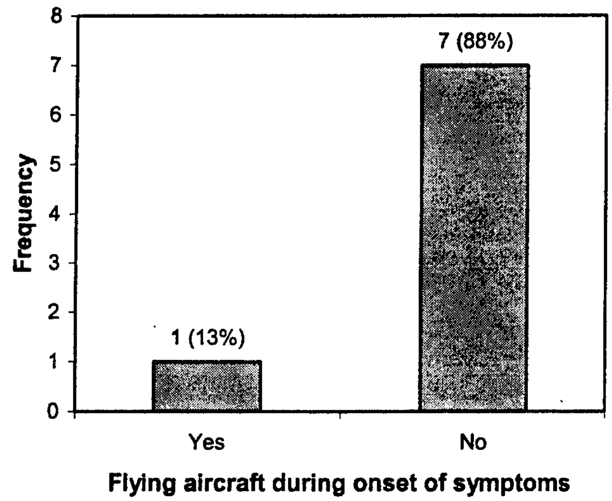
29c. If 'YES', how long does this effect last? (tick one only)



30a. Have you ever experienced symptoms of faintness, greying or loss of vision of any kind during periods of "aggressive" flying?



30b. If "YES", were you flying the aircraft at the time?



Describe the symptoms, their severity and duration, and the flight profile at the time of the incident.

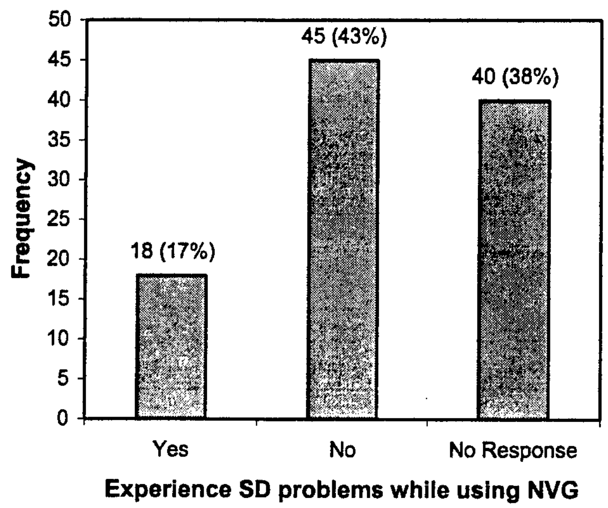
DISORIENTATION

The definition of Spatial Disorientation (SD) used in the UK is as follows:

A failure to perceive correctly one's position, motion or attitude with respect to the earth's surface (horizontal reference) or the acceleration due to gravity (vertical reference).

It is NOT getting lost - that is geographical disorientation.

32a. Have you ever experienced any SD problems while using NVG?



32b. If yes, please explain the situation and cause. Include degree of SD with a description:

- It was demonstrated once but that was it.
- Temporary SD due to poor goggle performance.
- The leans, very mild.
- Reduced depth perception and therefore separation analysis. Loss of peripheral field reduces awareness of speed.
  While landing on snow covered lake. While snowing in middle UK for CASEVAC (Casualty evacuation). In Norway severe SD until more references gained by ground troops.
- SD in confined area in [Northern Ireland]. Instructor took control.
- From looking through goggles to viewing instruments for too long (+1 min). A/C altitude changed took 3-4 seconds to readjust (minor SD).
- Low light levels mainly jungle flying (winching and confined areas) degree ranges from mild to moderate with occasional vomiting after landing. Increased frequency of NVG flying normally improves situation de-sensitized.
- Valley flying. Knew valley bottom. Sloped away from me but appeared to be climbing. The river looked as trough it was flowing up hill.

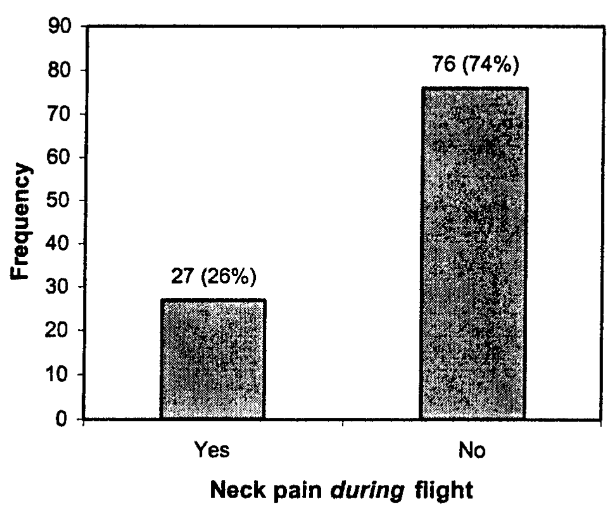
- During flight "white out" conditions in Norway, a transitional loss of SD due to lack of external references and insufficient references to AC instruments.
- Leans IF.
- On instruments occasionally.
- I am an inexperienced pilot with experienced commander. Who asked me to do a gate approach on NVG when never done. Lack of reference nearly over torque.
- Entry into dust cloud and landing at night.
- Minimal during initial NVG try. Drift in hover etc.
- It can sometimes take time to pick up the drift. Especially after a quick manoeuvre or quick acceleration or deceleration.
- Subtle drift in hover.
- Due to smaller focal circle/ no peripheral vision.
- Instrument flying occasional 'leans'. Only minor.

NECK PAIN

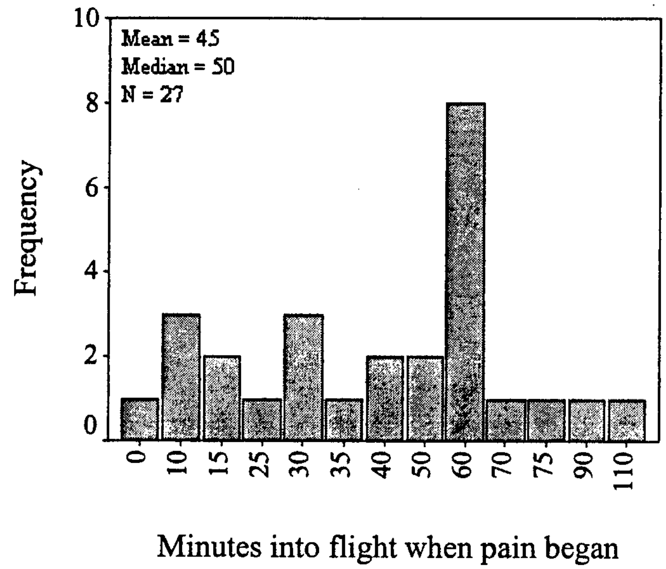
For the purposes of this survey, neck pain is pain ABOVE (but not including) the level of the shoulder blades. THERE ARE SEPARATE QUESTIONS ON NECK PAIN DURING AND AFTER FLIGHT.

40. Neck pain DURING flight

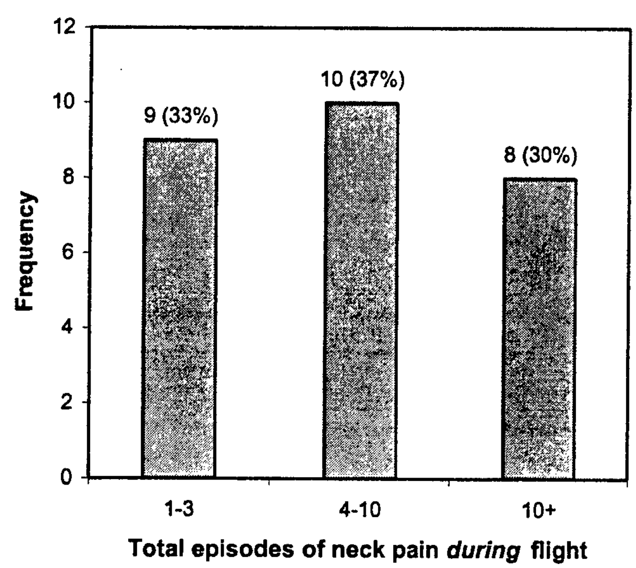
a. Have you ever experienced neck pain during a flight?



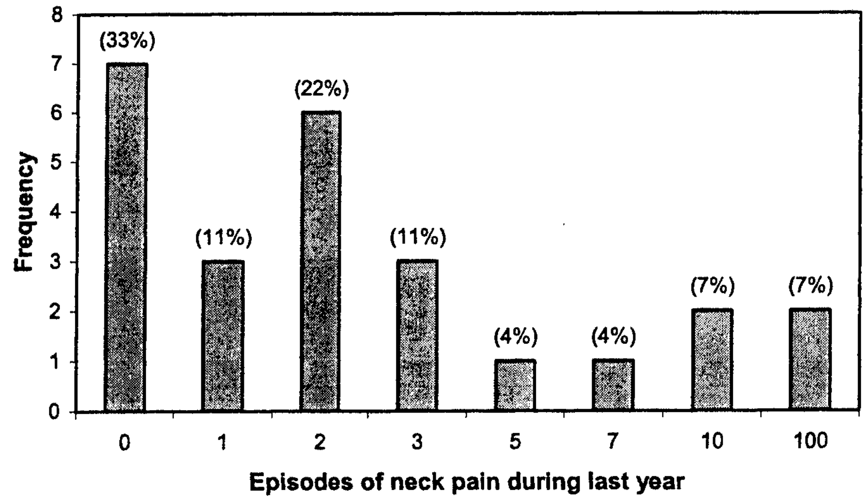
b. If you have experienced neck pain <u>during</u> flight, how long into the flight were you before the pain began? _____ minutes



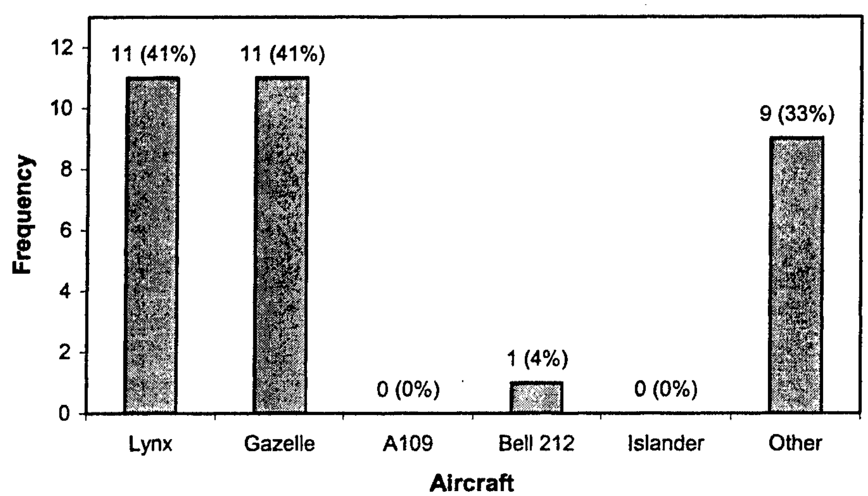
c. Please indicate the total number of episodes of neck pain you have experience <u>during</u> flight. (Tick one box only)



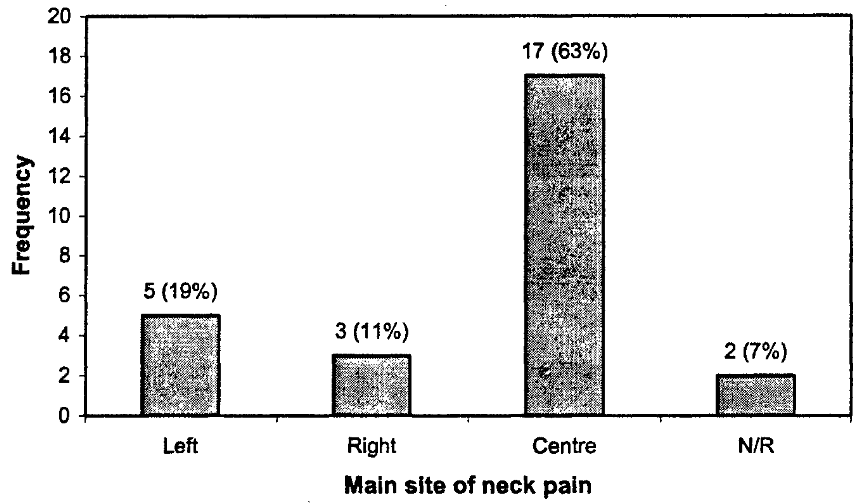
d. How many episodes of neck pain *during* flight have you had in the last year? ___



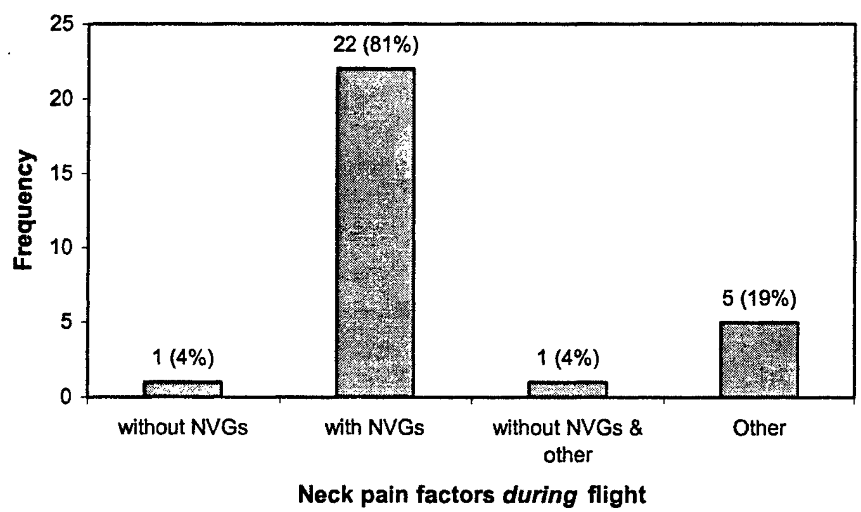
e. In which aircraft have you experienced your most frequent neck pain (circle 1 or more)



f. Where is the main site of your neck pain? (tick one only)

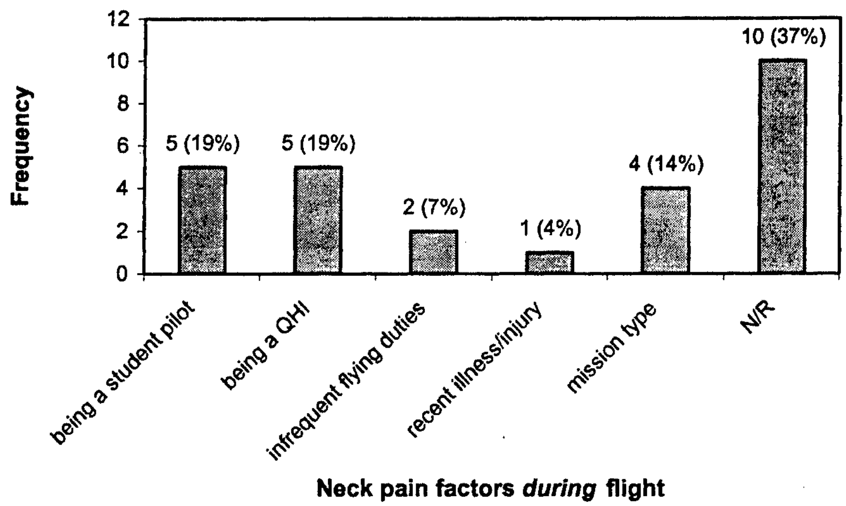


g. Which of the following factors resulted in your neck pain <u>during</u> flight?



- Display flying-Eagle Roll.
- Both with and without. With NVG more severe.
- I.F (Instrument flying).
- Weight of helmet worse when have not flown in a while.
- Incorrect weight fitted at rear of helmet. New helmet.
- Gazelle seat position.

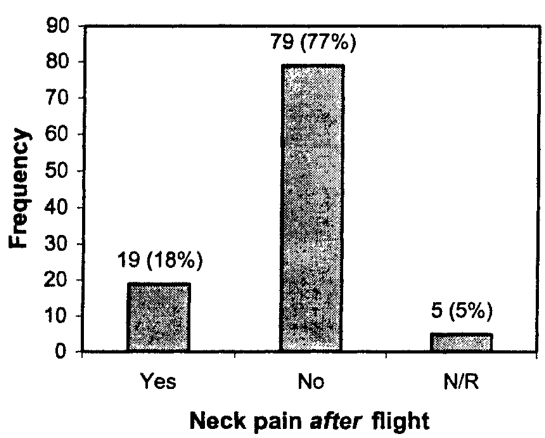
h. Indicate if any of the following factors may have influenced your neck pain <u>during</u> flight:



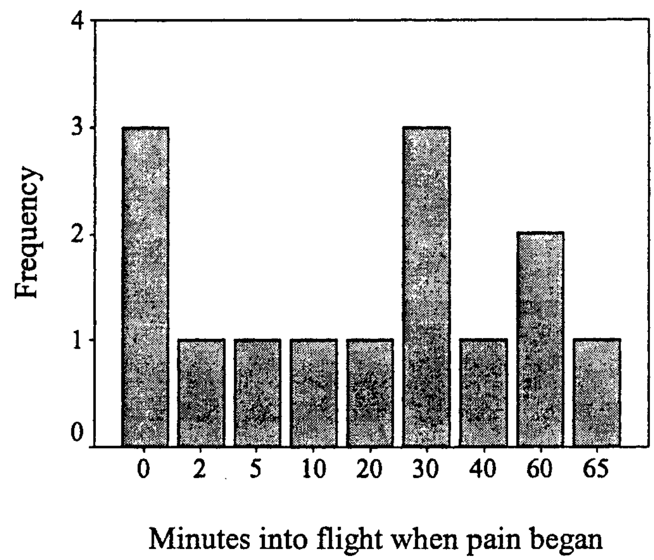
- Multiple A/C operations in Northern Ireland.
- Over 1 hr.
- Low-level missions.
- Chronic injury.
- Left hand seat Gazelle. Cramped cockpit stressful NVG sortie in mountainous terrain. No counterweight.

41. <u>Neck pain AFTER flight</u>

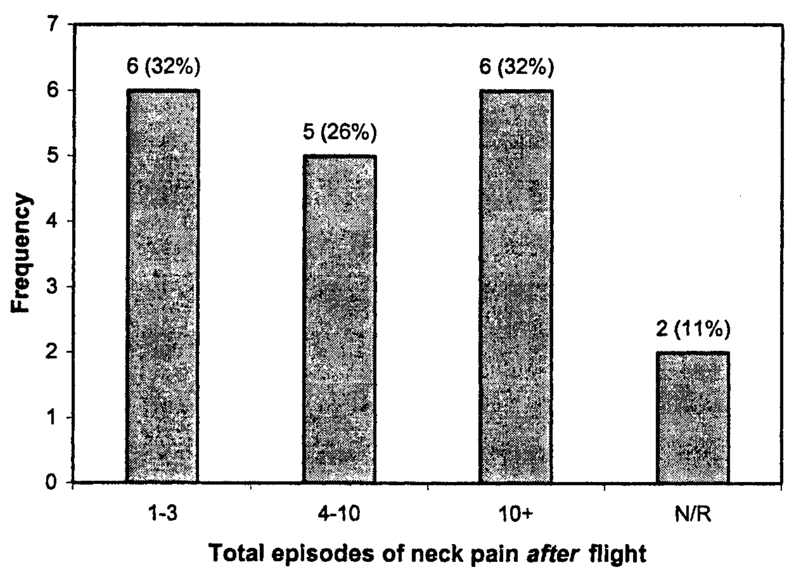
a. Have you ever experienced neck pain <u>after</u> a flight?



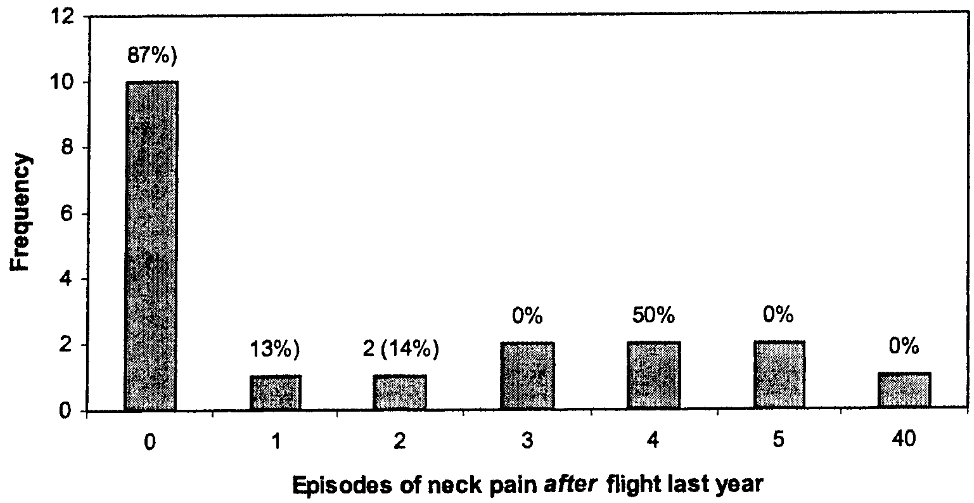
b. If you have experienced neck pain after flight, how long into the flight were you before the pain began? _____ minutes



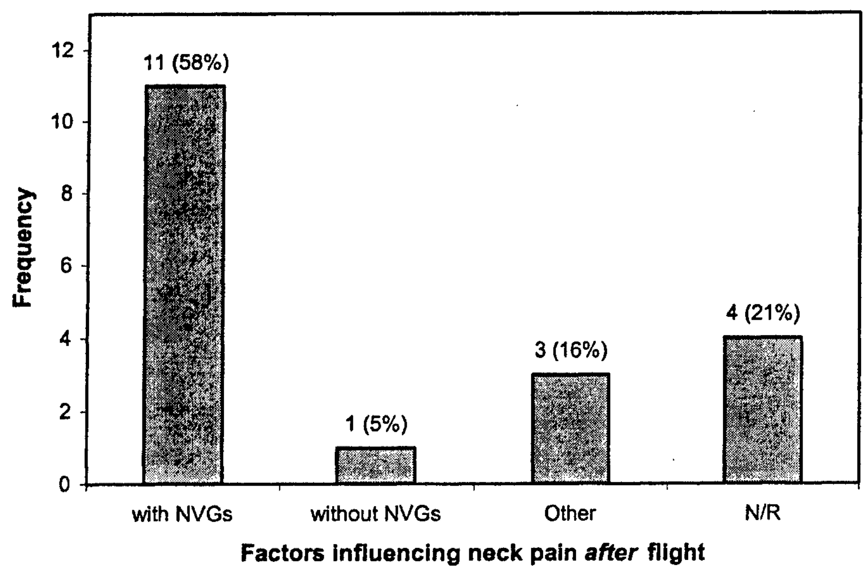
c. Please indicate the total number of episodes of neck pain you have experienced *after* flight. (Tick one box only)



d. How many episodes of neck pain *after* flight have you had in the last year? ___



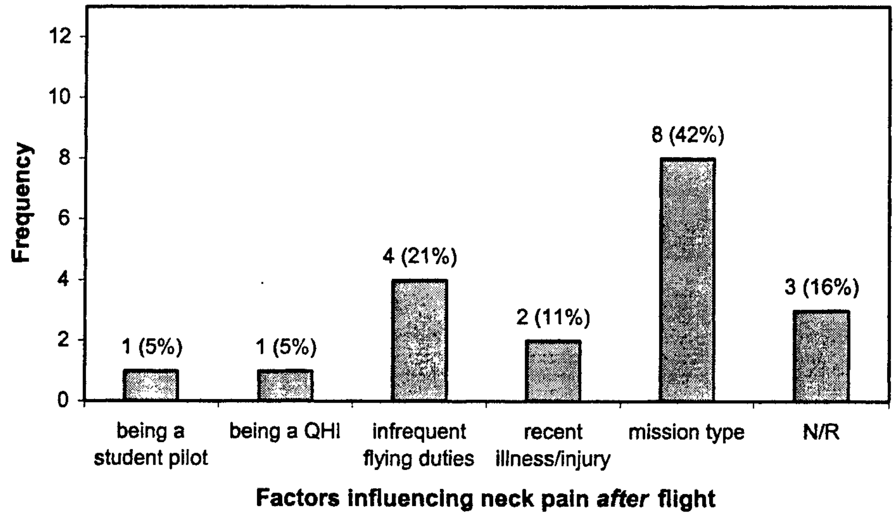
e. Which of the following factors resulted in your neck pain after flight?



please specify __________

- Injury

f. Indicate if any of the following factors may have influenced your neck pain <u>after</u> flight:



please specify __________

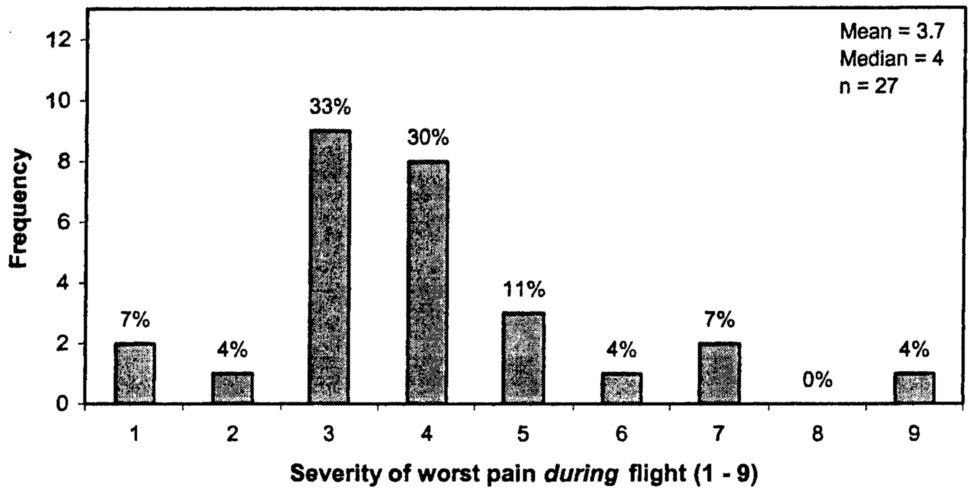
- Shown NVG mission in one night.
- + 1 HR.
- A lot of NVG flying at night/NVG flying in QH2 in France.
- Low level cat 2.
- Chronic injury.
- 5 hour tasking on NVG in Bosnia.
- Stressful NVG sortie in mountainous terrain. No counterweight.
- Multiple A/C operations in Northern Ireland.

42. Indicate the severity of neck pain, for the <u>worst</u> episode of pain experience during flight and after flight.

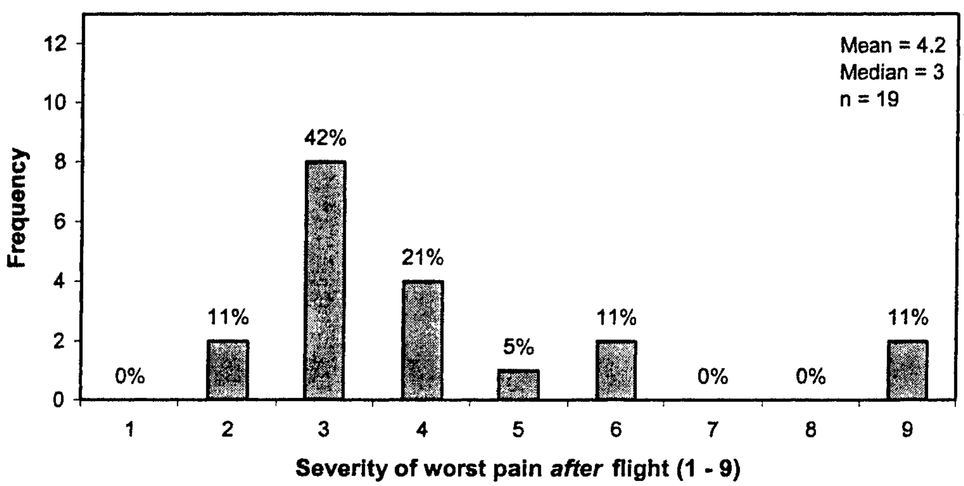
Grade the severity on a scale of 1 to 9.

1 = no pain 9 = incapacitating (e.g. resulting in handing over control or aborting the mission)

DURING FLIGHT __________



AFTER FLIGHT __________

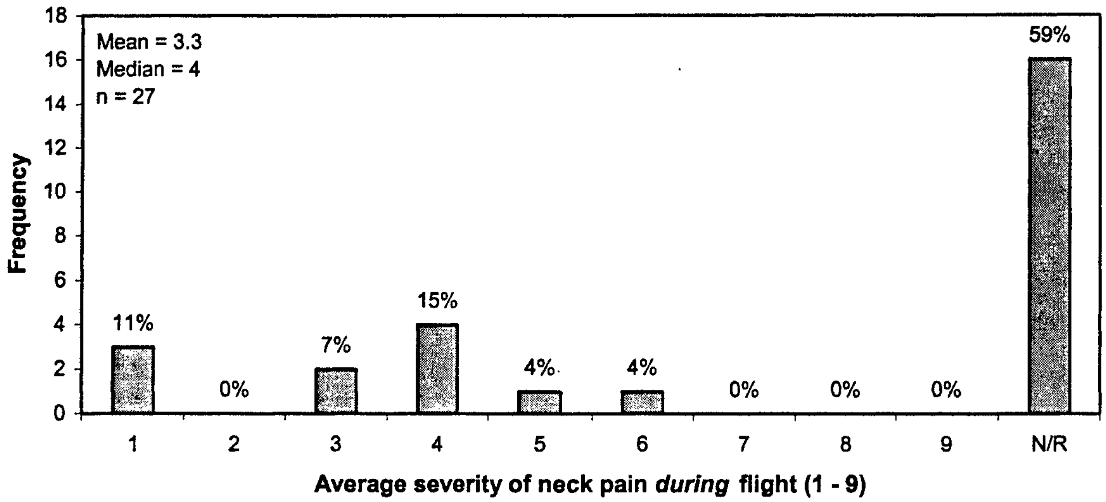


43. If you COMMONLY experience neck pain, please indicate an <u>average</u> severity of pain experienced.

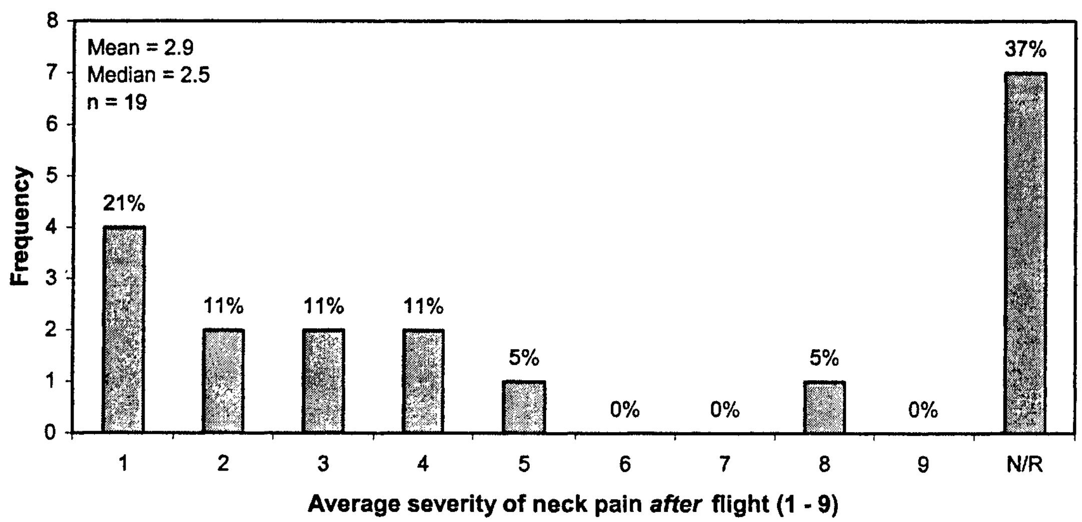
Grade the severity on a scale of 1 to 9.

1 = no pain 9 = incapacitating (e.g. resulting in handing over control or aborting the mission)

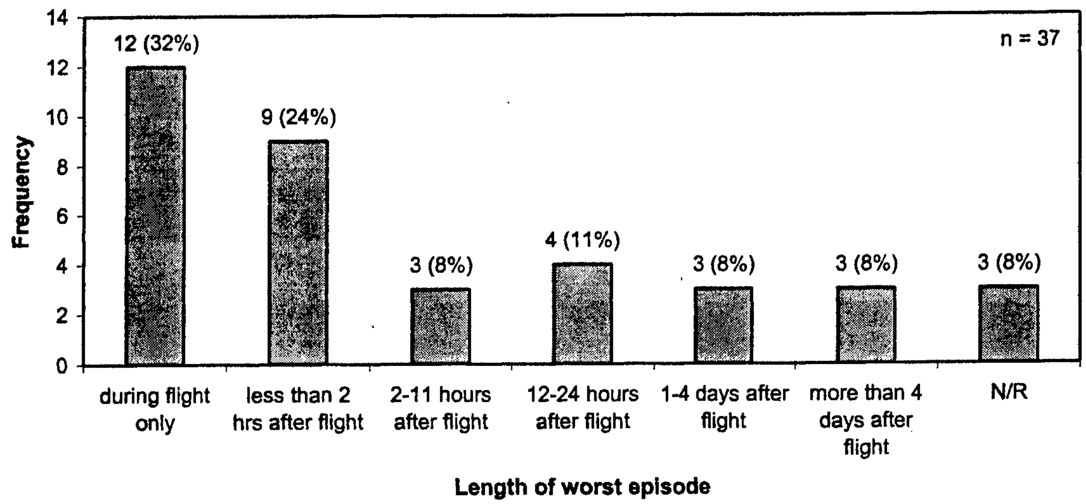
DURING FLIGHT ________



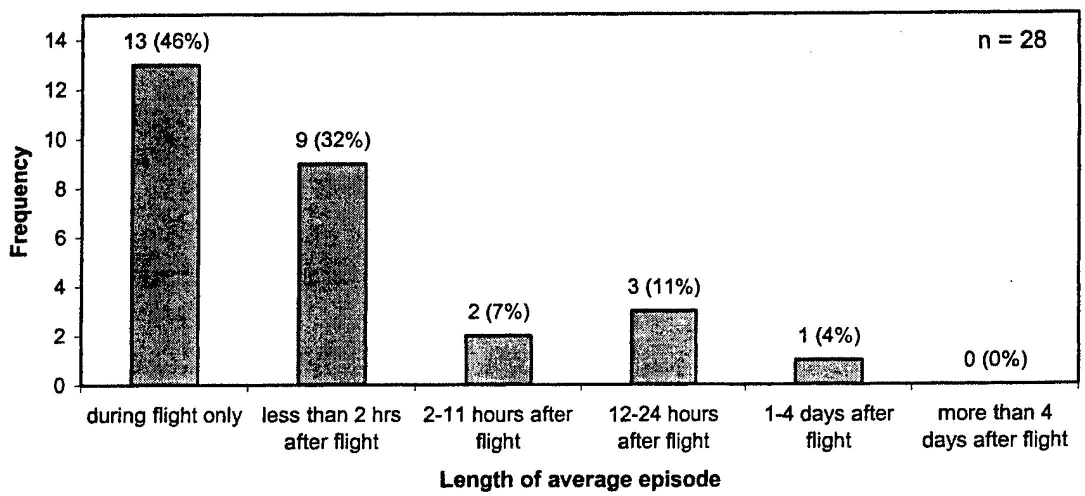
AFTER FLIGHT ________



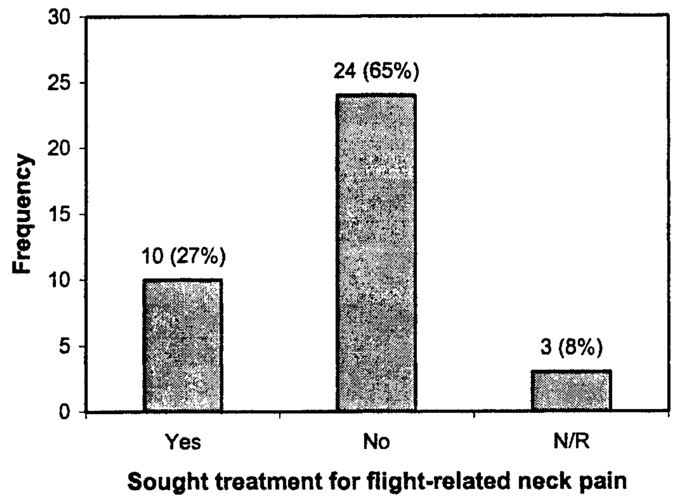
44. How long did the symptoms persist for the worst episode of neck pain?



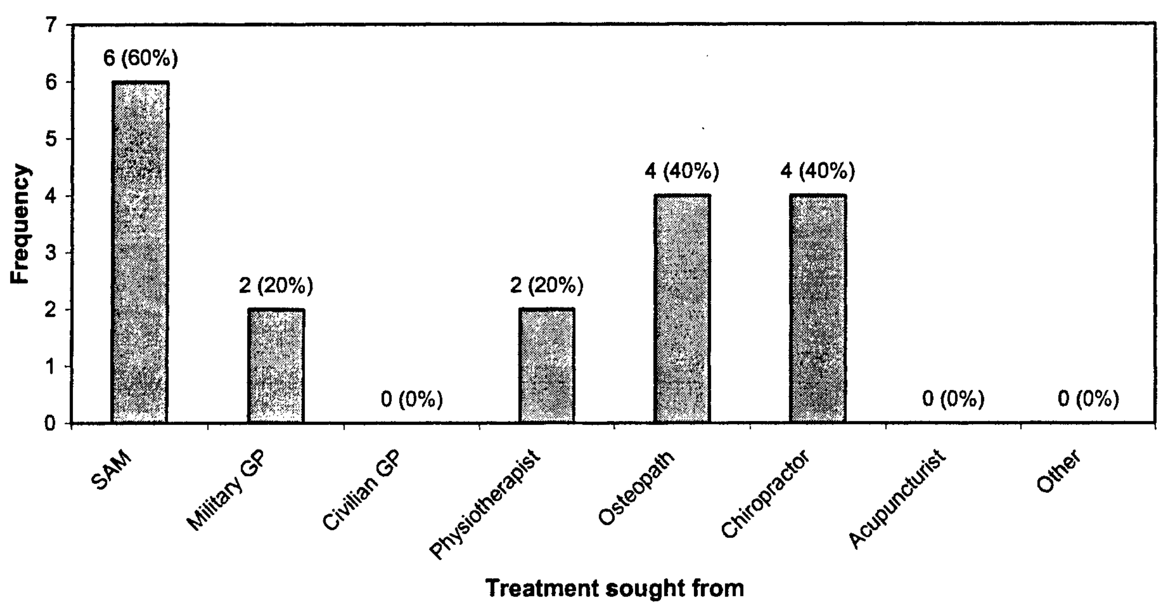
45. How long do the symptoms usually persist for the average episode of neck pain?



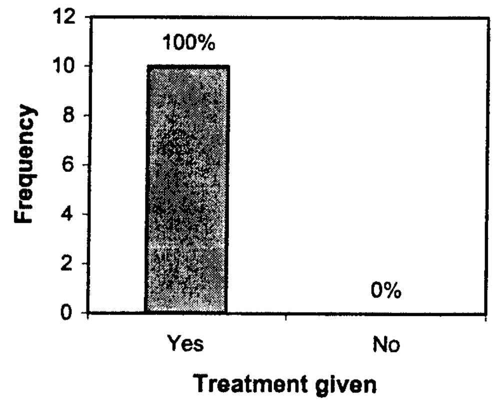
46a. Have you ever sought treatment for flight-related neck pain? (n = 37)



46b. If yes, was the treatment sought from: (n = 10)



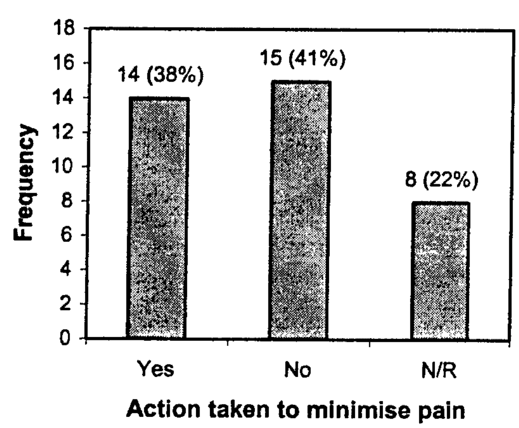
46c. Were you given any treatment for your neck pain?



46d. If 'YES', please describe briefly the treatment you received:

- Put wells back in.
- Osteopath…still in treatment now at 6 monthly appointments.
- Back support.
- [Analgesic] neck cream, physiotherapy.
- Physiotherapy for approximately 4 months advised to visit a chiropractor.
- Rest.
- Massage and manipulation that treated the problem in 3 visits.
- Chiropractor.
- Chiropractor. Due to posting, regular chiropractor not used… in the process of seeking new one.
- Consulted orthopedic [doctor].

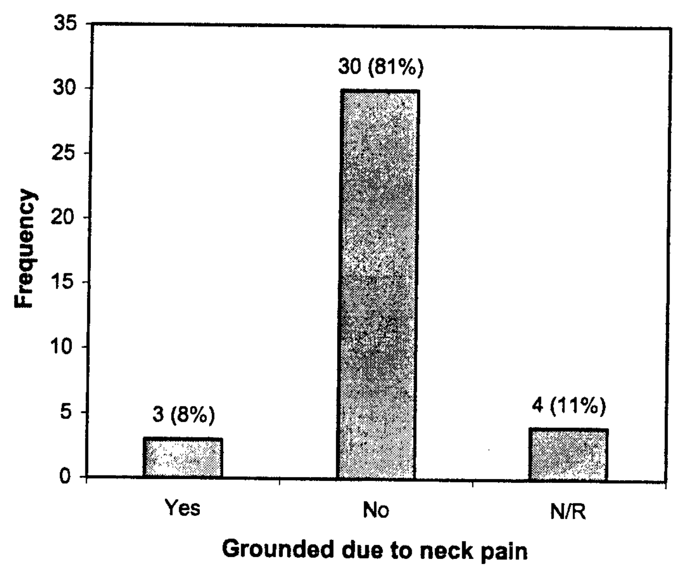
46e. Have you ever taken any action in order to minimize or avoid flight-related neck pain?



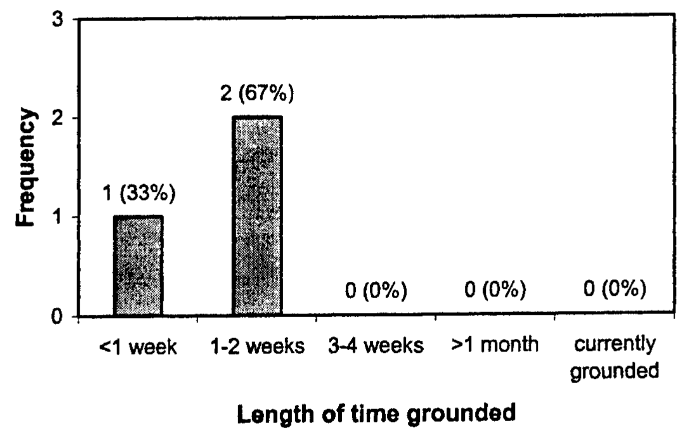
If 'YES', please describe the type of action taken and if the action taken was effective:

- Tried to alter position but it was not conducive to if flying.
- Fit correct balance weight with nite O (type of NVG).
- Ensure correct fitting of NVG and counter balances/weights to minimize effects.
- Exercise not always.
- Exercise, anti-inflammatories prior to NVG flying.
- Wearing back support.
- NVG counterweight.
- Bigger weight on helmet.
- Neck exercise.
- I do neck warm up exercises before NVG flights.
- Exercise.
- Chiropractor. Due to posting regular chiropractor not used in the process of seeking new one.
- Pain occurs from forcing eyes/head around to check for obstacles. Limited field of view on NVG that is twist body around.

47a. Have you ever been grounded as a result of flight-related neck pain?



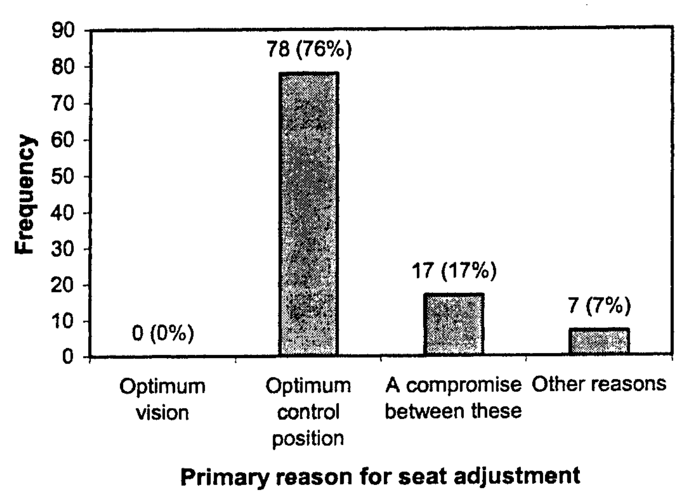
47b. If 'YES', please indicate how long you were grounded:



BACK PAIN

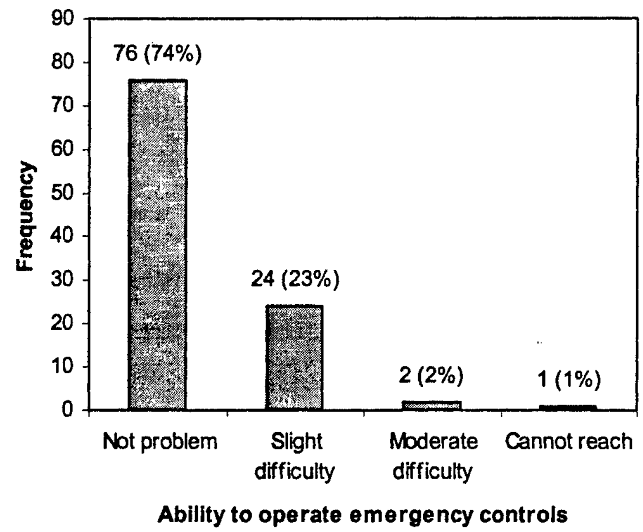
For the purposes of this survey, back pain is pain at or BELOW the level of the shoulder blades THERE ARE SEPARATE QUESTIONS ON NECK PAIN DURING AND AFTER FLIGHT.

48. For which of the following reasons do you primarily adjust your seat? (tick one only)

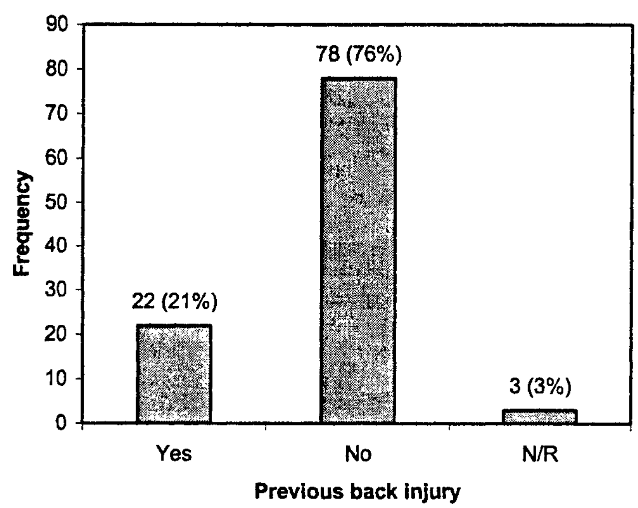


- Most comfort.
- To minimize back pain in flight.
- To prevent legs becoming tense.
- Comfort.
- Gear settings in all aircraft are insufficient for tall people.

49. With your seat in the normal position, and sitting in your normal flying posture with the harness inertia reel locked, how easily can you reach and fully operate the critical and emergency controls and switches?



50. Have you had a previous back injury?



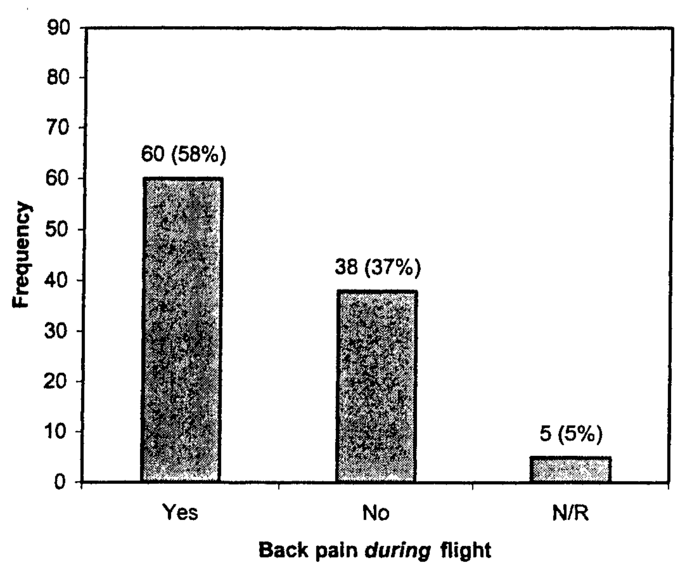
If yes please give the date and brief details:

- October1995 fractured side process of T4.
- Slipped disc in 1996.
- March 1999 narrowed disc space between L4 and L5.
- Two episodes of back strain. First at age 17 from playing rugby and second at 30.

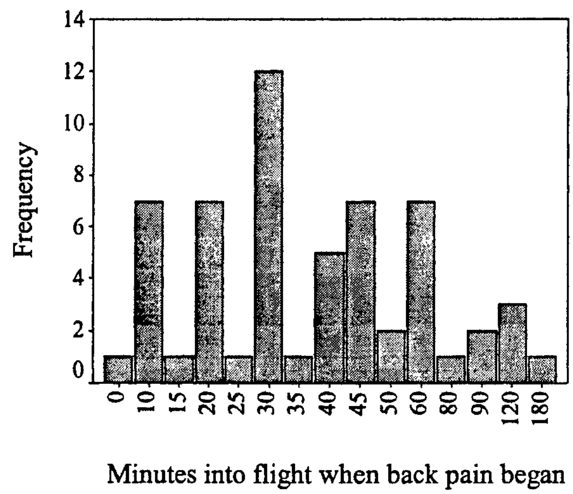
- Prolapsed L3, L4, L5 1995 in Cyprus on exercise.
- In October 1985 injured lower back during firearms carry run. July 1996 injured lower back whilst lifting person on shoulders. Late 1996 re injured lower back after slipping on oil in hanger whilst pushing aircraft into bay.
- Suspect slip disc at 16 years old.
- Progressive 1996-1997 rowing lower back damage.
- In 1984-1985 operation on lower spine. Fused S1-S5. Good results.
- Sore back resulting from car crash.
- Car bomb in NI (Northern Ireland).
- In 1991 rock climbing. Vertical drop approximately 2 meters. Jarred spine at the small of back.
- In 1992 injury to right shoulder whilst playing rugby.
- April/May 2000 jarred lower back on a cross-country run.
- Slipped/prolapsed disc due to weight lifting.
- Fall from horse in 1997.
- Rugby, car and bike injuries.
- Back pain caused by lifting strain in November 2000. Currently under observation.
- Undergoing treatment from Osteopath.
- Variety of back problems through sport and since joining the Army.
- Rugby injury stem from limited movement of lower spine.

51. Back pain DURING flight

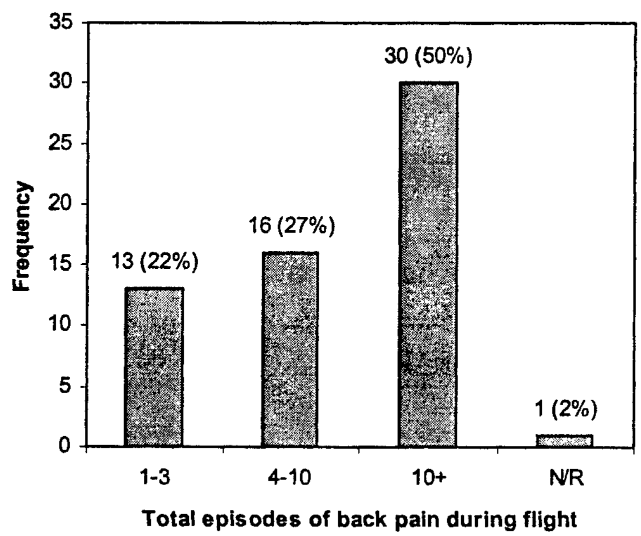
a. Have you ever experienced back pain during a flight?



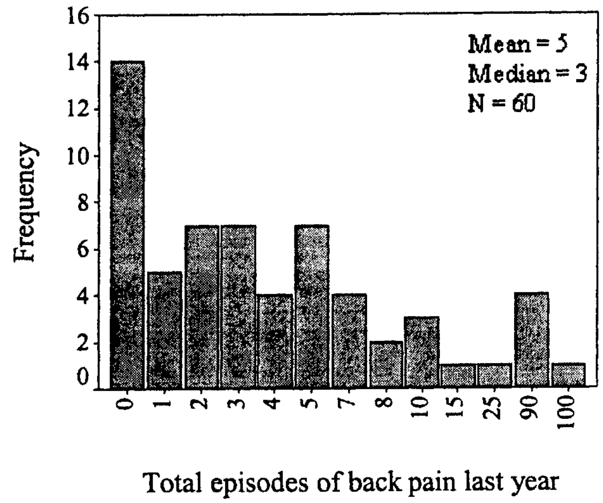
b. If you have experienced back pain during flight, how long into the flight were you before the pain began? _____ minutes (n=60)



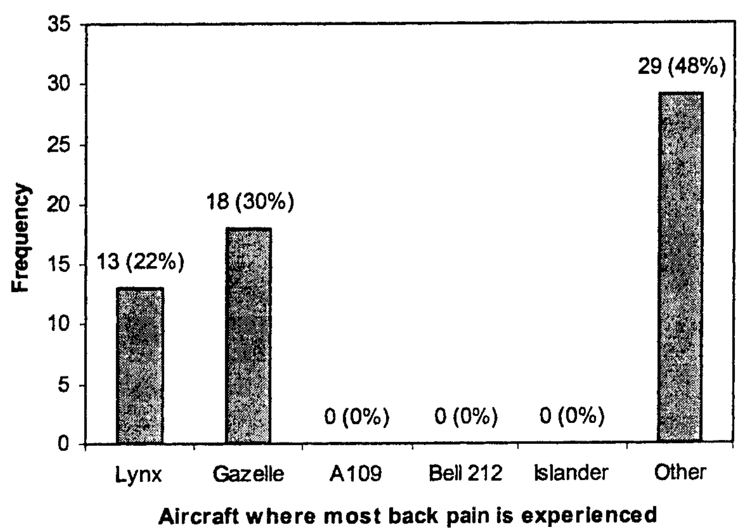
c. Please indicate the total number of episodes of back pain you have experienced during flight:



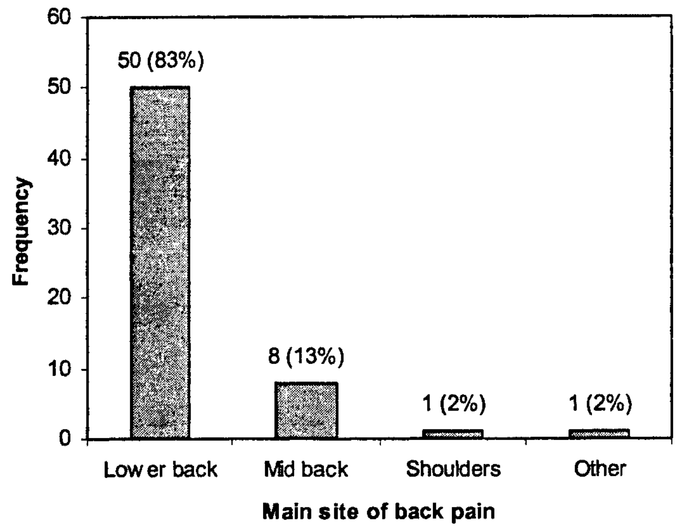
d. How many episodes of back pain <u>during flight</u> have you had in the last year?



e. In which aircraft have you experienced your most frequent back pain (circle 1 or more)



f. Where is the main site of your back pain? (tick one only)



g. Indicate if any of the following factors may have influenced your back pain during flight:

-Unsatisfactory seat position Yes [30(50%)] (please explain below)

- Non-adjustable seat with parachute present.
- Poor design of seat that leads to poor posture.
- Bad posture hands in unsymmetrical position causing body to twist.
- Lack of support in lower back.
- I did not adjust the seat position correctly.
- Lack of lumbar support rather than position.
- Crouched forward position.
- Seat too small for 6'4" man.
- Ergonomics of gazelle seats.
- None of the above was found when hands on in RHS of Lynx.
- Poor lumbar support in gazelle and head interaction with GOA (Gazelle Observation Aid).
- Back position to maintain control of all controls.
- Gazelle seat!!
- More seat design.
- Seat too far back, over extension to reach controls, now sit closer, happens on instruments flying (IF) mostly.
- The seat provides no lower back support.
- More to do with poor posture.
- Gazelle seat has no lumbar support.

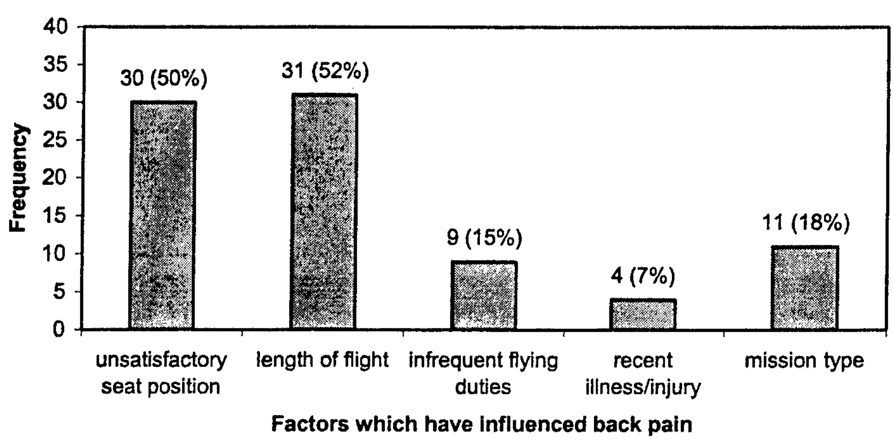
- Tend to crouch forward to view.
- Insufficient lumbar support.
- Shape of seat.
- Armored seat makes for uncomfortable flying position.
- Firefly is very small and uncomfortable and I'm 6'4" tall.
- Inadequate lumbar support.
- Abdominal lumbar posture- poor support.
- Poor lumbar and back support and effects on seat harness.
- I seem to be slumped in seat.

- Length of flight YES [31(52%)]

(how long <u>before pain began</u>?________minutes)
- Time frame ranged from 0-120 minutes

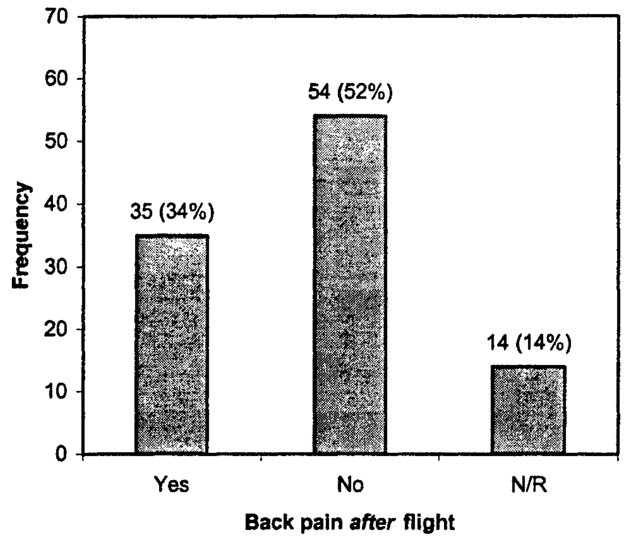
-Mission type [11(18%)] (please explain below)

- Instrument flying.
- Low level now much worse.
- After not flying for a couple of weeks.
- NVG.
- Low level.
- Long periods of flying on NI duty.
- Back pain develops quickly in individual flight when several flights are made each day.
- Flying with body chest plate NI.
- Student flying.
- IF flying - "winced" (squint) to view instruments.
- Prolonged hover over Belfast solo pilot.
- IF flying, position of head and shoulders constantly looking down.

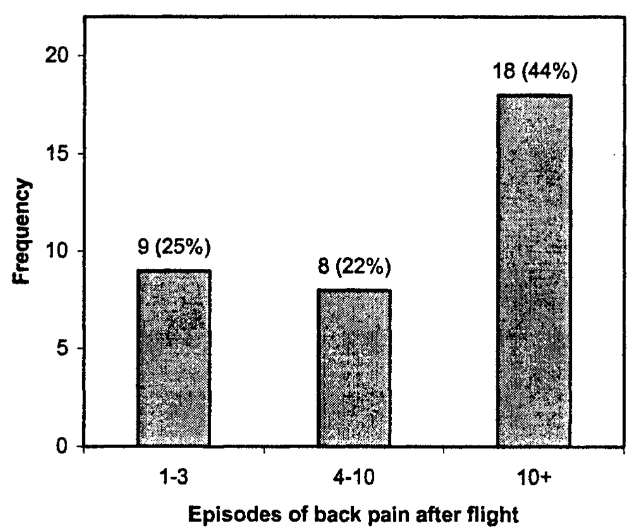


52. Back pain AFTER flight

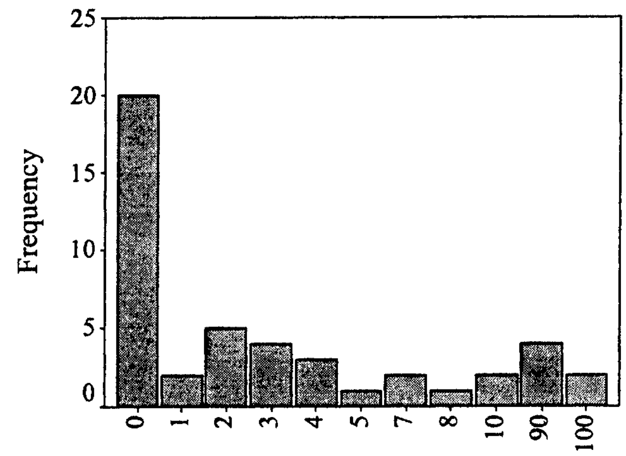
a. Have you ever experienced back pain after a flight?



b Please indicate the total number of episodes of back pain you have experienced after flight:

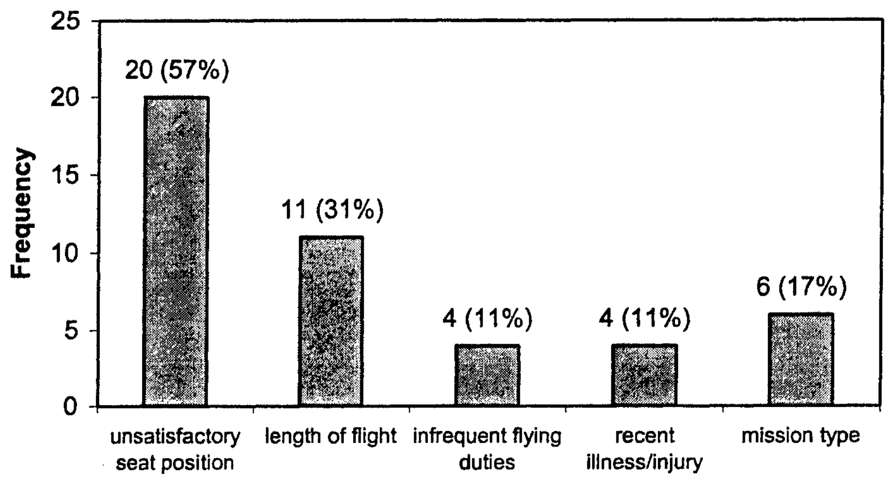


c. How many episodes of back pain after flight have you had in the last year?



Episodes of back pain last year

d. Indicate if any of the following factors may have influenced your back pain "after" flight:



Factors influencing back pain after flight

(please explain below)

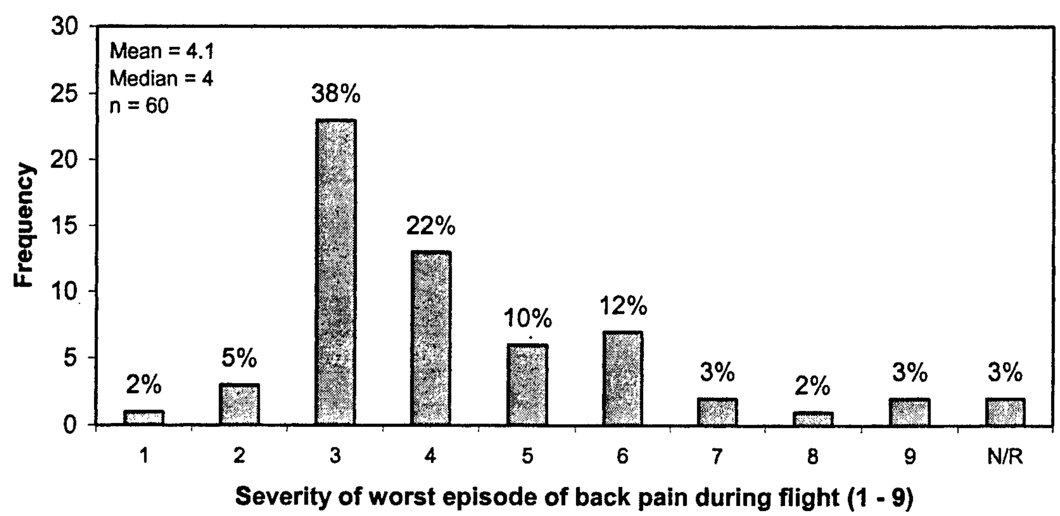
- Possible poor posture in seat as a student pilot.
- I did not adjust the seat properly.
- Lack of lumbar support rather than position.
- Crouched forward position.
- Poor lumbar and back support and effects of seat harness.
- None of the above was found when hands on in the right hand seat of Lynx.
- Hunched under controls.
- Poor lumbar support in Gazelle and head interaction with Gazelle Observation Aid.
- Gazelle.
- More to do with poor posture.
- Gazelle seat has no lumbar support.
- Tend to crouch forward to view.
- Gazelle seat height.
- Tend to crouch.
- Shape of seat.

53. Indicate the severity of back pain, for the <u>worst</u> episode of pain experience during flight and after flight.

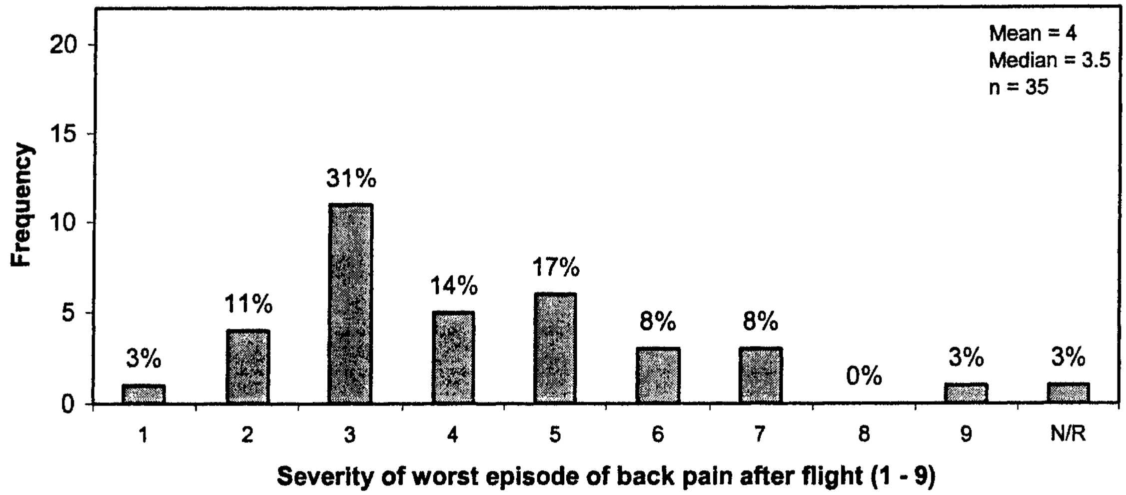
Grade the severity on a scale of 1 to 9.

1 = no pain 9 = incapacitating (e.g. resulting in handing over control or aborting the mission)

DURING FLIGHT __________



AFTER FLIGHT _________

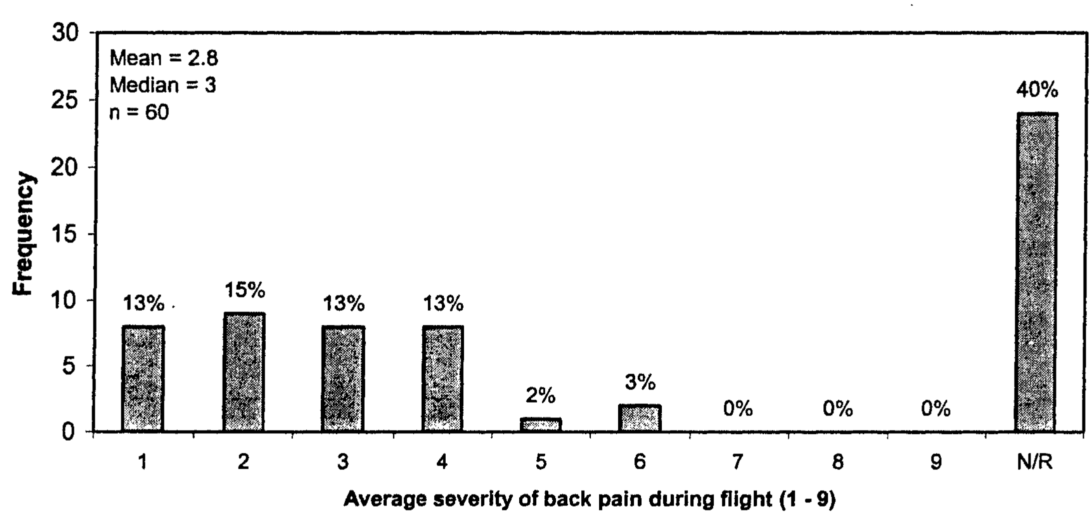


54. If you COMMONLY experience back pain, please indicate an <u>average</u> severity of pain experienced.

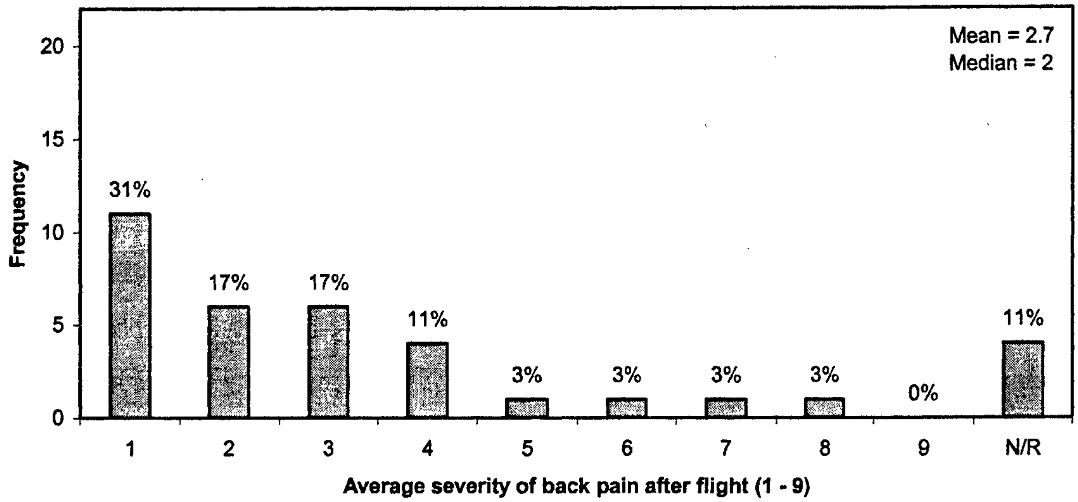
Grade the severity on a scale of 1 to 9.

1 = no pain 9 = incapacitating (e.g. resulting in handing over control or aborting the mission)

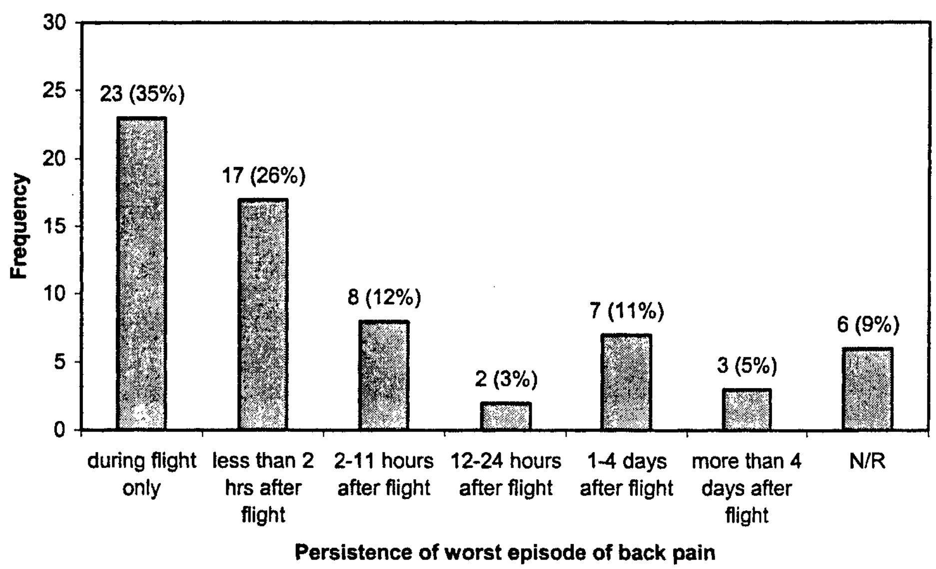
DURING FLIGHT _________



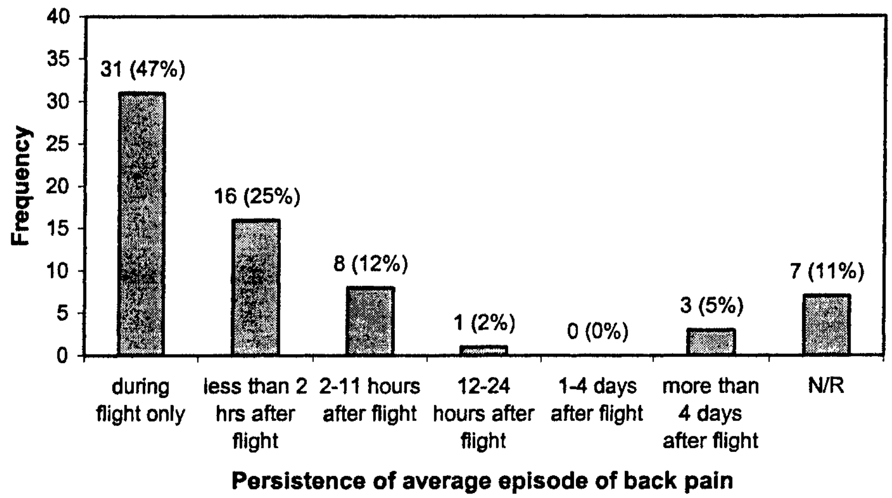
AFTER FLIGHT __________



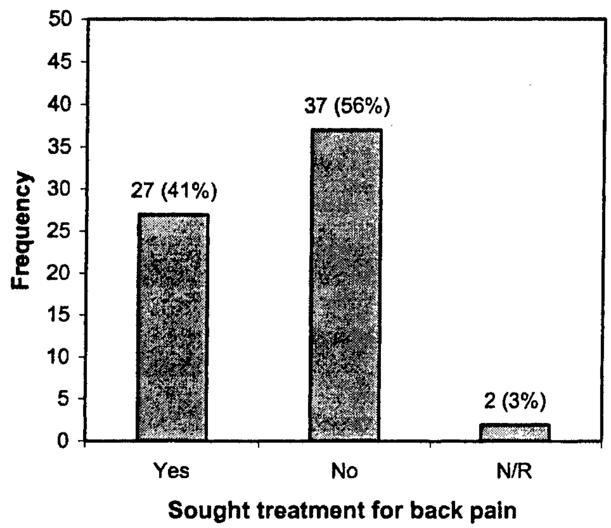
55. How long did the symptoms persist for the worst episode of back pain? (n = 66)



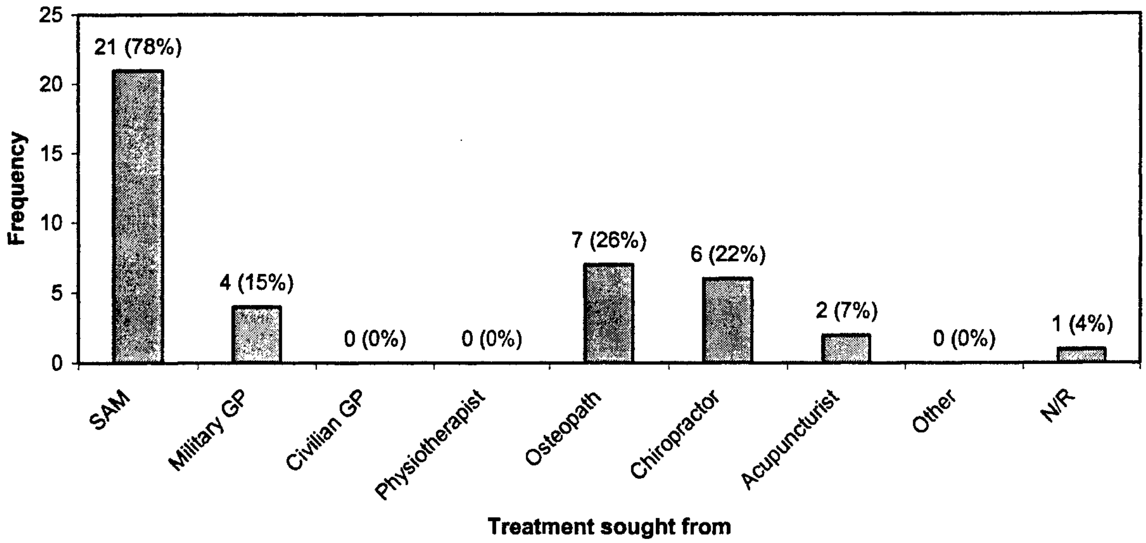
56. How long do the symptoms usually persist for the <u>average</u> episode of back pain? (n = 66)



57a. Have your ever sought treatment for flight related back pain?

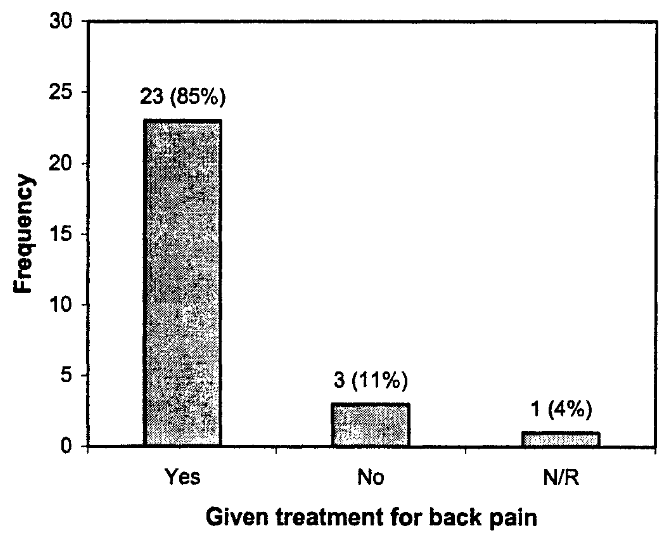


57b. If yes, was the treatment sought from:



Note: Total percentages may exceed 100% because subjects sought help from more than one source.

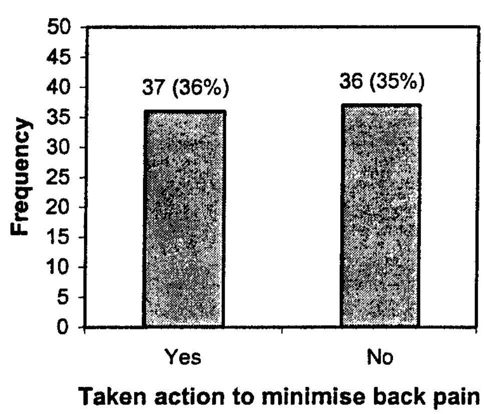
57c. Were you given any treatment for your back pain?



57d. If 'YES', please describe briefly the treatment you received:

- Four physical sessions and course of 14 x voltarol (75 mg) tablets.
- Exercises that stretched and strengthened back muscles.
- Molded lumbar support.
- RAF back protector made and issued.
- Military GP + SAM brufen (ibuprofen)/rest. Physio [Physiotherapist]: manipulation/self treatment program physio [Physiotherapist];Osteopath: manipulation; chiropractor manipulation.
- Use of removable lumbar back support.
- Osteopath put back "back in".
- Physio [Physiotherapist] sessions and referral for lumbar support.
- Osteopath as per neck.
- Acupuncture and stretching exercise.
- Seat back from N. Luffenham.
- Physio [Physiotherapist] prescribed various stretches.
- Issue of [Physiotherapist] back support (N. Luffenham).
- Lumbar support.
- Spinal adjustment at chiropractor.
- Chiropractic treatment.
- Rubber band exercises.
- Fitted for lumbar support for Gazelle operation in 1988.
- Physio [Physiotherapist] including Acupuncturist and Osteopath.
- Military SAM - no help. Physio [Physiotherapist]-exercises and Chiropractor lots of help.
- Molded fiberglass.
- Exercise.

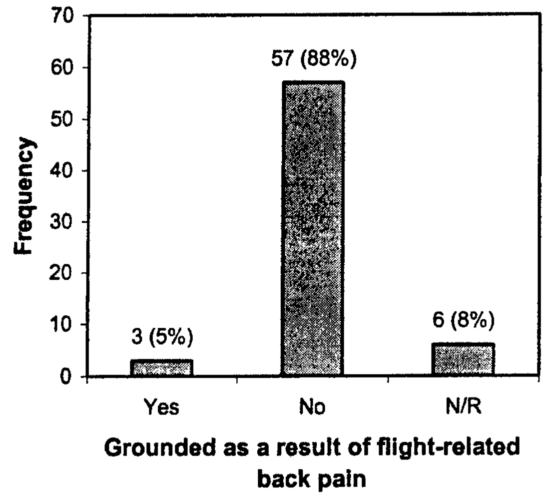
57e. Have you ever taken any action in order to minimise or avoid flight-related back pain?



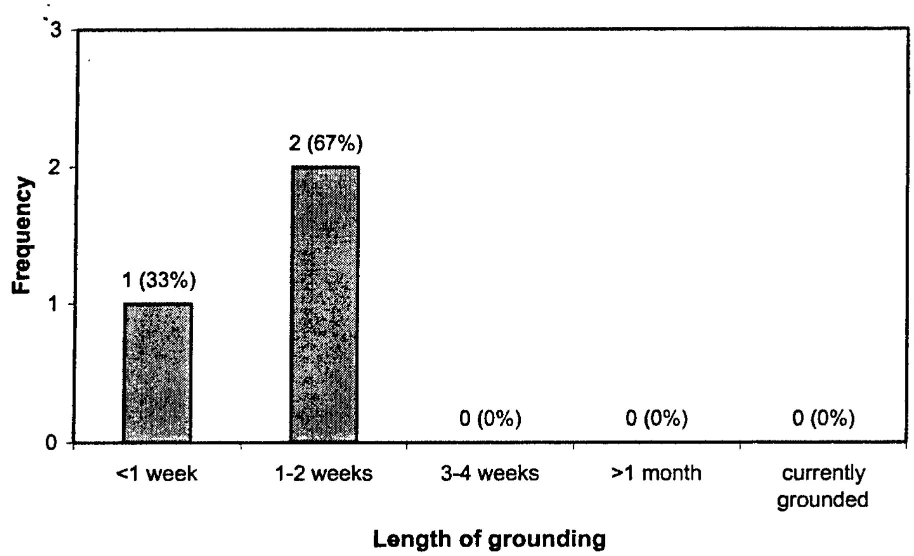
57f. If 'YES', please describe the type of action taken and if the action taken was effective:

- Seat cushion and back support (molded) partially effective.
- Try to move around more often during instrument flying (IF) and avoid slouching.
- Slight change in seating position. During flight i.e. sitting up straight.
- Improved cockpit posture relax leg and buttocks muscle-stretches.
- Sit properly in cockpit but then I do not feel comfortable in a flying sense.
- Adjust seat correctly.
- Use of molded lumbar support.
- Back support-yes. Self Physio [Physiotherapist] exercises -yes.
- Weight training -yes. Stretching-yes.
- Use lumbar support. Ensure correct seat positioning. Carry out back strengthening exercises-some effect.
- Minimized 'hands on time'.
- Changing seat position, stretching cushion in lower back.
- Stretching, moving position and trying different seat positions.
- Exercise.
- Stretching.
- Exercise and anti-inflammatory .
- Physiotherapy exercises.
- Seat back support.
- Stretching exercise very effective.
- Adjust seating position forward it was effective.
- Lumbar support. Very effective.
- Lower back exercises (dorsal raises) and adjusting seat position.
- Exercise for lower back.
- Regular exercise and stretching is moderately effective.
- Stretch lumbar and lower back preflight where possible. Slightly effective.
- More effort to sit upright during flight.
- Cushion works sometimes.
- Numerous visits to the doctor for X-rays.
- Stretching and warm up exercise.
- I used to use my inflatable lumbar support when flying the Gazelle.
- Back support in NI however, it was removed by SAM at Middle Wallop as not cleared for aircraft.
- Frequent stretching and general warming of the muscles.
- When I've learnt to relax. I'm sure that the pain will go!!!
- Moving seat and stretching.
- Ensuring good lumbar support.
- Lumbar support cushion.
- Inflatable lumbar cushion.

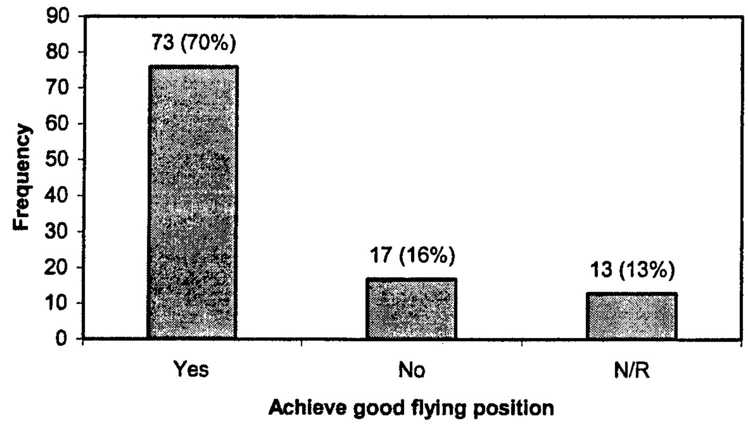
58a. Have you ever been grounded as a result of flight-related back pain?



58b. If 'YES', please indicate how long you were grounded:



59a. Do the standard procedures for adjusting the seat allow you to achieve a good flying position?



59b. If "NO", explain any difficulties you have with the seat adjustment mechanism. Include any additional methods you use to improve your flying position:

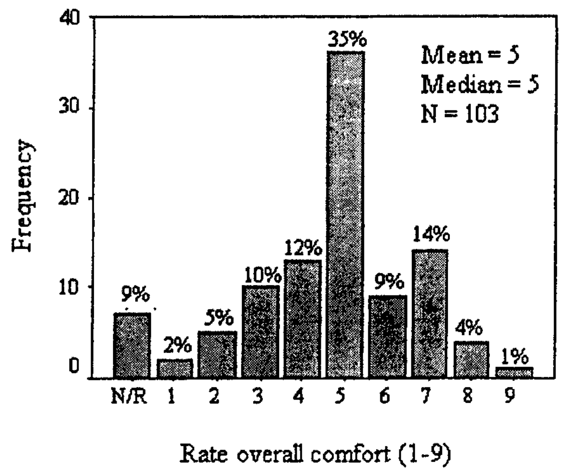
Comments:

- Service provided back support is uncomfortable due to twisting of lower spine. GOA sight interacts with head and lateral position atrophies in leaning forward.
- Seat requires adjustable lumbar support.

60a. How would you rate the overall comfort of the seat on a scale of 1 to 9.

____

1 = extremely uncomfortable 5 = adequate 9 = extremely comfortable



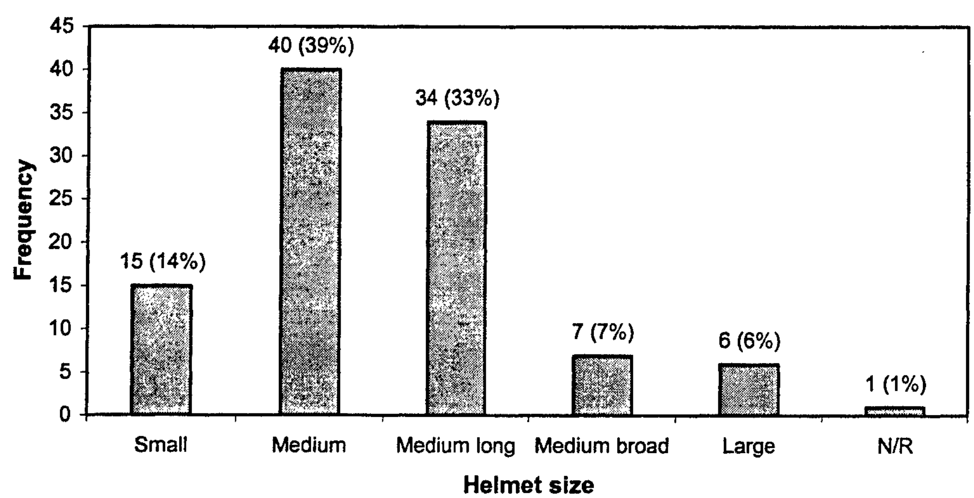
60b. If there is any discomfort, what causes it?

- The parachute and lifetime of crouching.
- Poor seat design and ergonomics.
- Too much of an upright position.
- Back support a little vertical causing you to lean forward slightly.
- Lumbar support area inadequate.
- Lack of support.
- Too rigid.
- Slight bend to left for collective.
- Lack of lumbar support.
- Too narrow and small, lack of lumbar support and lack of adjustment.
- Flying posture.
- Poor back support/position.
- Cockpit ergonomics.
- Pain! Seat design and weight of NVG.
- Existing back problems.
- Poor seat cushions and lack cushions.
- Having to hunch no real back support.
- Low position of seat belt, twist spine caused by helo controls, GOA.
- Gap in lumbar area.
- Seat too upright.
- Lack of lumbar support during extended period of flight.

- Poor/worn out seat cushions. Lack of lumbar support.
- The cut out in the seat.
- Already present back pain.
- No lumbar support.
- Poor shaping to fit body contours.
- Lynx armored seats.
- Seat shape and control position.
- Lack of lumbar support.
- Armored seating and cushion support.
- Poor seat cushions.
- Poor seat design.
- Very little cushioning/ very upright seat no flex in back support. Have to lean over instruments.
- Helicopter seats hate in general, too upright.
- Long periods of flying.
- A hard seat.
- Lack of lumbar support.
- Poor seat cushion in seat pain.
- Loss of normal lumbar position or shape.
- Numb arse during prolonged flights.
- Lack of cushioning.
- Scanning position on instrument flying (IF).
- Slouching.
- Constant leaning forward and concentration.

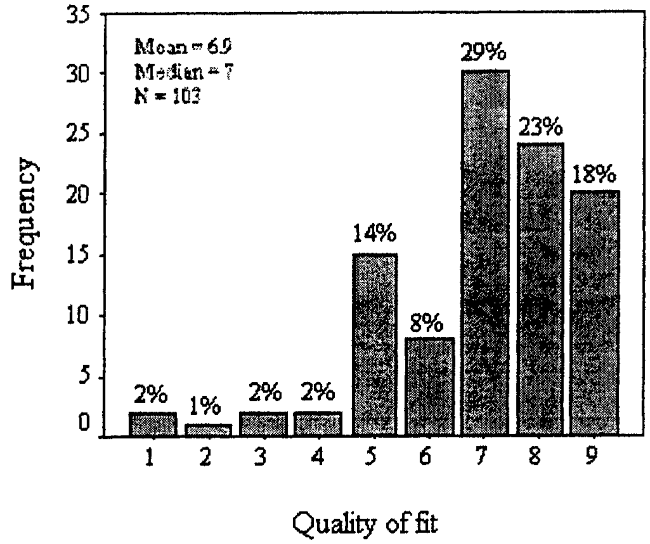
HELMET USAGE

61. What Mk 4 helmet size do you wear? (tick one only)



62a. Grade the quality current fit on a scale of 1 to 9. ________________

1 = unsatisfactory
5 = adequate
9 = excellent

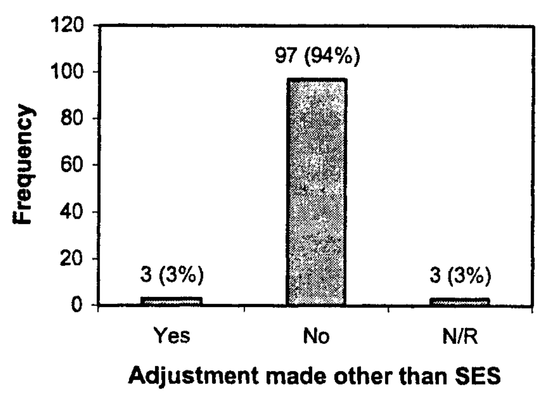


62b. If less than perfectly satisfied, please describe any problem the fit causes.

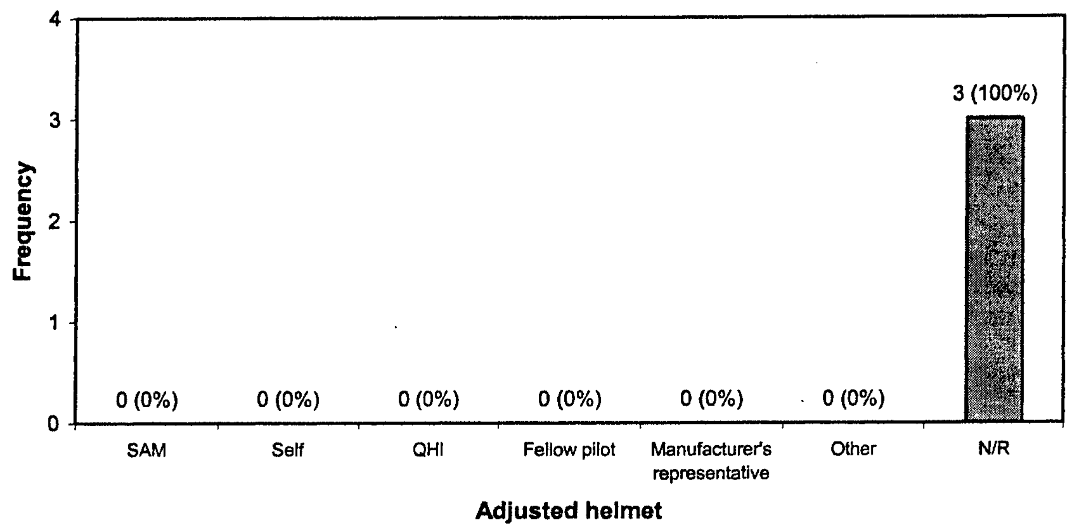
- Sometimes digs into the top of my head whilst using the NVG.
- I believe that current helmet on issue is a bad design. It's complicated to fit correctly and can cause pain in several areas of the head. I am willing to discuss this further face to face.
- Ear cup comfort.
- Neck strap requires to be tight, but causes pressure on head especially with goggles on.
- Some movement.
- Having one helmet that is utilized for both NVG and normal flight is not ideal, as these two flying profiles require different helmet tightness.
- Helmet rolls a lot with NVG fitted. Protracted use leads to requirement for refit and tighten.
- Squashes left ear lobe.
- Slight wobble when filled.
- Still get slight movement of helmet which if tightened causes discomfort.
- Tight around forehead.
- Visor too low.
- Ear cup tension slightly too high (squeezes head) adjustment is at lowest setting already.
- Slightly tight across forehead.
- Pain with hair pulling back front of scalp.

- Sometimes too tight around forehead also wearing visor in fully locked down position causes it to catch to bridge of nose.
- I am on the border of having medium or long. Medium is just a little short and the long is far too long needing all the straps tightened to their fullest extent.
- Helmets require constant readjustment to maintain correct fit.
- Movement on head despite extensive attempts to rectify i.e. refit.
- Front pad sticking to forehead.
- Tight in many areas but my head is on the boundary between two sizes and I was issued the smaller size.
- Tends to cause some discomfort at the front if worn for long periods of time (3 hrs+).
- Occasionally fitting is required on a number of occasions until a comfortable fit is achieved.
- During long flights I sometimes get a headache.
- Mike boom not long enough. Only reaches just past left side of mouth.
- Brow pad can become uncomfortable. Visor sometimes seems low and close to the nose.
- Occasional foe and aft slippage.
- A little tight on ears.
- It is tight on my forehead and takes a couple of flights to 'bed in' after servicing.
- Sweaty ear cups after long flights.
- Helmet could be less restrictive and lighter.
- Slightly too tight around ears.
- There is no problem but wearing a helmet is obviously less comfortable than wearing no helmet.
- Helmet is very heavy and can get hot. The fit is good.
- Frontal headaches.
- Additional weight on NVG causes vertex discomfort.
- Heavy and less ventilation.
- The adjustment straps loosen frequently which is irritating when flying with NVG.
- Pressing on forehead nothing too uncomfortable.

63a. Has your helmet been adjusted by anyone other than the Safety Equipment Section fitters?



63b. If YES, by whom?



65. Have you experienced any breakage, binding, slipping, or other malfunction with any of the following? (circle one in each row)

Visors	No	[ ]	Yes	[ ]
Visor activators	No	[ ]	Yes	[ ]
Chinstrap	No	[ ]	Yes	[ ]
Suspension assembly	No	[ ]	Yes	[ ]
Microphone	No	[ ]	Yes	[ ]
Microphone Boom	No	[ ]	Yes	[ ]
Earcups	No	[ ]	Yes	[ ]
Helmet internal speakers	No	[ ]	Yes	[ ]
HDU mounting bracket	No	[ ]	Yes	[ ]
Communication cable	No	[ ]	Yes	[ ]
Electronics cable	No	[ ]	Yes	[ ]

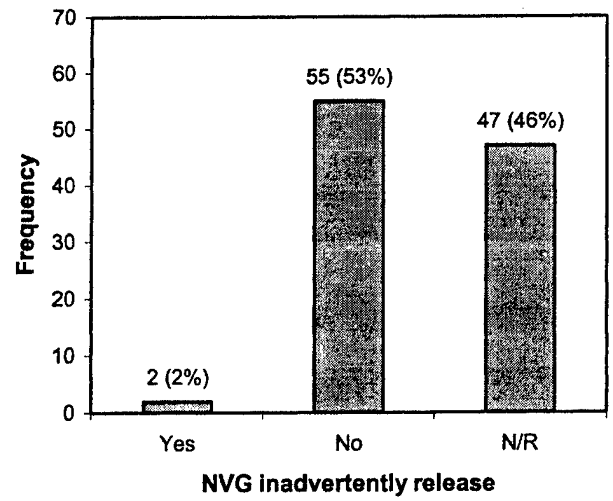
Remarks:

- Mike boom is often loose causing mike to fall away from optimum position.
- Ear cups have loosened off.
- Unstrap periodically during flight despite securely fastening in preflight.
- Moisture occasionally prevents mic [microphone] from working. Comms [communication] cable connector becomes dirty and results in a poor contact.
- Intermittent I/[(intercom] on radio.
- The visor problems due to servicing.
- Some problems during FW (fixed wing) phase fixed by technician easily.
- Intermittent mike sometimes.

- Visors holders broke apart, microphone, ear cup, cable all become dornoned and lole hearing.
- Helmet Internal Speakers rattling earpiece.
- Suspension assembly slips continually due to bad size and fit. Microphone boom had to be bent in order to reach my face.
- Microphone got wet on preflight walk rounds.
- Ear cup, pull strap has broken on occasion.
- Lynx seat banging against sight.
- Mic [microphone] boom came loose on one occasion.
- It fits well but it is a little heavy.
- Occasional internal comms [communication] okay but I cannot transmit on any radio. I can hear.
- Scratched visors, broken cable.
- Loose wires.
- Occasional poor electrical union between male and female connections.
- Visor especially the dark visor is easily scratched when checking the overhead.
- Not so much of a problem now but have had security strap break. A recurring helmet is faulty/intermittent function of internal speakers.
- Comm [communication] cable repaired immediately.

	Yes	No	No response
Microphone	32 (31%)	63 (61%)	8 (8%)
Communication cable	28 (27%)	65 (63%)	10 (10%)
Microphone boom	22 (21%)	71 (69%)	10 (10%)
Helmet internal speakers	16 (16%)	78 (76%)	9 (9%)
Visors	16 (16%)	77 (75%)	10 (10%)
Earcups	13 (13%)	79 (77%)	11 (11%)
Suspension assembly	11 (11%)	78 (76%)	14 (14%)
Visor activators	9 (9%)	80 (78%)	14 (14%)
Electronics cable	9 (9%)	75 (73%)	19 (18%)
Chinstrap	8 (8%)	80 (78%)	15 (15%)
HDU mounting bracket	7 (7%)	71 (79%)	25 (24%)

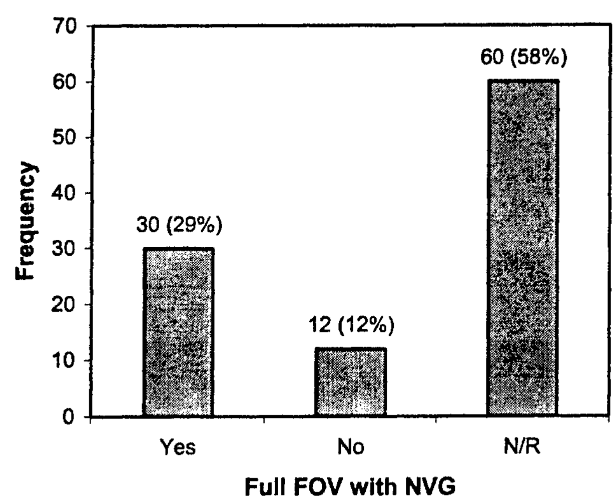
68a. Have the NVG ever inadvertently released during flight?



68b. If yes, how many times has this happened?

Occurrence	1	4
Number of respondents	1(50%)	1(50%)

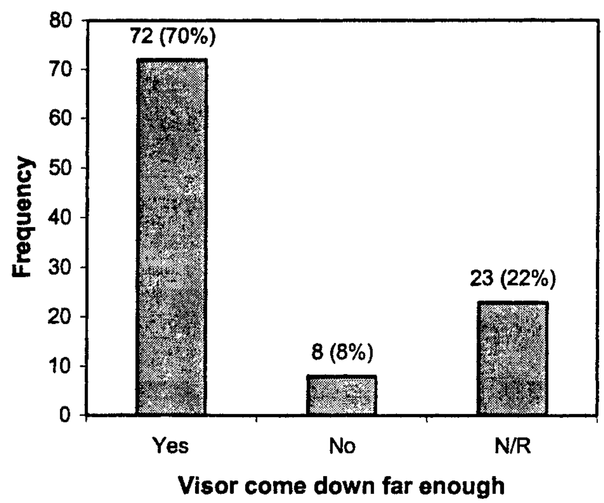
69a. Do you currently achieve a full field of view with the NVG?



69b. If NO, assess which items of information you are not seeing:____________
- Detail.
- Peripheral.
- As per NVG field of view.
- Peripheral vision.
- Wider field.
- 60 %.
- Peripheral vision.
- It's an aircraft issue. The door frames prevents 90% field of view.

70. NO QUESTION DUE TO ERROR IN NUMBERING.

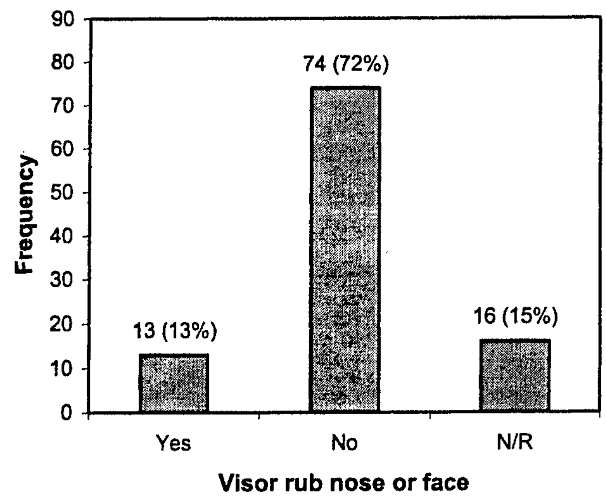
71. Does the visor come down far enough? (not Face Protective Visor)



Remarks:
- When NVG not fitted.
- Do not use visor when flying with NVG.
- Do not use clear visor due to interaction with NVG. Dark visor does not permit use to see at night.
- Not worn due to steaming.
- NVECP attachment prevents use of helmet visor.

72. NO QUESTION DUE TO ERROR IN NUMBERING.

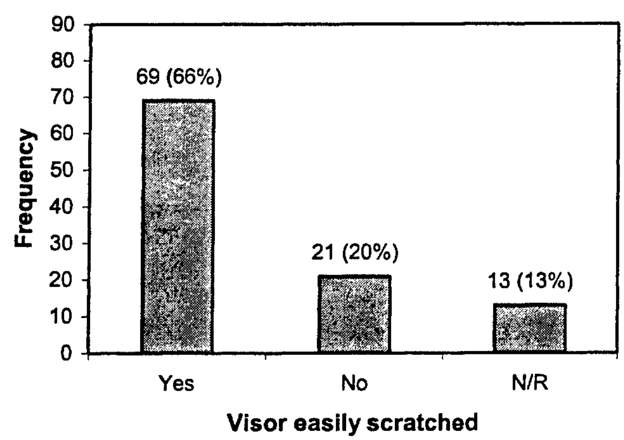
73. Does the visor rub your nose or face when extended?



Remarks:

- Nose but push helmet up to reduce it.
- Peanut head.
- If helmet slips slights forward.
- Sometimes too tight around forehead also wearing visor in fully locked down position causes it to catch the bridge of nose.
- Edge of nose.
- FPV can touch my nose but easily pushes up.

74. Is the visor easily scratched?



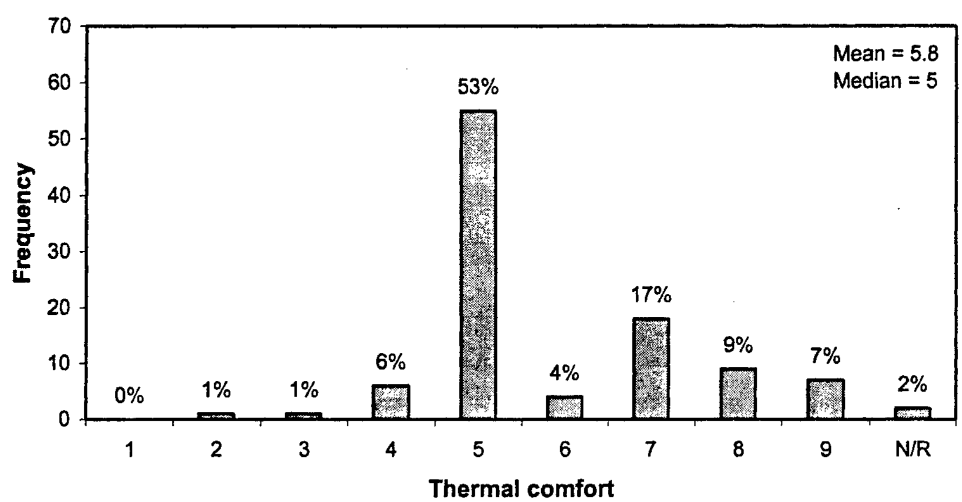
Remarks:

- Not with proper care.
- Mainly to glasses.
- Gazelle and Lynx sight!!!
- Due to head close to roof, Lynx close to roof slight.
- Navy style visor cover (hard plastic) prevented this.
- Only when dark visor comes into contact with tow roof sight.
- Aircraft with sighting system Lx (Lynx) tow LH (Left hand) seat and Gazelle GOA.
- Top of perspex screen in Squirrel. The bar going across.
- Relates to seating position with LHS Lynx with tow sight etc. above helmet.
- On walk arounds.
- Especially on Lynx with sights.
- Often getting into A/C.
- Generally done on walk around.
- Tow roof sight (dark visor when up).
- On articles in the cockpit example.
- Internal from CFS. External from roof mounted equipment.
- Particularly the dark visor.

75. How would you rate the THERMAL comfort of the helmet on a scale of 1 to 9

____

1 = extremely uncomfortable 5 = adequate 9 = extremely comfortable



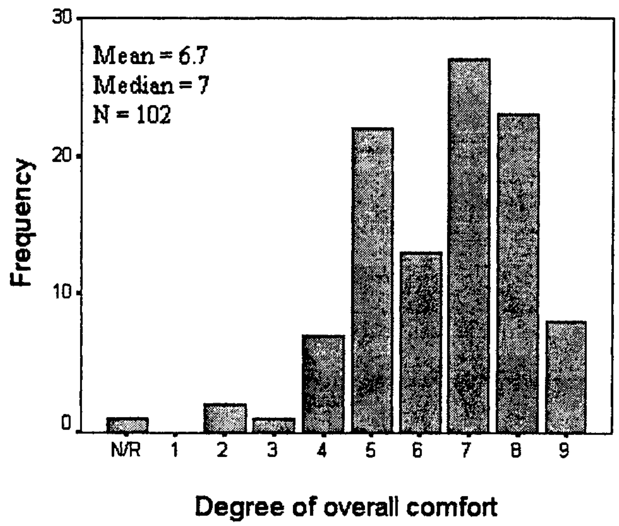
If there is any discomfort, what causes it?

- Worry, guilt and frustration.
- Probably student brain overheating.
- Very insulating but acceptable for the level of protection it provides.
- No discomfort but can get very hot.
- Sweaty ear pieces if no cloth covers available.
- Can get hot.
- Tight bindings.
- Very hot and uncomfortable in warm weather.
- Can get excessively hot in the summer.
- Leather and plastic ear cups becomes extremely cold during the winter.
- Long flights.
- Very sweaty in summer.
- Too hot in the summer.
- Requires better ventilation sweat absorbent lining would be more comfortable.
- Not enough air circulation.
- Sometimes too hot during summer months.
- Can be uncomfortable in high ambient TBPMS.
- Can become uncomfortable in hot weather.
- In the summer it gets very hot.
- Very hot after exposure to heating in sunlight.
- Very little ventilation.
- The helmet can get hot. There is very little venting.
- Frontal headaches.
- Suspension assembly with NVG.
- Quite easy to overheat on hot days.
- Lack of ventilation.
- For prolonged periods in the summer, helmet becomes hot to wear over 1.5 hours.
- Too hot sometimes when working hard.
- Can get too hot.

76. How would you rate the overall comfort of the helmet on a scale of 1 to 9

____

1 = extremely uncomfortable 5 = adequate 9 = extremely comfortable

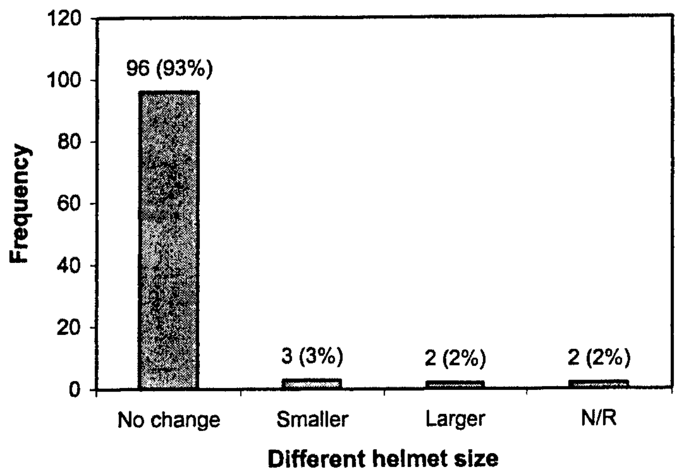


If there is any discomfort, what causes it?

- After a refit it can take a number of revisits to the SES for readjustment.
- Weight.
- Too big and heavy.
- Only if fitted too tight.
- Brown pad.
- Ear cups hot in certain environments.
- Add ons, NVG.
- Helmet weight too heavy.
- NVG wearing.
- Ear being crushed.
- Weight.
- After prolonged flight the crown of head is sore due to Helmet padding shapes.
- Helmet tight around forehead.
- Ear cup tensioners as previously mention.
- General compression of head.
- Hair.
- Compression at the top on the crown of head.
- Discomfort when NVG fitted.
- Frontal pad/brown pad.

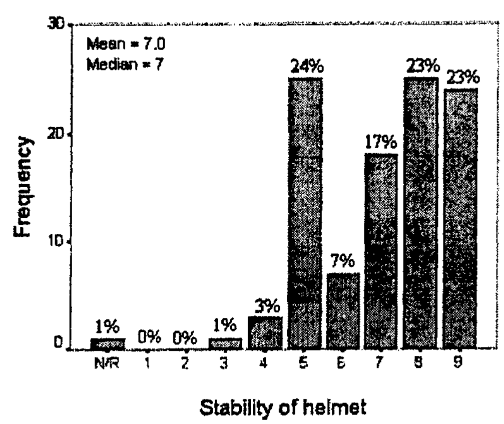
- The fitting harness.
- When hot or warm for long periods.
- Occasional hot spots.
- Too tight gives me hotspots on forehead.
- Weight.
- Frontal headaches.
- Suspension assembly.
- Weight and lack of ventilation.
- Too hot sometimes when working hard.

77. Do you feel that you currently need a different size helmet? (TICK ONE ONLY)



78. How would you rate the STABILITY of the helmet on a scale of 1 to 9 ______________

1 = extremely unstable 5 = adequate 9 = extremely stable



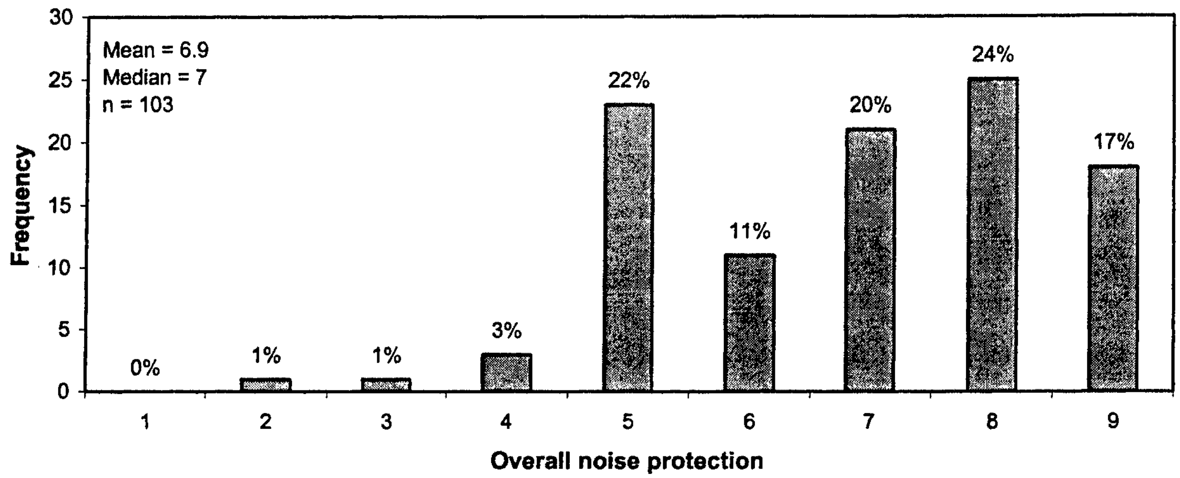
If there is any instability, what causes it?

- Slips forward with NVGs fitted.
- NVG.
- Balance NVG counter weight.
- Design of suspension system/shell.
- Bumping the top of seat with back of helmet.
- NVG + weight occasionally/rarely.
- Sweat, haircut, strap loosening.
- Haircut.
- NVG in the fore/aft axis.
- The only real grip is on the ears.
- Slight forward movement.
- Too much relied on ear cups.
- Slipping against hair.
- Slipping on side of head.
- Bad sizing helmet too big with straps tightened to the max.
- My head shape.
- NVG.
- Ear transioner laxity after 3-4 post service.
- Slight rocky motion before and after.
- Foe and aft adjustment.
- Loosening of fittings.
- Weight/size.
- The weight and size causes instability.
- The desire not to have it too tight to avoid frontal headaches.
- Weight.
- Straps adjustment readily loosens which require visit to LES.

79. NO QUESTION DUE TO ERROR IN NUMBERING.

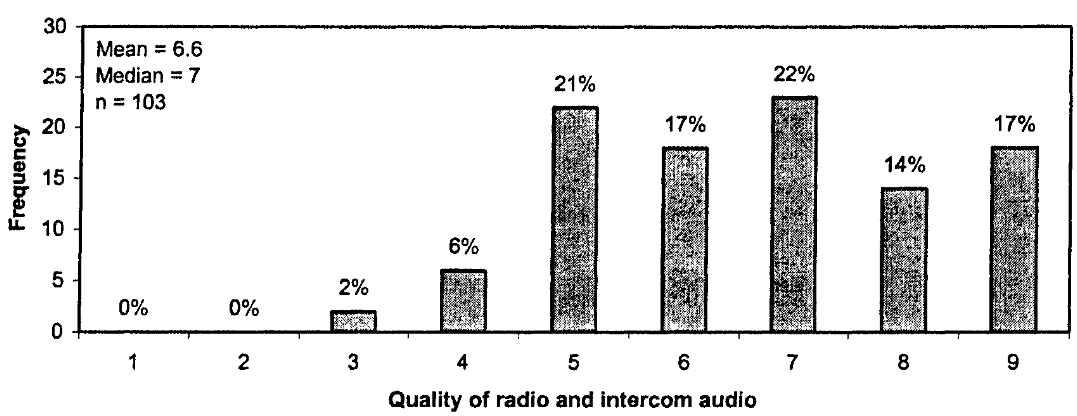
80. How would you rate the overall noise protection that you have experienced in flight on a scale of 1 to 9 ____________

1 = extremely noisy 5 = adequate 9 = extremely quiet

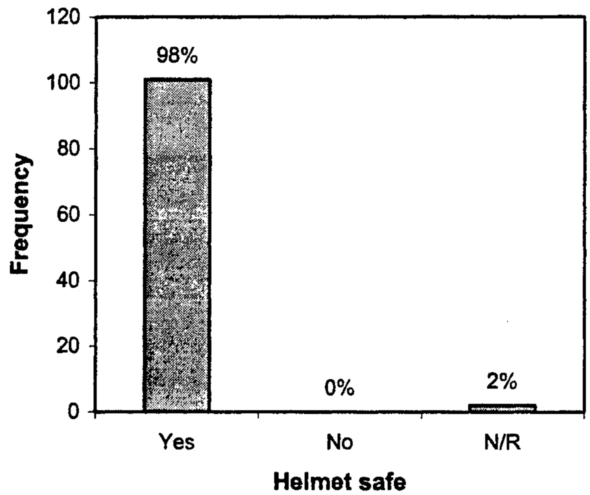


81. How would you rate the overall quality of radio and intercom audio that you have experienced in flight on a scale of 1 to 9 ____________

1 = extremely poor 5 = adequate 9 = extremely good



82. Are the capabilities of your current helmet sufficient to allow you to safely meet all mission requirements?



If you would like to make additional comments, which have not been fully addressed by this survey, please do so below.

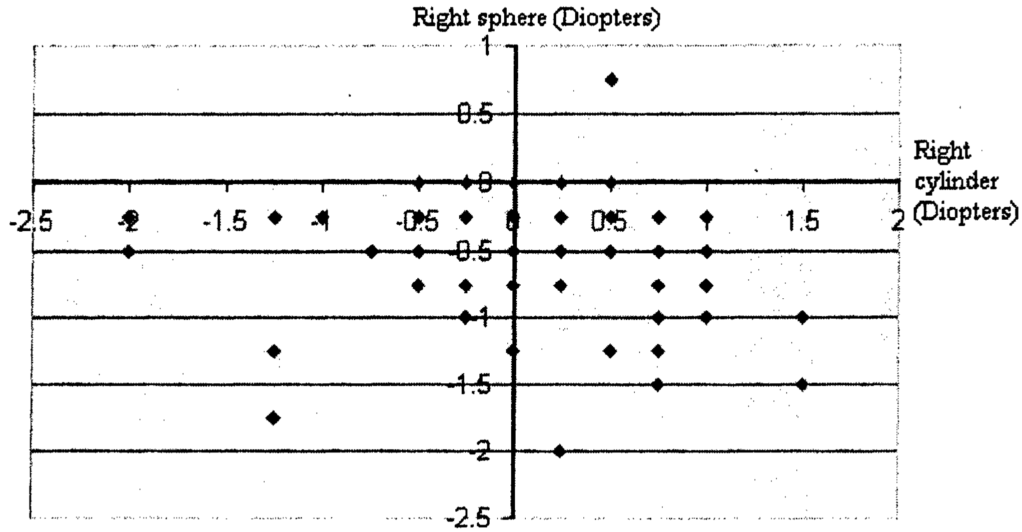
- Although I have answered yes to this question I do believe that we can benefit from a better design of helmet. I think there can be a tendency in the Army to "put up with what is issued."
- Please note [that] as a trainee pilot, I have limited experience with flights lasting longer than 1.25 hours. I have not reached the NVG stage of the course. I am probably not the ideal candidate for the study.
- NVG [training] not done yet but can foresee the helmet being too loose.

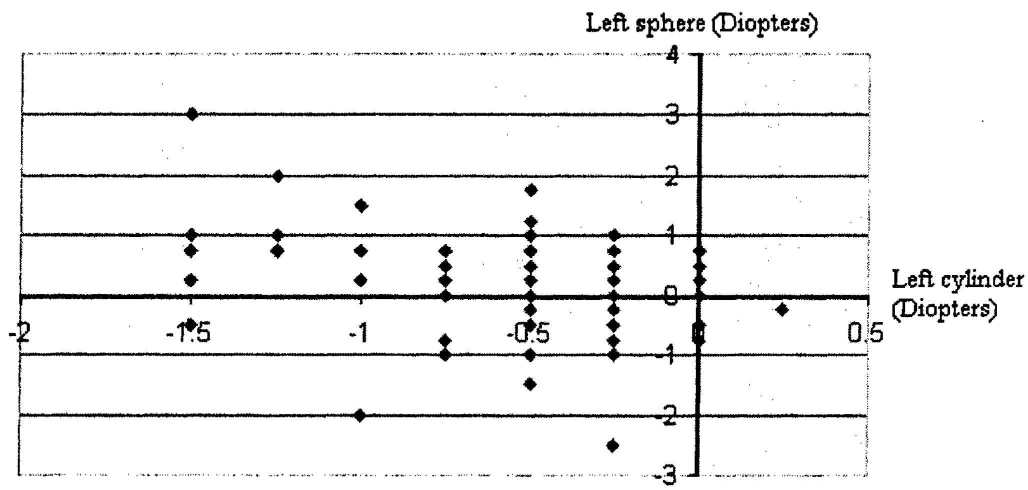
Appendix C.

Non-Apache (control) pilot eye examination.

Control

Manual Refraction:
OD: Sphere _____ Cylinder ______ Axis ______
OS: Sphere _____ Cylinder ______ Axis ______





Refractive error data for control subjects

Subject Number	Right			Left		
	Sphere ± Cylinder X Axis			Sphere ± Cylinder X Axis		
011	0.25	-0.25	165	0.50	-0.25	22
022	-2.00	-0.25	77	-2.50	-0.25	5
023	0.25	-2.00	103	-0.75	-0.75	81
029	0.00	-0.25	14	0.75	-0.75	164
039	-0.50	-0.50	29	-1.00	-0.50	75
042	-2.00	-0.50	153	-2.00	-1.00	19
046	0.75	0.75	100	0.75	-0.25	95
050	0.25	-0.75	88	0.25	-0.75	83
052	1.50	-1.00	178	0.00	-0.75	1
053	0.50	-0.25	164	0.50	-0.25	2
054	1.00	-0.50	177	0.75	-0.25	2
055	0.25	-0.75	88	0.25	-0.75	83
056	0.75	-0.25	27	1.75	-0.50	53
057	-0.50	-0.50	29	-1.00	-0.50	75
072	-2.00	-0.50	153	-2.00	-1.00	19
093	0.50	-0.25	164	0.50	-0.25	2
094	1.00	-0.50	177	0.75	-0.25	2
095	0.25	-0.25	61	0.00	-0.25	97
096	1.00	-0.50	11	0.75	-0.25	2
097	-0.75	-0.50	9	-1.00	-0.75	13
059	0.25	-0.25	108	0.00	-0.25	20
060	0.00	-0.25	122	0.25	-0.25	100
061	0.75	-1.00	83	0.00	-0.25	7
083	0.50	-0.50	107	0.75	-0.50	65
073	-0.25	-.25	53	0.00	0.00	0
074	0.25	-0.25	121	1.50	-1.00	58
075	0.50	-0.50	173	0.50	-0.25	143
076	0.00	0.00	0	0.25	-0.25	139
077	0.75	-1.00	107	0.00	-0.75	49
080	0.75	-1.50	94	0.75	-1.50	92
098	-1.25	-1.25	112	-1.50	-0.50	41
099	0.25	-0.25	72	-0.50	0.00	0
007	0.00	-0.50	12	0.00	0.00	0
013	-0.50	0.00	0	-0.25	-0.25	49
016	0.00	0.00	0	0.00	-0.50	4
017	-1.25	-0.25	88	-0.75	-0.25	20
020	1.00	-1.00	92	0.75	-0.75	73
021	0.75	-1.25	96	0.75	-1.25	70
027	.75	-1.25	91	1.00	-1.25	72
032	0.50	-0.25	23	0.50	-0.25	136
063	0.75	-0.50	45	1.25	-0.50	119
064	0.00	-1.25	9	-0.50	-1.50	9

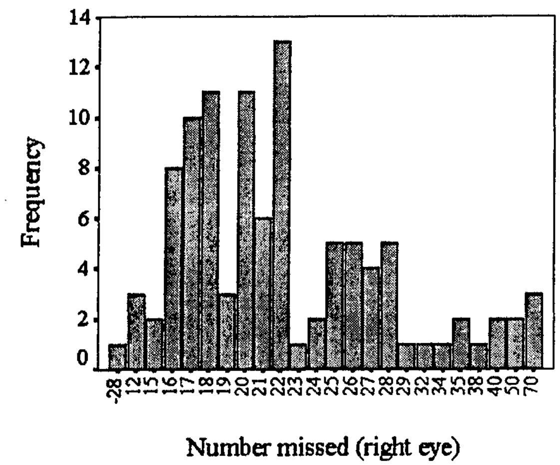
Subject Number	Right			Left		
	Sphere ± Cylinder X Axis			Sphere ± Cylinder X Axis		
078	-0.25	-0.75	15	0.25	-1.50	80
079	1.00	-0.25	176	0.75	0.00	23
040	0.00	-0.75	175	0.50	-0.75	30
041	0.50	-0.50	1	2.00	-1.25	153
043	0.25	-0.25	19	0.50	-0.50	156
045	0.00	-0.25	16	0.25	-0.50	72
069	0.50	0-.50	22	0.25	-0.25	177
065	0.00	-0.75	100	-0.25	-0.50	47
012	0.75	-0.75	0	1.00	-1.50	73
014	-0.25	-0.25	82	0.25	0.25	39
018	0.50	-0.50	108	0.50	-0.25	61
024	0.00	0.00	91	0.25	-0.25	73
036	0.25	-0.25	77	0.25	-0.25	115
068	-0.25	-0.25	49	-0.25	-0.25	49
066	0.25	-0.25	12	0.00	0.00	0
067	0.50	-0.25	177	0.75	-0.25	50
070	-0.25	0.00	0	0.00	-0.25	73
071	0.25	0.00	0	0.50	-0.25	81
106	-0.50	-0.75	4	-0.50	-0.25	35
107	0.50	-0.25	9	0.00	-0.25	69
108	-0.50	0.00	0	-0.25	-0.25	14
109	0.00	0.00	0	.00	-0.25	59
110	0.50	-1.25	96	0.25	-1.00	85
111	0.50	-0.50	98	0.75	-0.75	102
112	1.00	-0.50	88	0.25	0.00	0
113	-0.25	0.00	0	0.50	-0.25	52
114	0.00	-0.25	155	0.00	-0.75	172
115	-1.25	-1.75	176	-0.75	0.00	2
008	0.75	-0.25	83	0.50	0.00	0
025	0.25	0.00	0	0.50	-0.25	29
026	0.00	-0.50	28	0.50	-0.25	6
030	0.00	-0.50	100	0.25	-0.75	42
009	0.50	0.75	42	0.75	-1.00	140
062	.75	-0.25	107	1.00	-1.25	80
047	1.00	-0.50	17	1.00	-0.25	168
081	-0.50	-0.25	26	0.00	-0.50	24
082	-0.25	0.00	0	-0.25	-0.25	39
084	-0.25	-0.25	81	-0.25	0.25	92
085	0.25	-0.25	2	0.00	-0.25	44
086	-0.25	0.00	0	0.00	-0.25	66
087	0.50	-0.50	92	0.25	-0.25	110
090	0.25	-0.25	47	0.25	0.00	0
088	0.00	-0.25	101	0.25	-0.75	90

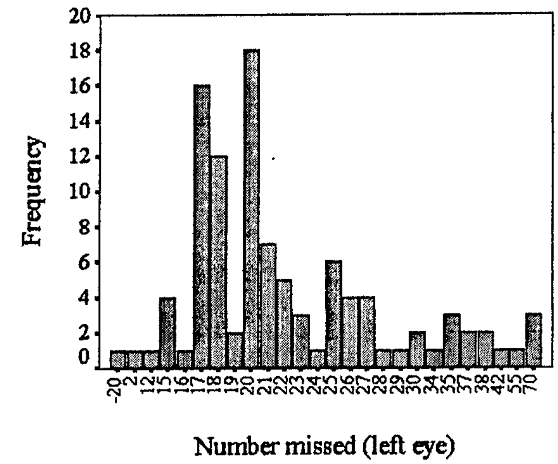
Subject Number	Right			Left		
	Sphere ± Cylinder X Axis			Sphere ± Cylinder X Axis		
116	0.50	0.00	9	1.00	-0.50	72
117	-0.25	-0.25	24	-0.25	-0.25	45
010	0.50	0.00	0	0.25	-0.25	32
015	0.00	-0.75	54	0.25	-0.50	49
031	0.00	-0.25	84	0.75	-0.50	106
034	0.75	-0.50	58	1.00	-0.25	94
035	0.50	-0.50	152	0.25	-0.25	18
037	0.00	-0.50	103	0.00	-0.50	66
049	0.75	-0.25	96	0.75	-0.50	91
104	0.50	-0.50	81	0.25	0.00	0
105	0.25	-0.75	13	0.50	-0.50	180
091	-0.25	-1.00	112	0.00	-0.75	60
092	1.50	-1.50	61	3.00	-1.50	87
100	1.00	-0.75	20	0.75	-0.25	21
019	0.25	-0.50	81	0.50	-0.25	85
028	-0.50	-0.50	116	-0.50	-0.50	82
038	1.00	-0.50	86	0.75	-0.25	39
048	-1.00	-0.50	40	-1.00	-0.25	117
Mean	0.17	-0.46	71	0.22	-0.47	61
SD	0.66	0.43	56	0.76	0.39	48

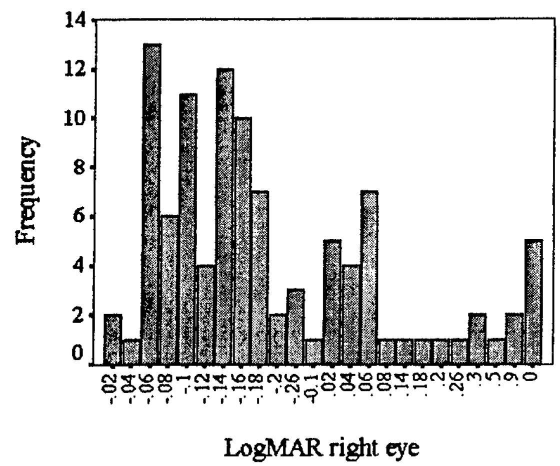
Bailey-Lovie High Contrast Visual Acuity

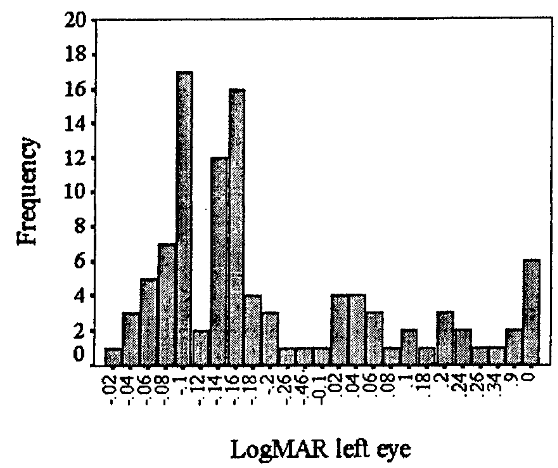
Total number missed for:

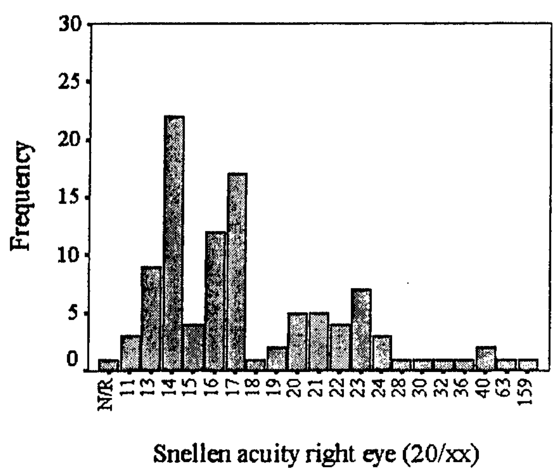
Right Eye: ______ Left Eye: ______

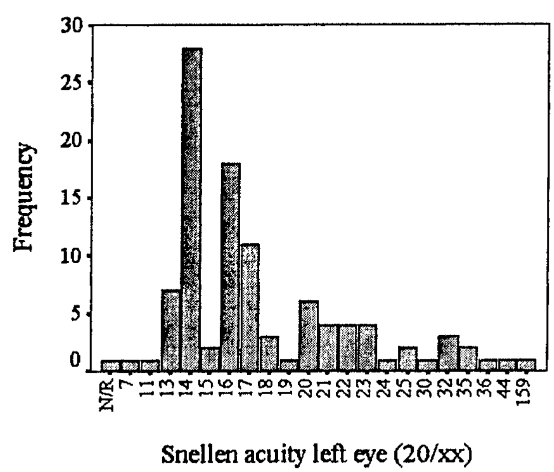






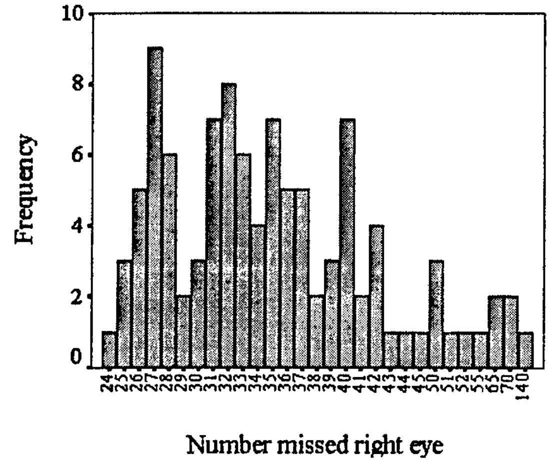


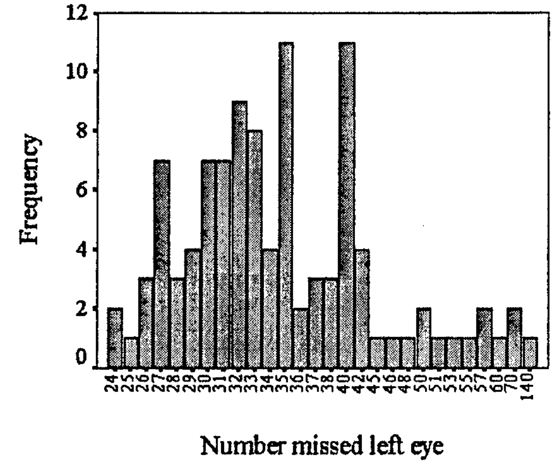


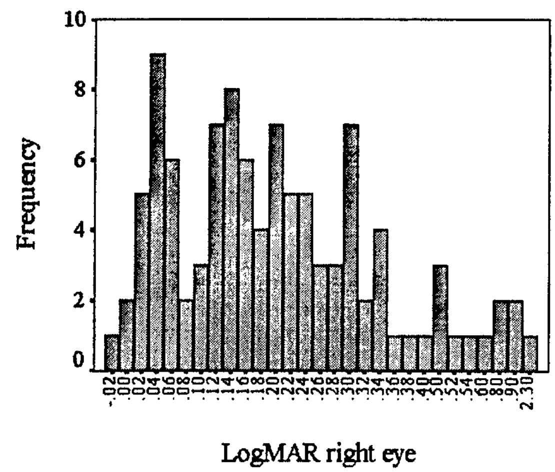


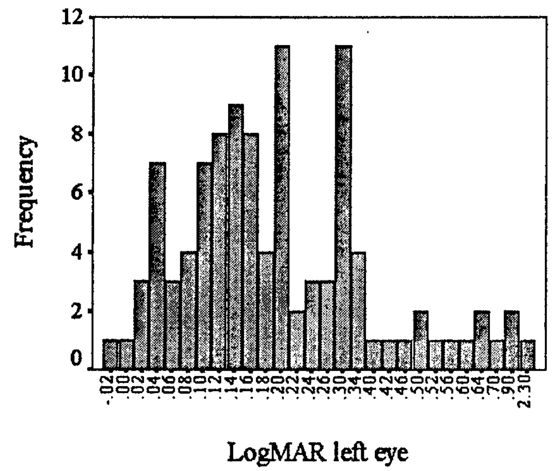
Bailey-Lovie Low Contrast Visual Acuity

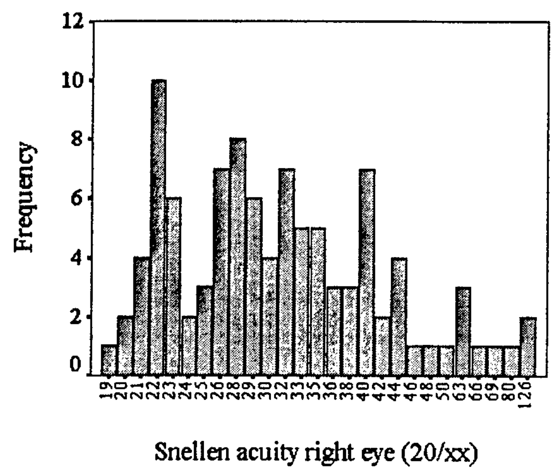
Total number missed for: Right Eye: ______ Left Eye:

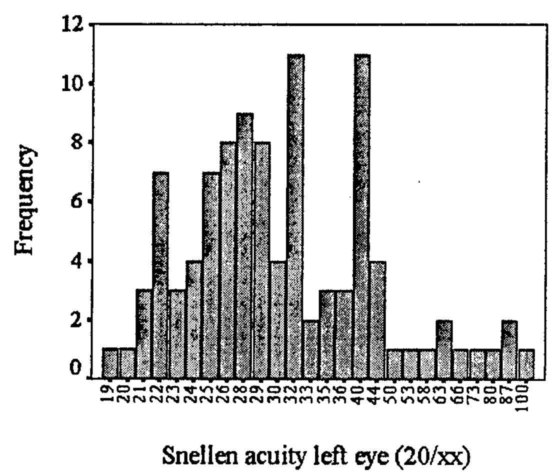






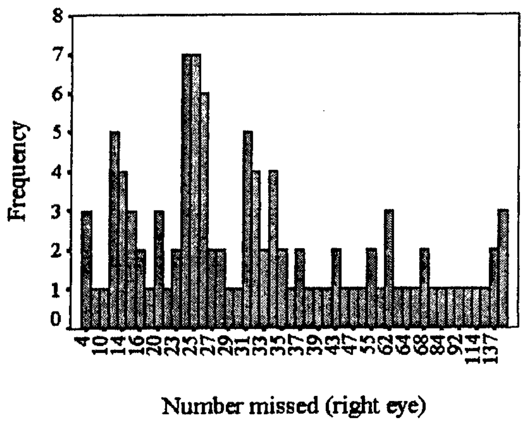


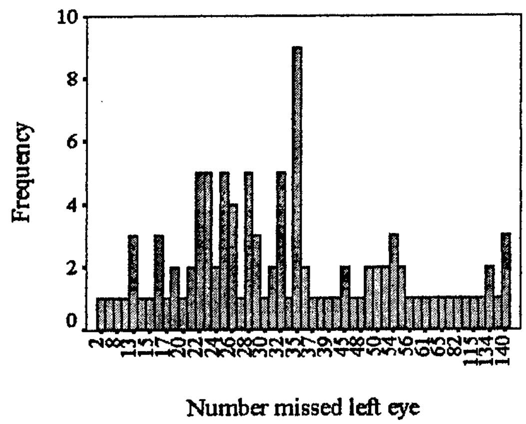


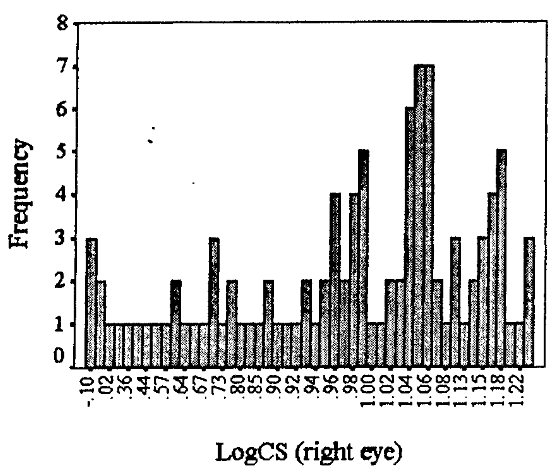


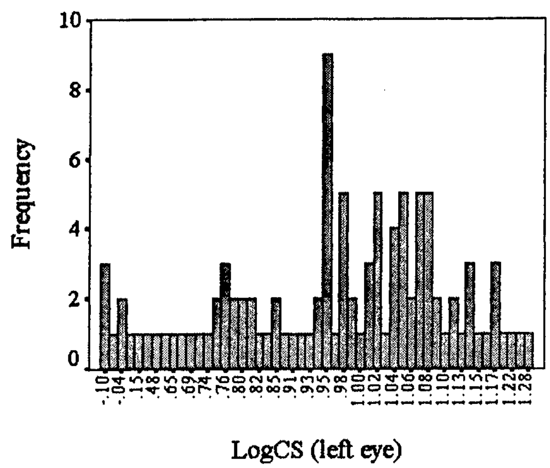
Small Letter Contrast

Total number missed for: Right Eye: ______ Left Eye: _______

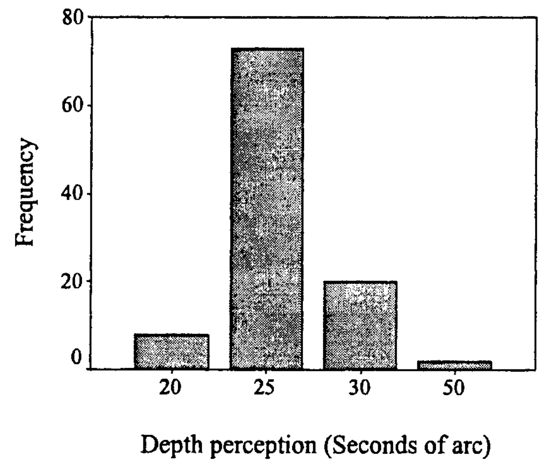








Depth Perception



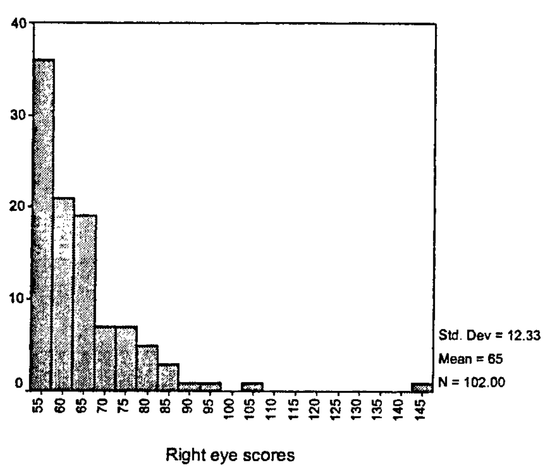
Color Perception

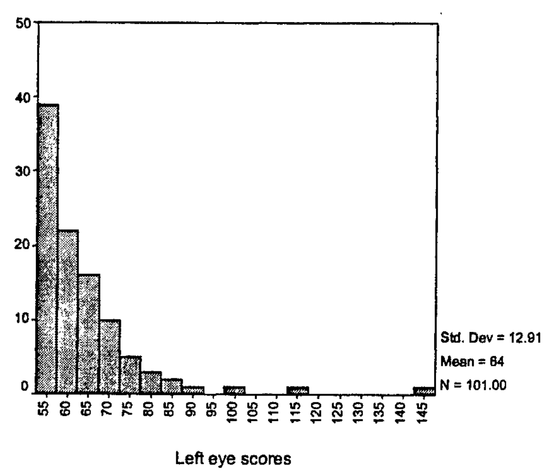
Right eye:
____ No reversal

__ 1 __ 2 __ 3 __ 4 __ 5 __ 6 __ 7 __ 8 __ 9 __ 10 __ 11 __ 12 __ 13 __ 14 __ 15

Left eye:
___No reversal

__ 1 __ 2 __ 3 __ 4 __ 5 __ 6 __ 7 __ 8 __ 9 __ 10 __ 11 __ 12 __ 13 __ 14 __ 15

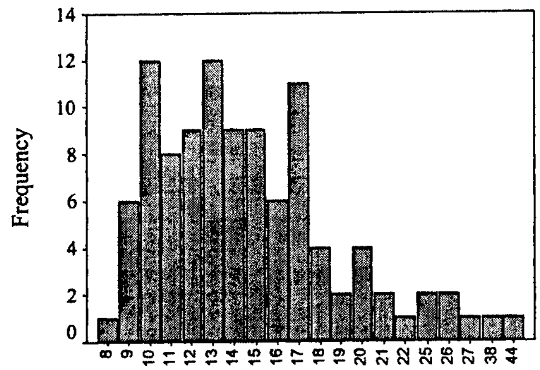




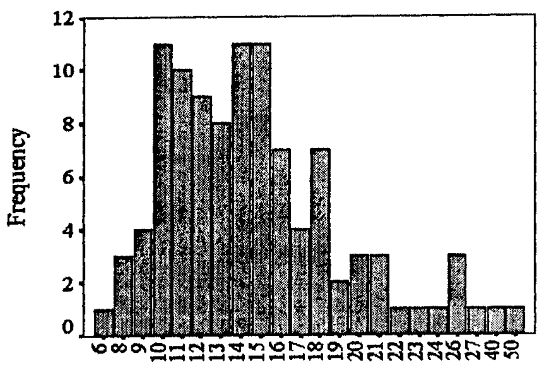
Accommodation

Without spectacles:

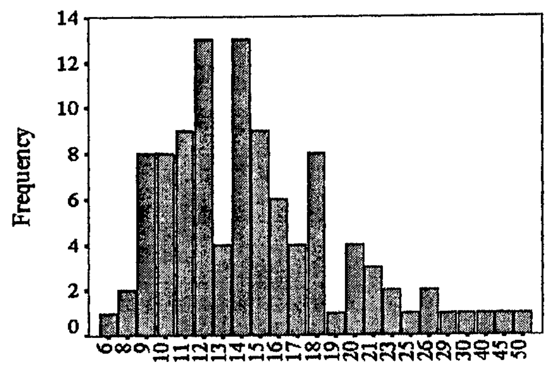
Both eyes: _____cm
Right eye: _____ cm
Left eye: _____ cm



Accommodation without spectacles both eyes



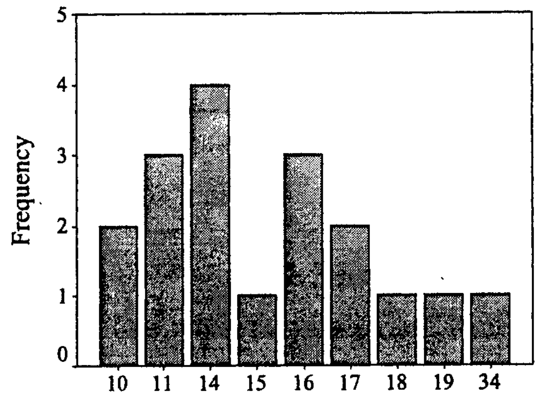
Accommodation without spectacles right eye



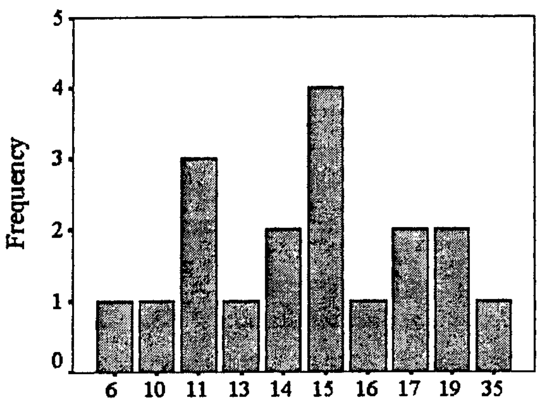
Accommodation without spectacles left eye

With spectacles

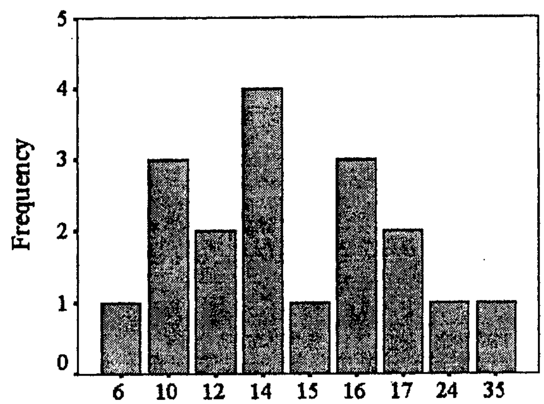
Both eyes: ____cm
Right eye: ____ cm
Left eye: ____ cm



Accommodation with spectacles both eyes



Accommodation with spectacles right eye



Accommodation with spectacles left eye

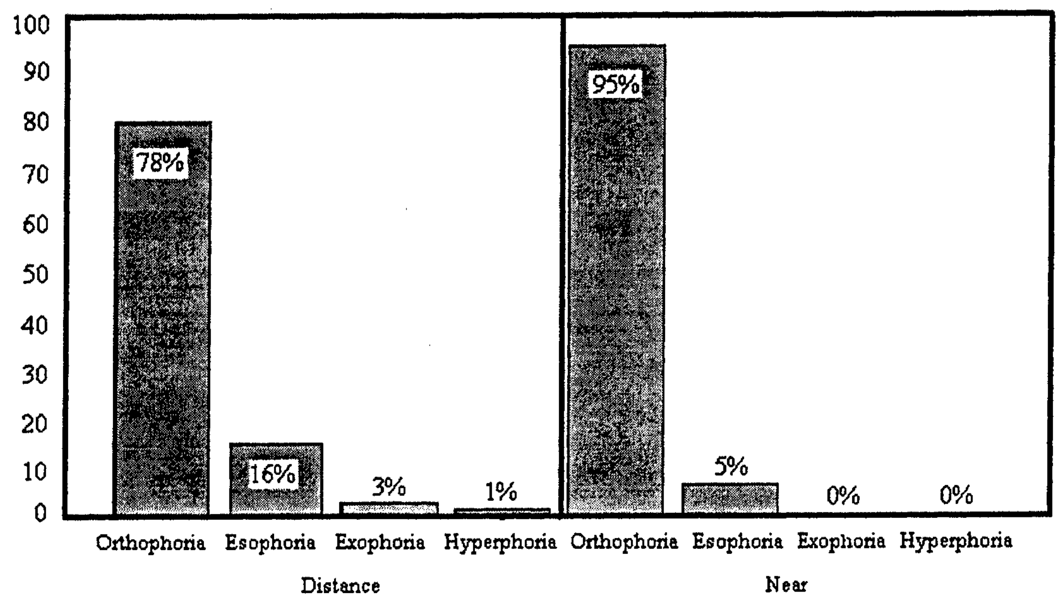
<u>Eye Muscle Balance</u>

<u>Distance</u>

Orthophoria: _____ Yes _____ No
Heterophoria: _____ Exophoria _____
Hyperphoria: Right: ____ Left eye ____

<u>Near</u>

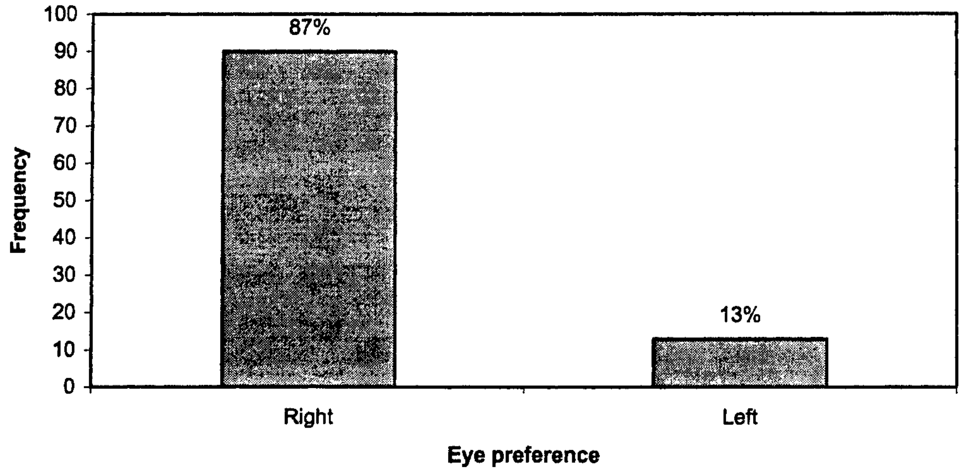
Orthophoria: _____ Yes _____ No
Heterophoria: _____ Exophoria _____
Hyperphoria: Right eye: ____ Left eye _____



Eye muscle balance

Eye preference

Right eye: ______ Left eye: _____



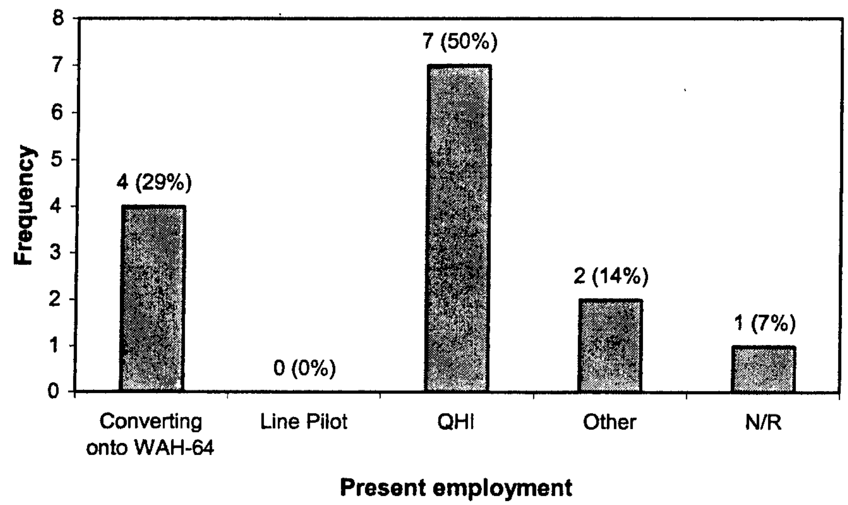
Appendix D.

Apache AH Mk 1 pilot questionnaire.

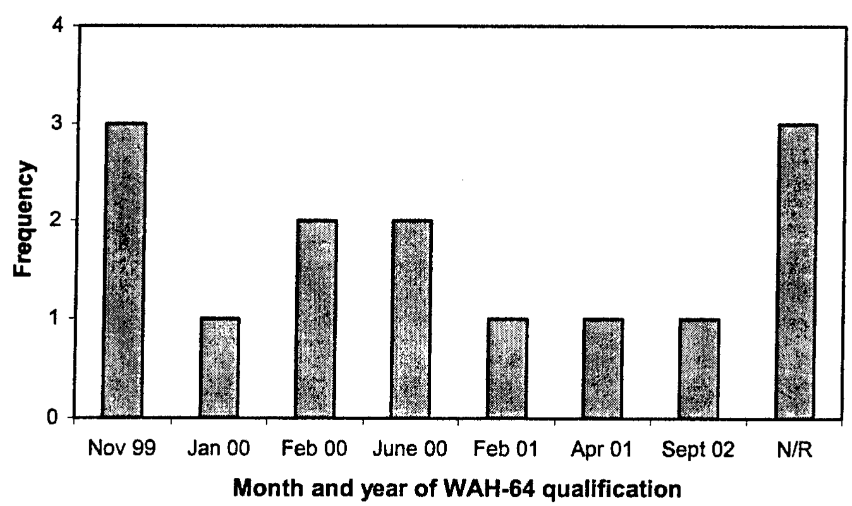
Date questionnaire completed: __________ **See Appendix A**

Current Unit: __________ **See Appendix A**

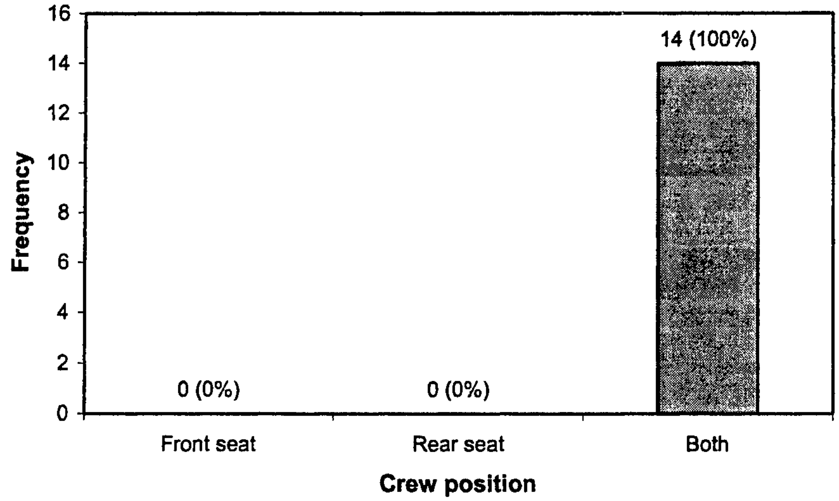
1. Present employment: Tick one only



2. Month and Year in which you were AH MK 1 qualified: __________

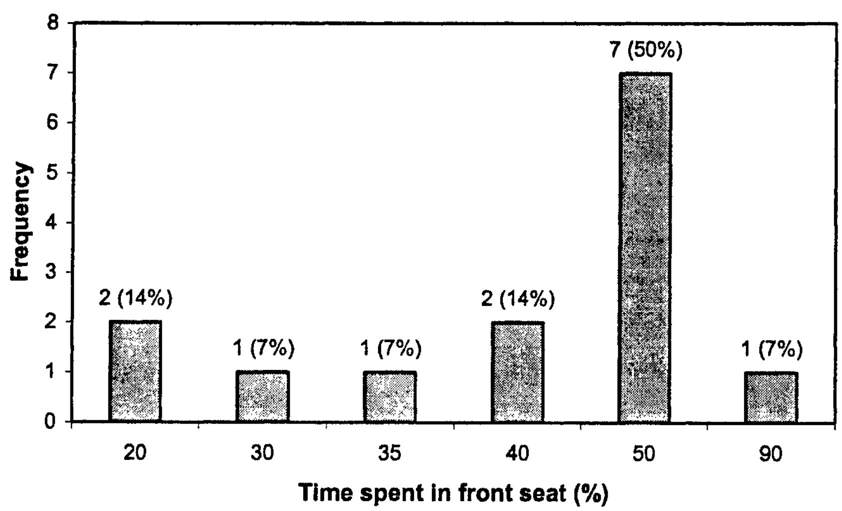


3a. In which crew position do you fly? Tick one only

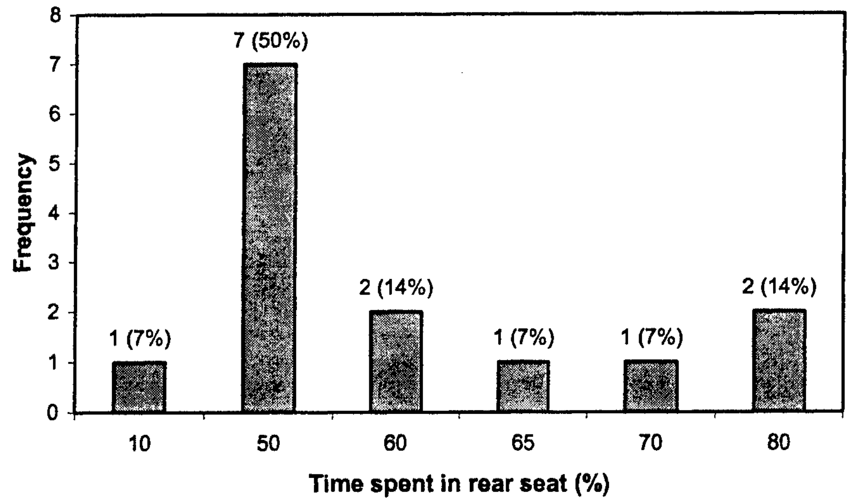


3b. If both, please estimate the percent of time you fly in each seat:

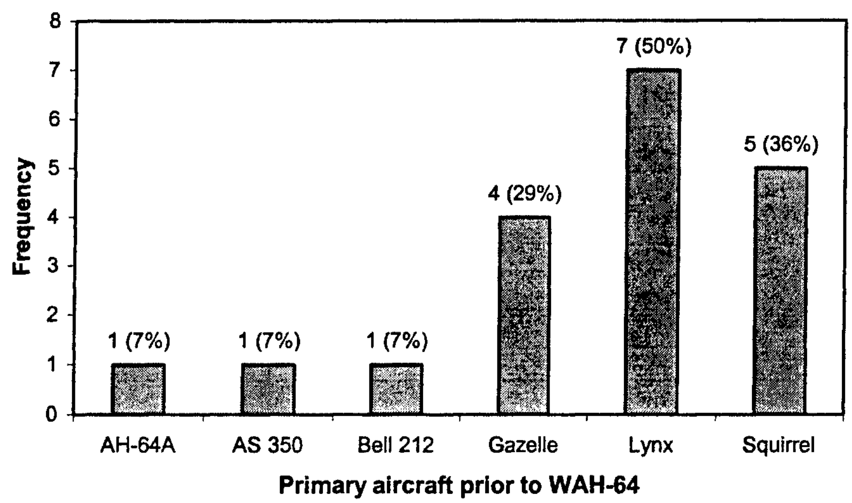
Front ______



Rear ______

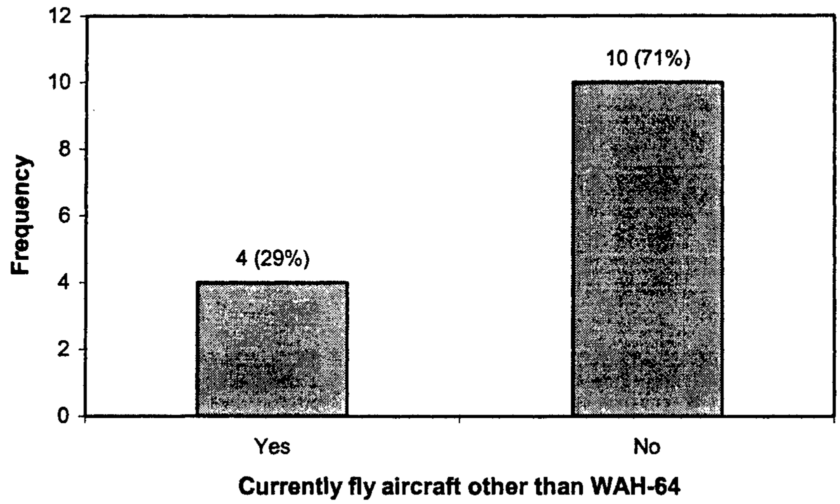


4. Primary aircraft prior to AH MK 1: ________________



5a. Do you currently fly aircraft other than AH Mk 1?

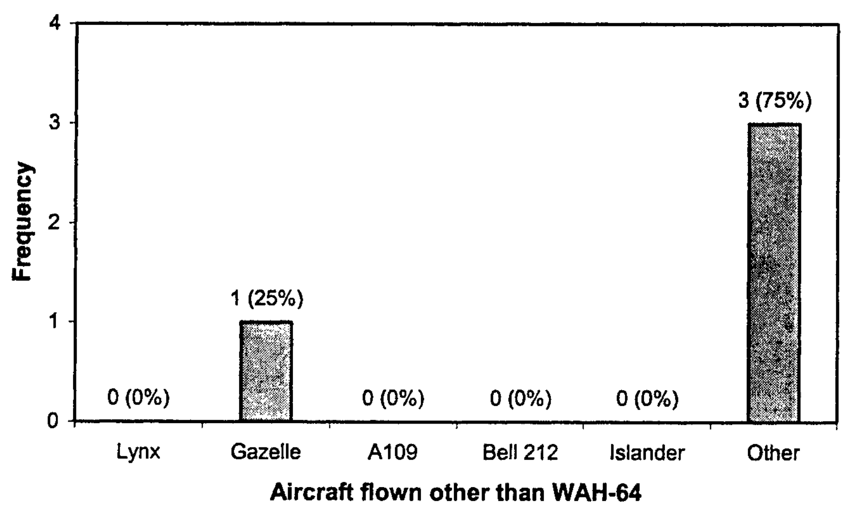
Yes [ ] No [ ]



5b. If yes, please specify (Circle one or more) .

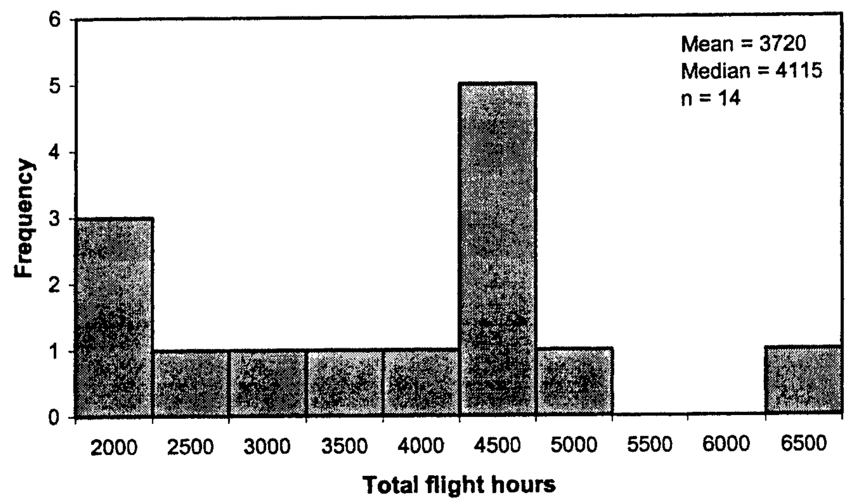
Lynx Gazelle A109 Bell 212 Islander

Other (please specify)________________

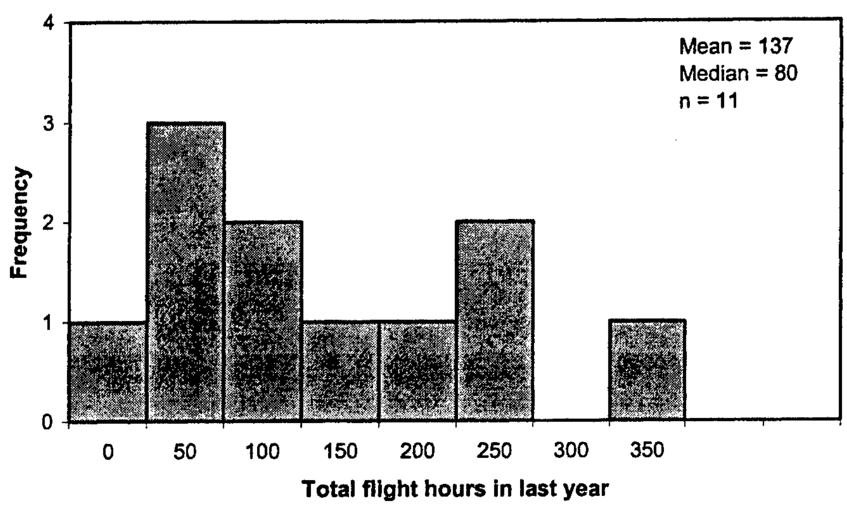


FLYING HOURS

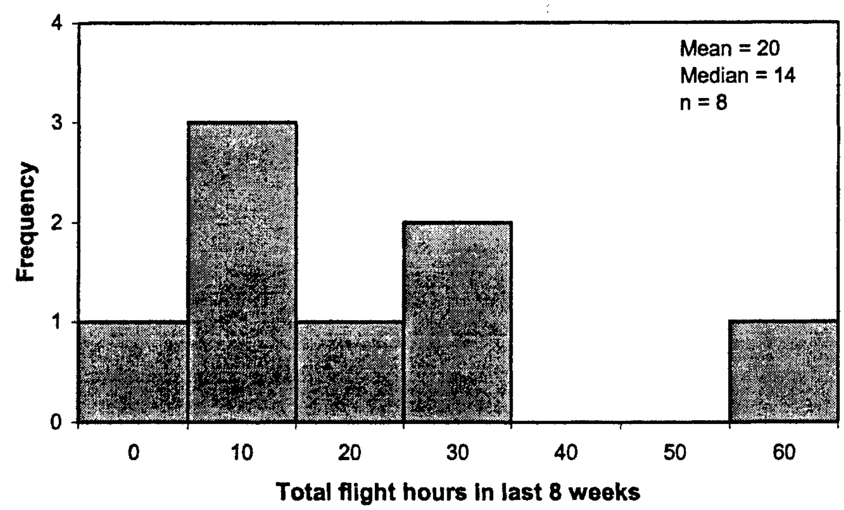
6a. Total flight hours (rounded to nearest 10): ______



6b. Total flight hours in last year (rounded to nearest 10): _____ redo

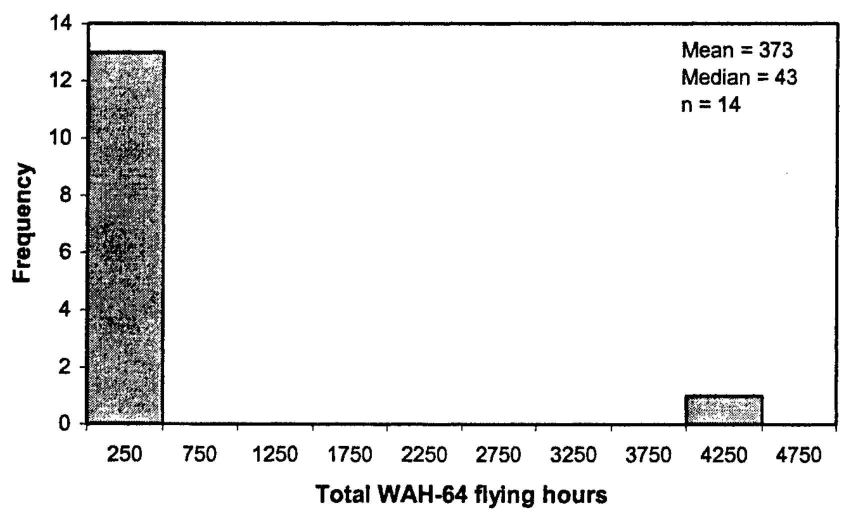


6c. Total flight hours in last 8 weeks (exact): _____

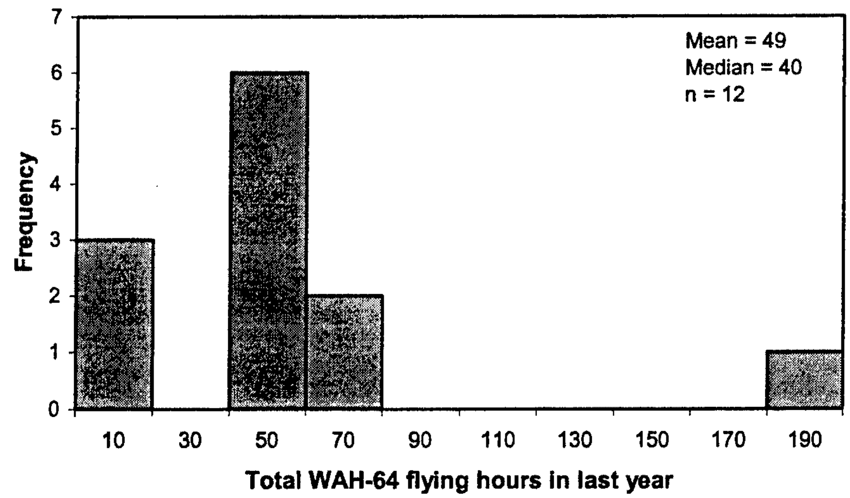


AH MK 1 flying hours

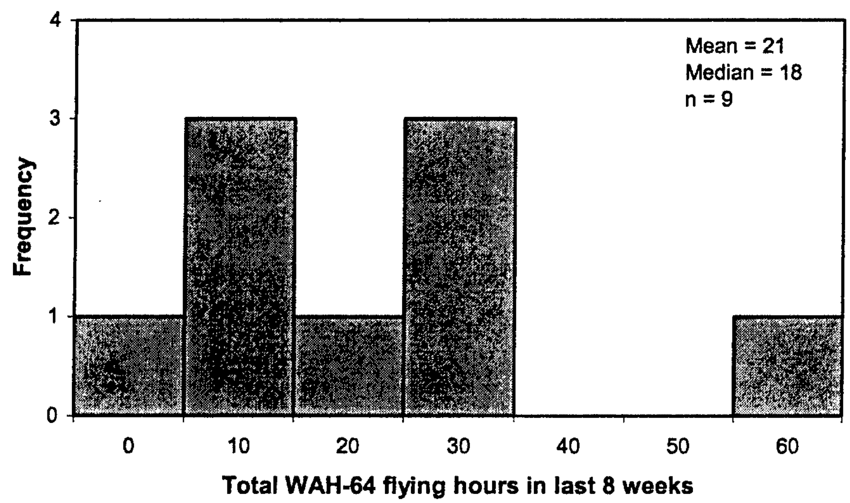
7a. Total AH MK 1 flying hours (rounded to nearest 10): ______



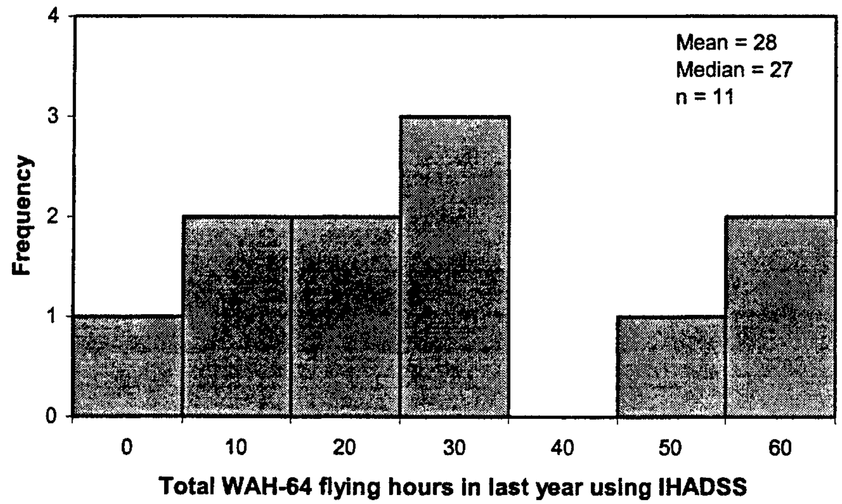
7b. Total AH MK 1 flying hours in last year (rounded to nearest 10):_____



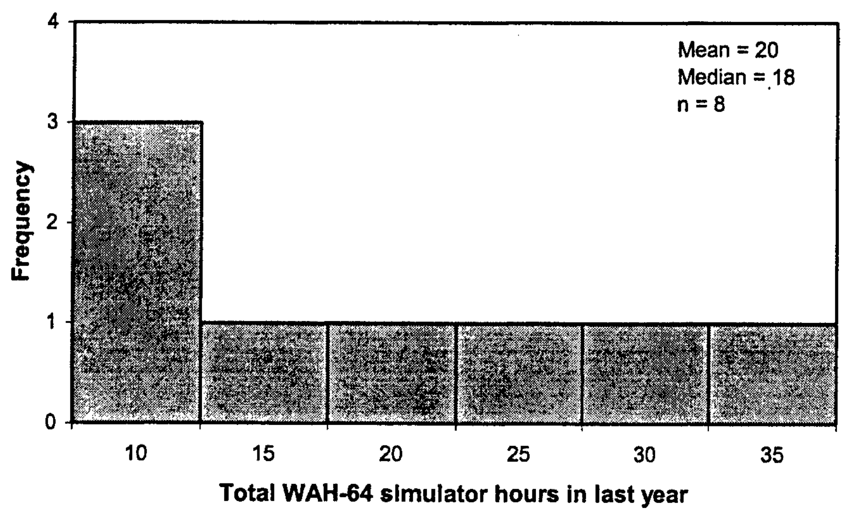
7c. Total AH MK 1 flying hours in last 8 weeks (exact): _____



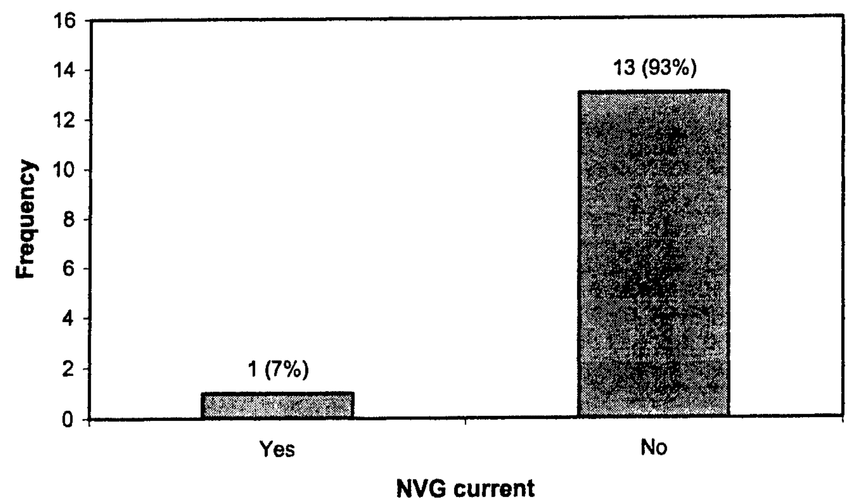
7d. Total AH MK 1 flying hours in last year using IHADSS (exact): ______



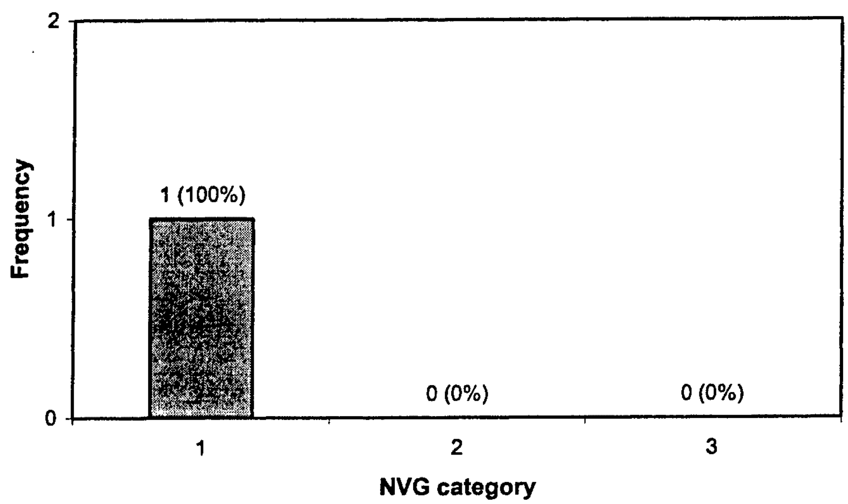
7e. Total AH MK 1 simulator hours in last year (rounded to nearest 10):_____
(include both FMS and FDS)



8a. Are you NVG current? (Tick one only)

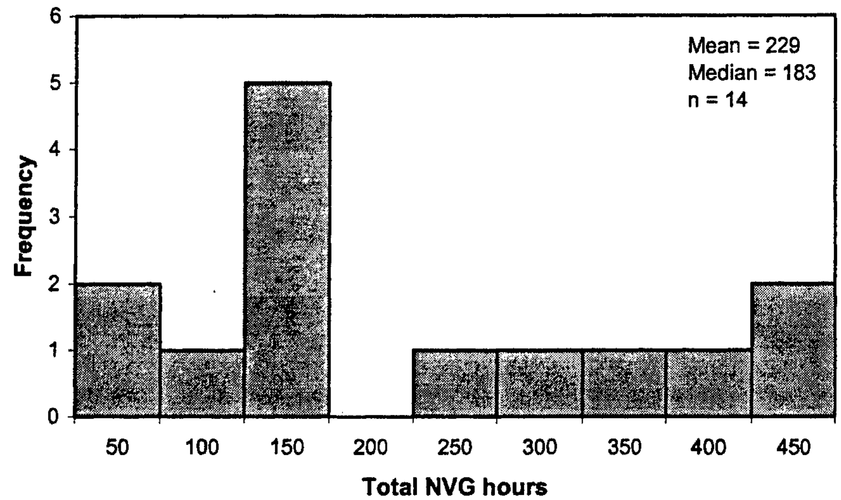


b. If yes, what category? (Circle one only)

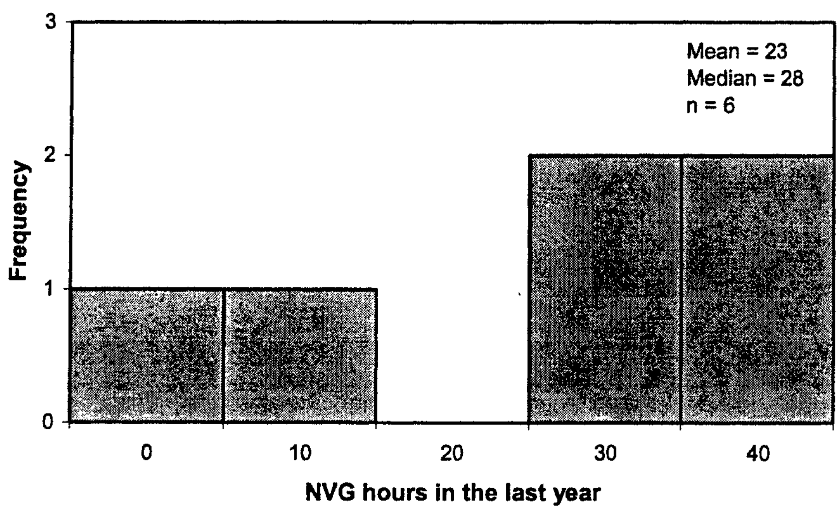


9. Please give approximate number of NVG hours

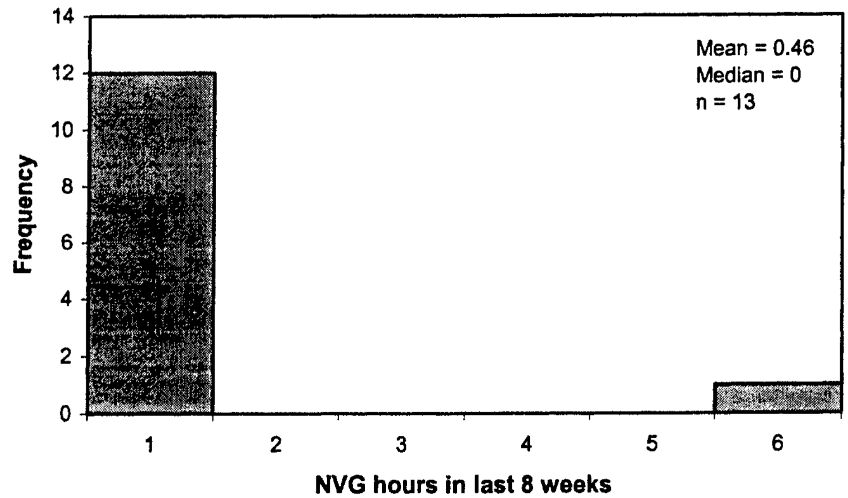
9a. Total NVG hours ____________



9b. In the last year: ____________

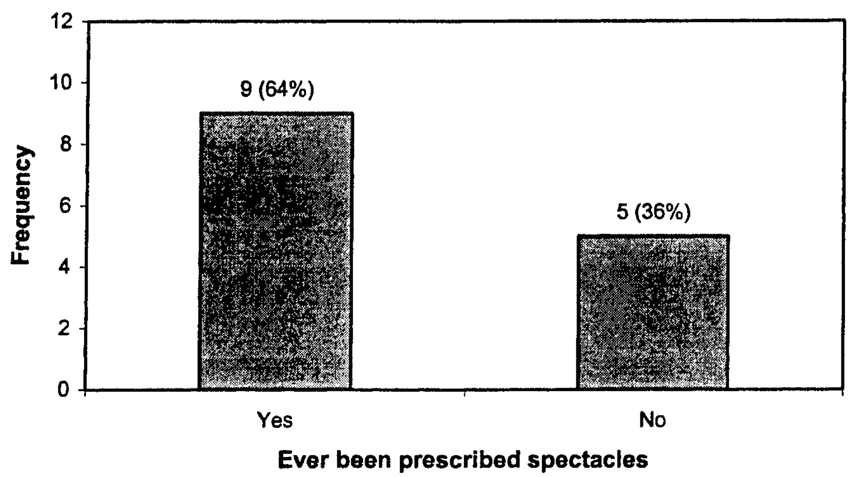


9c. In last 8 weeks ____________



VISION HISTORY

10a. Have you ever been prescribed spectacles? (Tick one only)

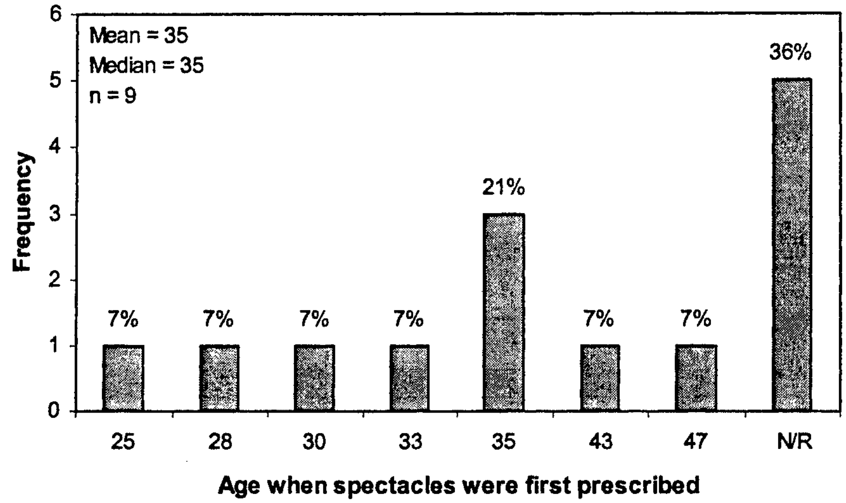


10b. If yes, please give reason for spectacles (For example, for distance, for reading/close work, all the time, flying only):

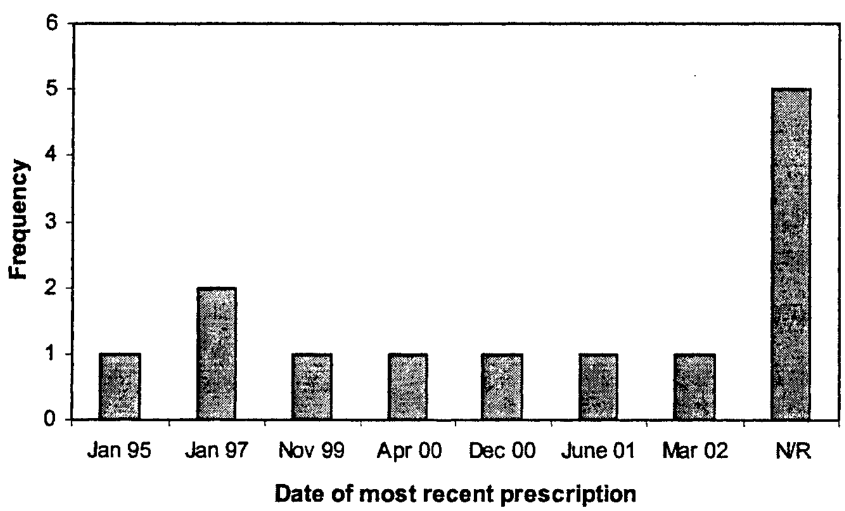
- To correct astigmatism and for distance.
- Reading.
- Short sightness.
- Flying only.
- Distance.

- Distance flying.
- Distance.
- For reading.
- Eye strain.

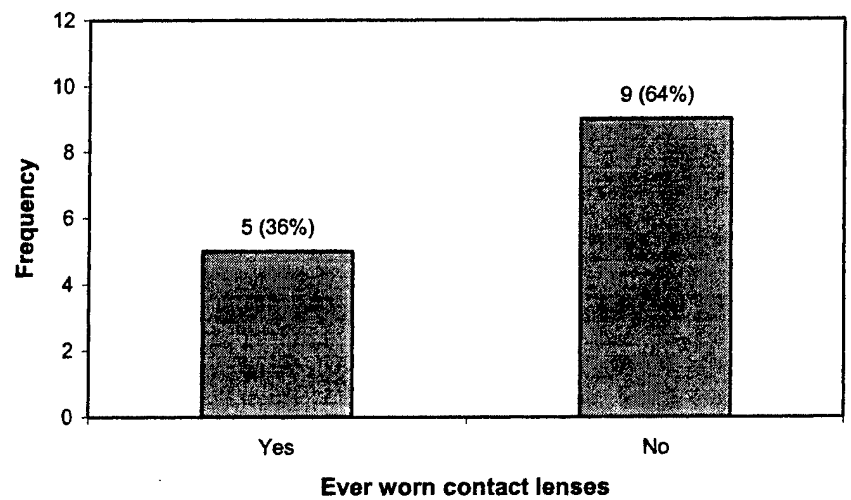
10c. Age when spectacles were first prescribed: ______________



10d. Date of most recent prescription: ________________

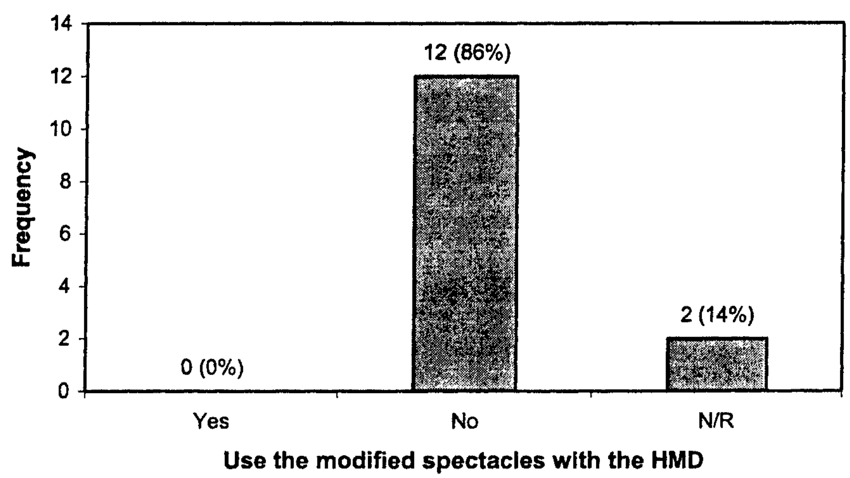


11. Have you ever worn contact lenses? (Tick one only)



If discontinued contact lenses within last year or presently using, please fill out the supplemental form (Appendix F) for contact lens users.

12a. Do you use the modified spectacles with the HMD? (Tick one only)



12b. If yes , do the modified spectacles interfere with your ability to see the HMD symbology?

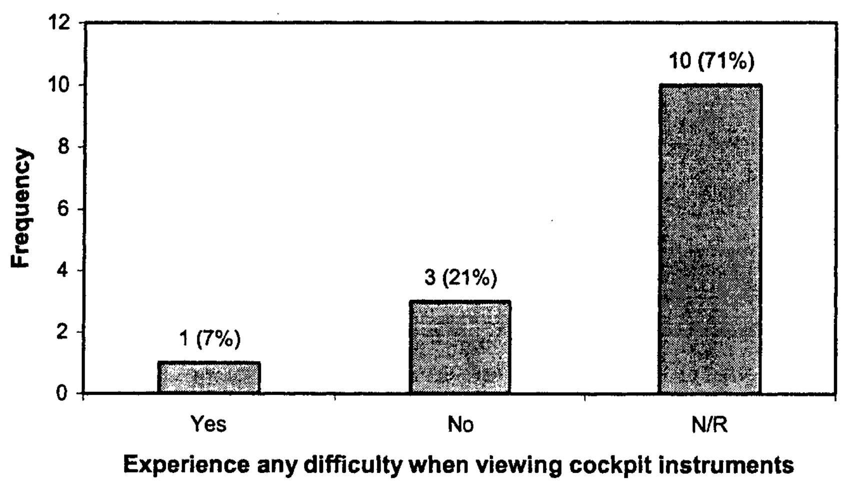
YES [0 (0%)]

12c. If yes, please explain:______________________________________

12d. If you use modified spectacles, do you remove the right lens?

13. If you do require spectacles for flying, but do <u>NOT</u> use the modified spectacles or contact lenses, do you experience any difficulty:

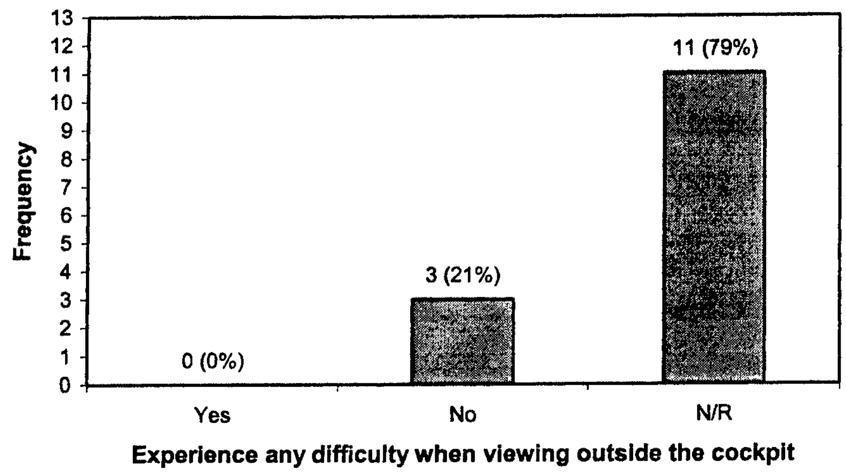
a. When viewing cockpit instruments?



b. If yes, please explain below.

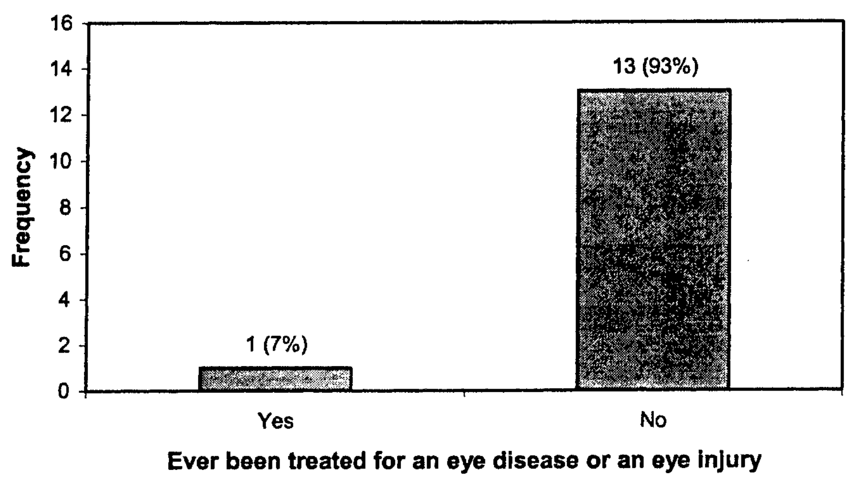
____

c. When viewing outside the cockpit?



d. If yes, please explain below:

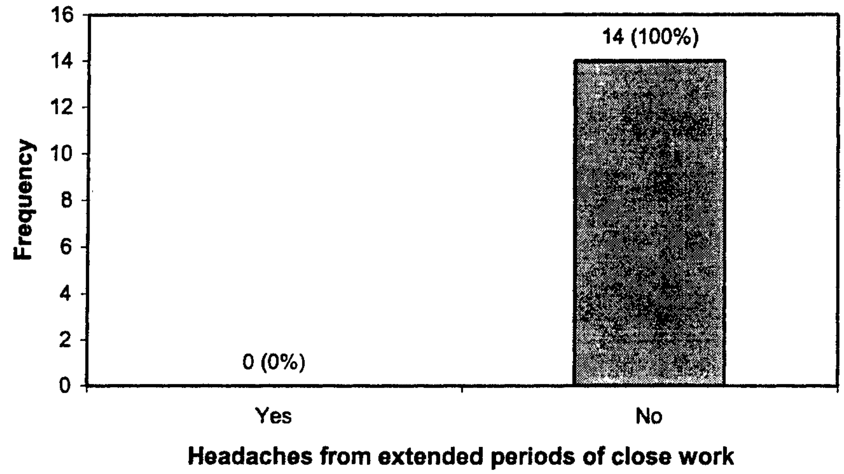
14a. Have you ever been treated for an eye disease or an eye injury?



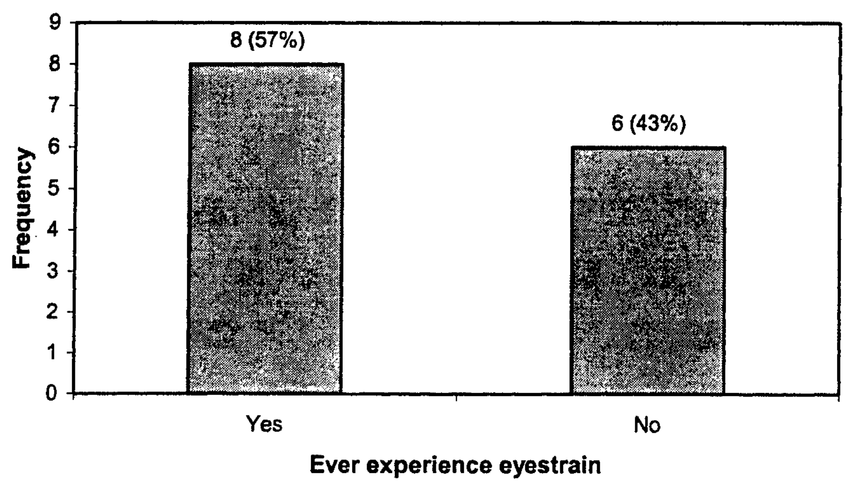
14b. If yes, please state when, for what reason, and do you have any continuing problems?

- In 1988 blow out fracture – left orbital floor.

15. Do you get headaches from extended periods of close work (For example, reading small print)?

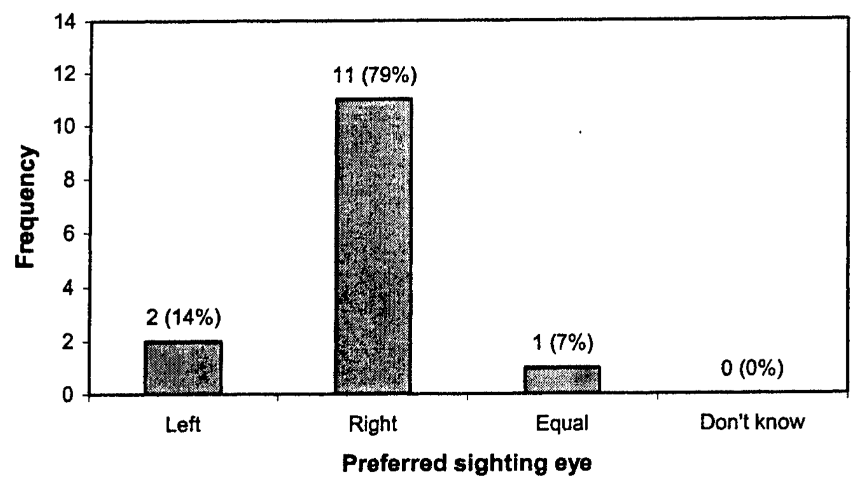


16. Do you ever experience eyestrain?

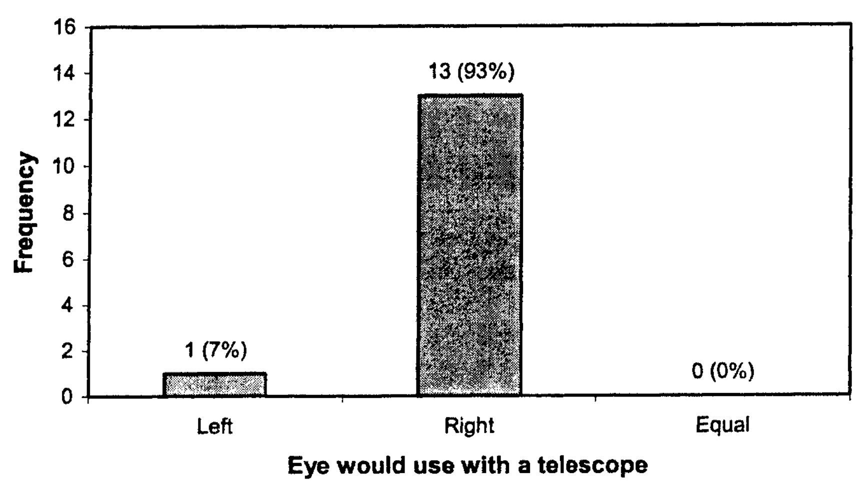


17. Which is your preferred sighting eye? (Tick one only)

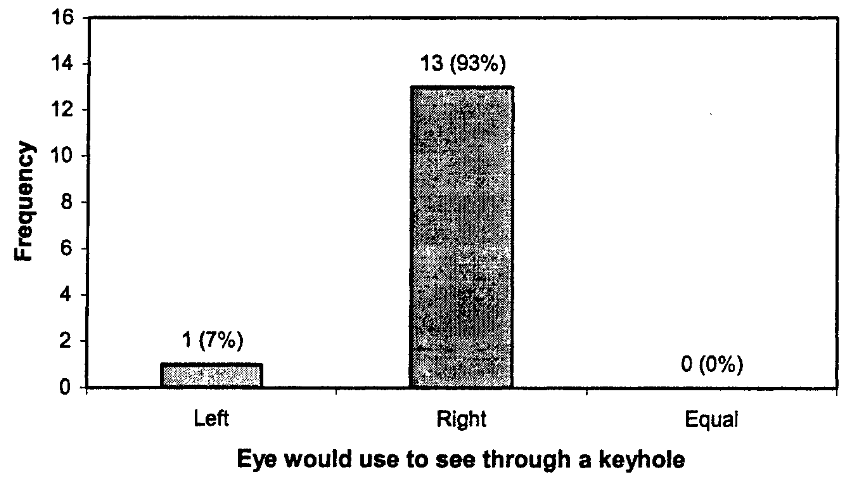
Left	[2 (14%)]
Right	[11 (79%)]
Equal	[1 (7%)]
Don't know	[0 (0%)]



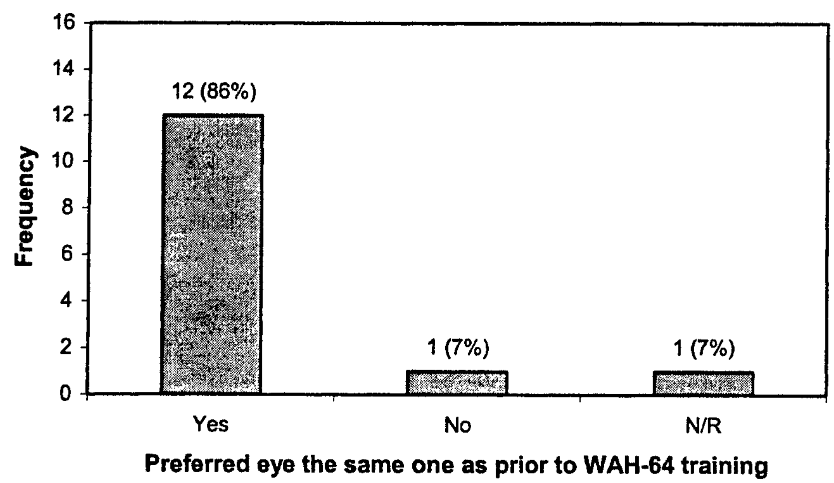
18. Which eye would you use with a telescope?



19. Which eye would you use to see through a keyhole?



20. Is your preferred eye the same one as prior to AH MK 1 training?



21. While flying the AH Mk 1, have you experienced (tick one box on each row only):

If other than never, please comment on how often, duration of symptoms, severity of symptoms and impact on that flight.

a. Visual discomfort: Never [ ] Sometimes [ ] Always [ ]

Comments:
- When HDU has been focused poorly/ severe eye ache.
- A mild form of strain in early stages.
- Discomfort using IHADSS during and after light.
- Converting from NVS to reversionary night flying

b. Headache: Never [ ] Sometimes [ ] Always [ ]

Comment:
- Due to helmet fit 1x sortie cancelled. Extremely difficult to concentrate.
- Poorly fitted helmet.
- Initially when under training.
- First flight in bag.
- Rarely but no impact.
- Poorly fitting helmet.

c. Double Vision: Never [ ] Sometimes [ ] Always [ ]

d. Blurred Vision: Never [ ] Sometimes [ ] Always [ ]

	Never	Sometimes	Always	N/R
Visual Discomfort	8(57%)	5(36%)	0(0%)	1(7%)
Headache	7(50%)	6(43%)	0(0%)	1(7%)
Double vision	13(93%)	0(0%)	0(0%)	1(7%)
Blurred vision	13(93%)	0(0%)	0(0%)	1(7%)

e. After Images: Never [ ] Sometimes [ ] Always [ ]

Comment:
- After night flying.

f. Disorientation: Never [ ] Sometimes [ ] Always [ ]

Comment:
- Short periods. Severe, flight continued.
- Sometimes the BAG training.

- Always end up head tilted to right when on system - often during training in the "Bag".
- During early stages of bag training.

g. Dizziness: Never [ ] Sometimes [ ] Always [ ]

Comment:

- Short periods. Severe, flight continued.

h. Nausea: Never [ ] Sometimes [ ] Always [ ]

Comment:

- Short periods. Severe flight continued.
- Early stages of "bag training" notably first couple of sorties.
- In simulator.

	Never	Sometimes	Always	N/R
After Images	12(51%)	1(7%)	0(0%)	1(7%)
Disorientation	9(64%)	4(29%)	0(0%)	1(7%)
Dizziness	13(93%)	1(7%)	0(0%)	0(0%)
Nausea	9(64%)	4(29%)	0(0%)	1(7%)

22. After flying the AH MK 1, have you experienced (tick one box on each row only):

If other than never, please comment on how often, how long post flight before symptoms began, duration of symptoms, and severity of symptoms:

a. Visual discomfort: Never [ ] Sometimes [ ] Always [ ]

Comment:

- Sore eyes.

b. Headache: Never [ ] Sometimes [ ] Always [ ]

Comment:

- Recedes fairly quickly after removing helmet.
- Poorly fitting helmet causing "hot spots".
- Morning after night flying.
- Rarely, no impact.
- Occasionally 1-2 hours minor post flight.

c. Double vision: Never [ ] Sometimes [ ] Always [ ]

d. Blurred vision: Never [ ] Sometimes [ ] Always [ ]

	Never	Sometimes	Always	N/R
Visual Discomfort	11(79%)	2(14%)	0(0%)	1(7%)
Headache	7(50%)	6(43%)	0(0%)	1(7%)
Double vision	13(93%)	0(0%)	0(0%)	1(7%)
Blurred vision	13(93%)	0(0%)	0(0%)	1(7%)

e. After Images: Never [ ] Sometimes [ ] Always [ ]

Comment:

- Pinking for 2-3 minutes.

f. Disorientation: Never [ ] Sometimes [ ] Always [ ]

g. Dizziness: Never [ ] Sometimes [ ] Always [ ]

Comment:

- After effects of simulator.

h. Nausea: Never [ ] Sometimes [ ] Always [ ]

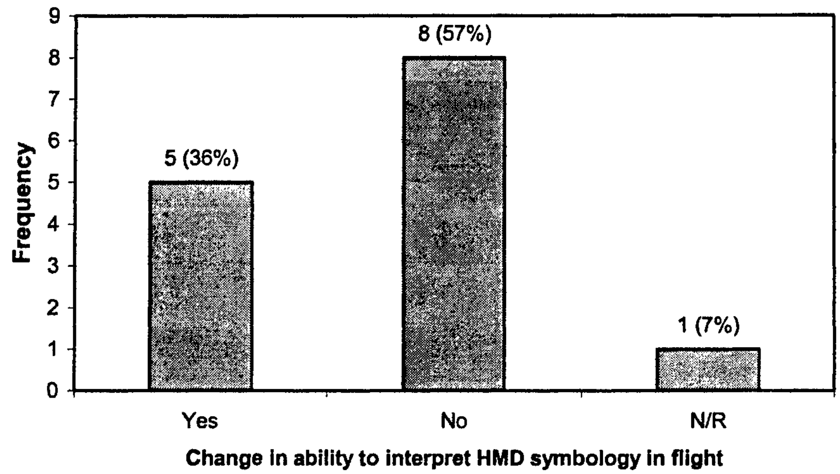
Comment:

- Early stages of "bag training" notably first couple of sorties.

i. Unsteadiness or trouble with balance: Never [ ] Sometimes [ ] Always [ ]

	Never	Sometimes	Always	N/R
After Images	12(86%)	0(0%)	1(1%)	1(7%)
Disorientation	13(93%)	0(0%)	0(0%)	1(7%)
Dizziness	12(86%)	1(7%)	0(0%)	1(7%)
Nausea	11(79%)	2(14%)	0(0%)	1(7%)
Unsteadiness	13(93%)	0(0%)	0(0%)	1(7%)

23a. Have you noted any change in your ability to see or interpret the HMD symbology during any phase of flight?



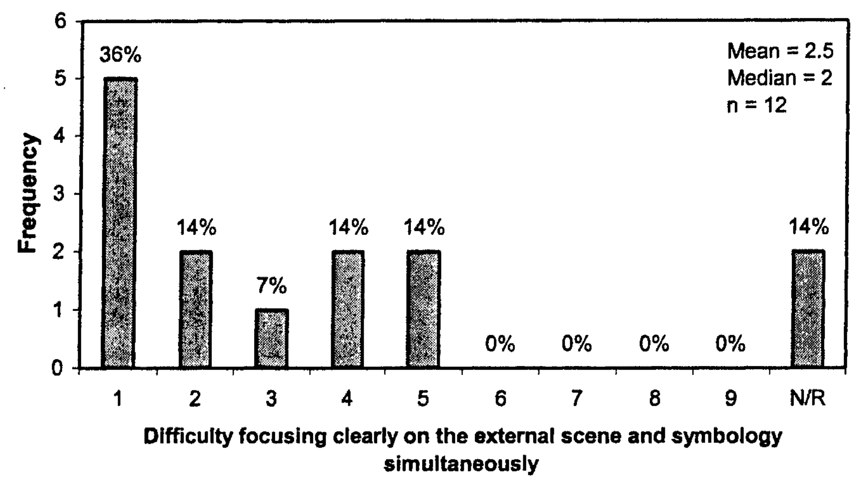
23b. If yes, please explain:

- During high cockpit workloads have to concentrate specifically on symbology.
- Poor helmet design.
- Focus required on combiner lens.
- Movement of HDU relative to eye.

24. When viewing through the HMD, do you have difficulty focusing clearly on the external scene and symbology simultaneously?

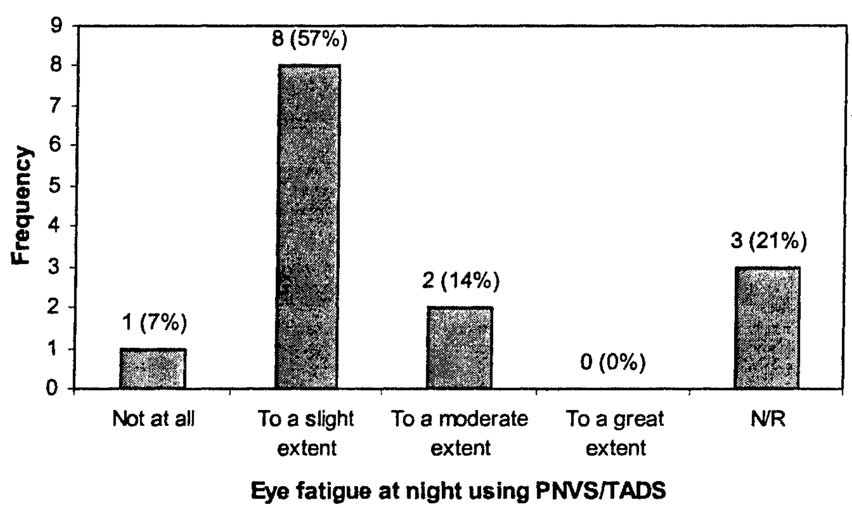
Grade how frequently this affects you on a scale of 1 to 9. ______________

1 = never 5 = 50% of the time 9 = always.

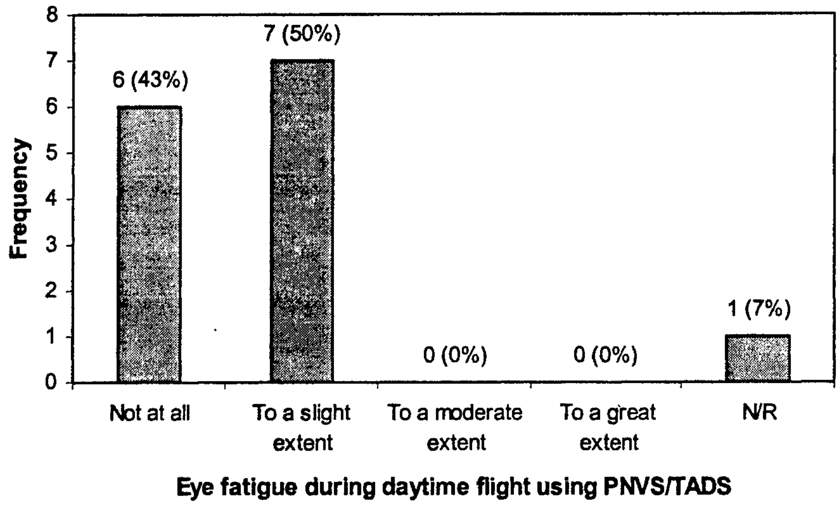


25. To what extent does flying by reference to the HDU cause eye fatigue?

a. At Night using PNVS/TADS (tick one box only)



b. During daytime flight using PNVS/TADS (tick one box only)



26. How do you use your visor? (tick one on each row ONLY)

a. Day: UP [ ] DOWN [ ]
b. Night: UP [ ] DOWN [ ]

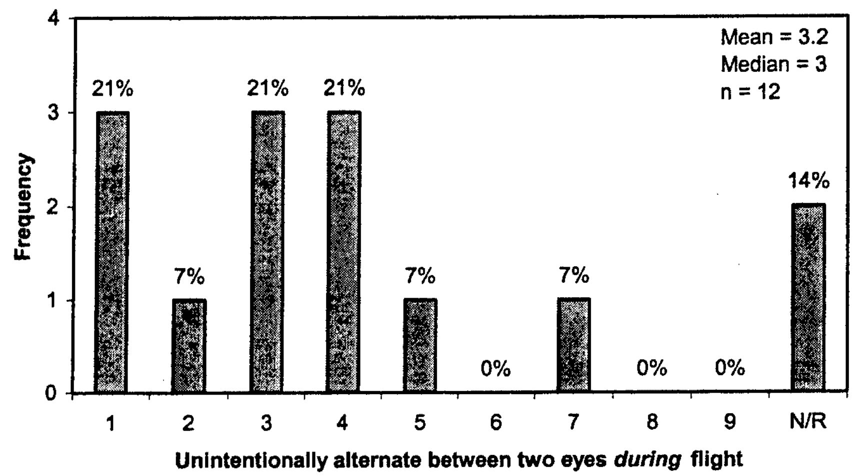
Use of visor	Up	Down	N/R
Day	3(21%)	10(71%)	1(7%)
Night	6(43%)	4(29%)	4(29%)

- Day down if sunny. Night 'up' to aid use of left eye.
- Answer is a combination of up and down. As only dark visor is fitted generally to IHADSS. I use it down to enhance symbology and as anti-glare as required.
- Only tinted visor fitted.
- Tint.
- Remove left eye cues.
- Allows me to use my left eye at night.

27. During AH MK 1 flight, does your vision sometimes unintentionally alternate between two eyes?

Grade how frequently this affects you on a scale of 1 to 9. ____________

1 = never 5 = 50% of the time 9 = always.



If other than never, please explain and estimate the duration.

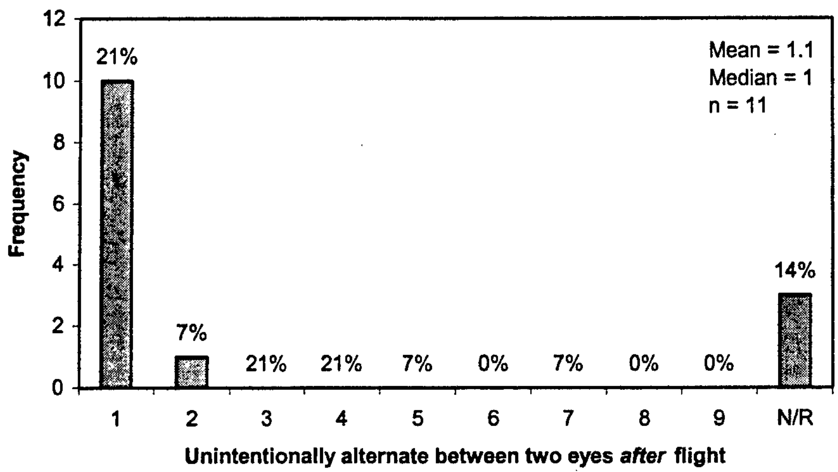
Comments:

- During bag training-left eye almost dominant once again due to in experience, this has improved during courses at Rucker and Mesa.
- Binocular rivalry during training. Periods of less than 5 seconds at night.
- Bag training after about 60 minutes duration. Disappears upon bunking.
- Lit areas outside cockpit.
- Standby compass in line of vision.
- Depends on outside light conditions. Left eye distractions.
- When peripheral vision is distracted by an object.

28. After AH MK 1 flight, does your vision sometimes unintentionally alternate between two eyes?

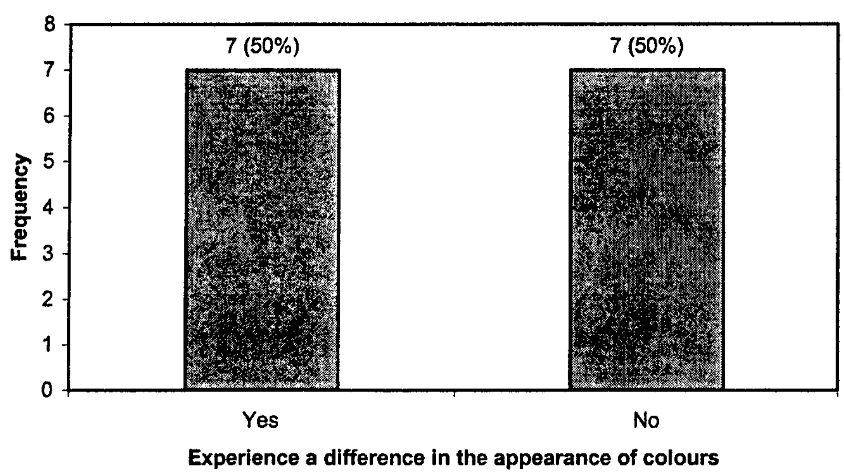
Grade how frequently this affects you on a scale of 1 to 9. ____________

1 = never 5 = 50% of the time 9 = always.



If other than never, please explain and estimate the duration.

29a. After using the IHADSS, do you experience a difference in the appearance of colors?

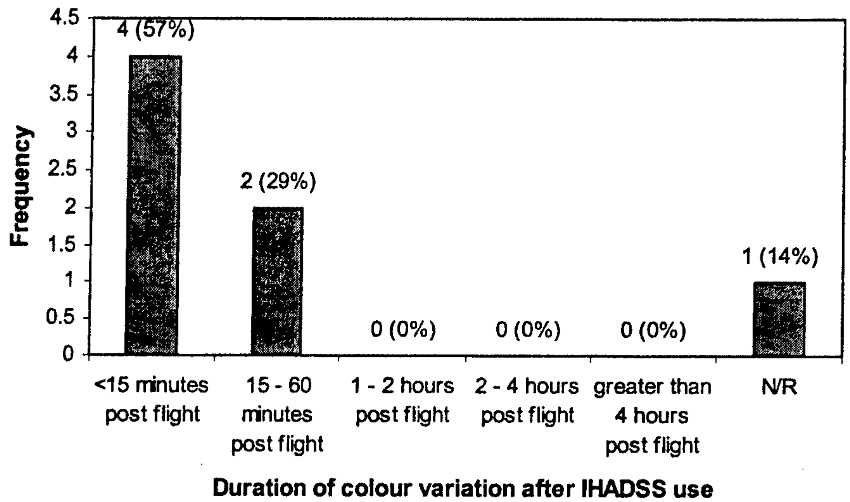


29b. If 'YES', please describe what seems different:

Comments:

- Pinking of vision for up to 5 minutes.
- Overall image appears brown from right eye.
- Slight brown eye.
- Brown eye night only.
- Right eye orange/brown tint for 30 or more minutes.

29c. If 'YES' (n=7), how long does this effect last? (tick one only)



30a. Have you ever experience symptoms of faintness, greying or loss of vision of any kind during periods of "aggressive" flying?

YES [0(0%)]

30b. If "YES", were you flying the aircraft at the time?

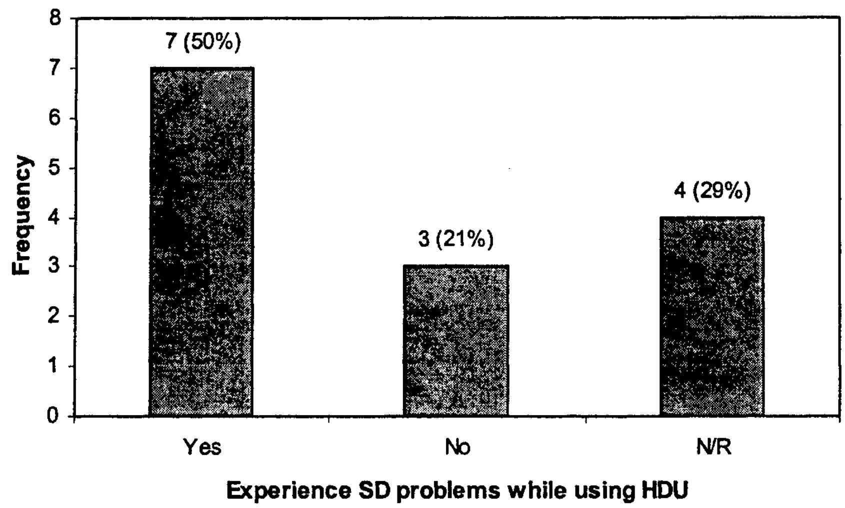
Describe the symptoms, their severity and duration, and the flight profile at the time of the incident.

DISORIENTATION

The definition of Spatial Disorientation (SD) used in the UK is as follows:

A failure to perceive correctly one's position, motion or attitude with respect to the earth's surface (horizontal reference) or the acceleration due to gravity (vertical reference). It is NOT getting lost - that is geographical disorientation.

31a. During your conversion onto AH Mk 1, did you ever experienced any SD problems while using the HDU?

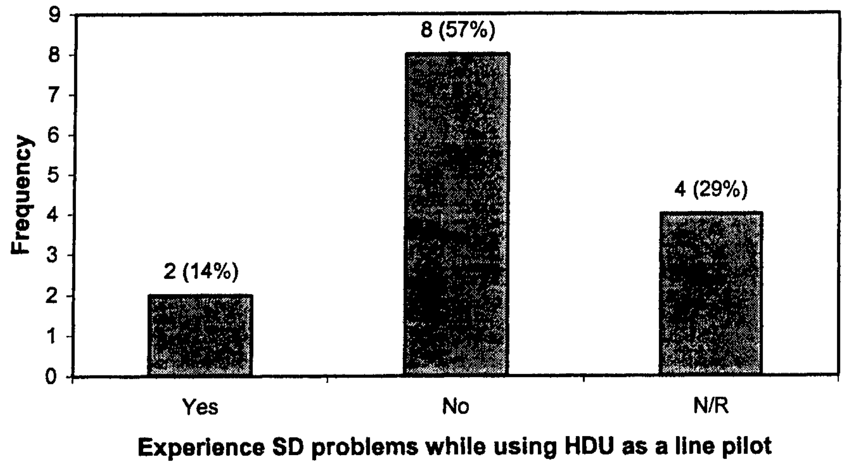


31b. If yes, please explain the situation and cause. Include degree of SD with a description:

Comments:

- During the bag training I had a few occasions where AC attitude was difficult to determine while hovering. Mainly pitch attitude assessment within $\pm$ 15 to 20 degrees.
- Turning down wind, continued to turn toward the correct heading and did not pick it up until through at least 180 degrees.
- Loss of height or lateral cues. Not use to system.
- During BAG phase when learning the system. Mainly conducting hover exercise e.g. laterals spot turns.
- In the bag looking down then rapid up.
- Back seat flight training during early "BAG" phase due to lack of visual cues with minor SD.

32a. As a line pilot, have you ever experienced any SD problems while using the HDU? (please exclude SD during the conversion course)



32b. If yes, please explain the situation and cause. Include degree of SD with a description:

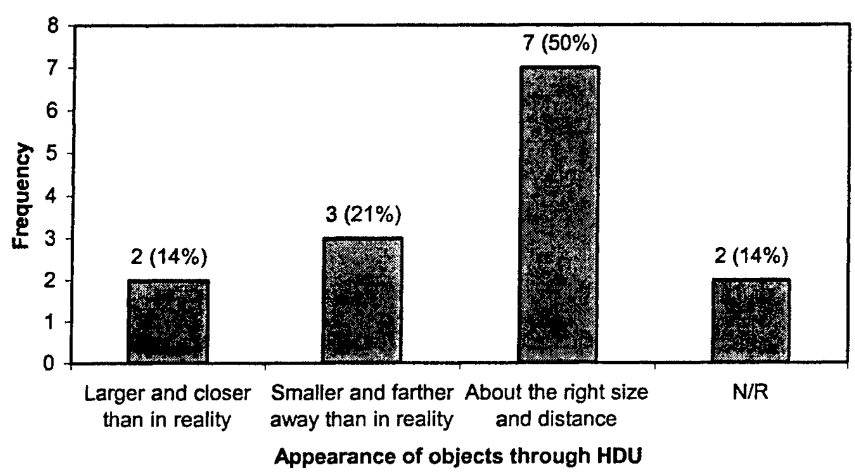
Comment:

- Experienced relative motion. Moderate however, containable with reference to flight symbology.

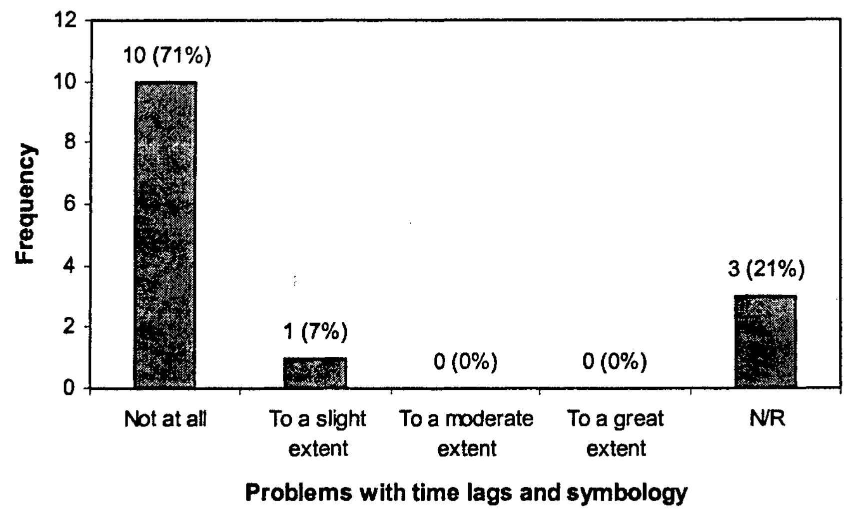
33. When viewed through the HDU, do objects appear: (Please tick one)

Any further comments:

- Ground cushion wore, hover, and laterals. Note they have improved with time on the system.



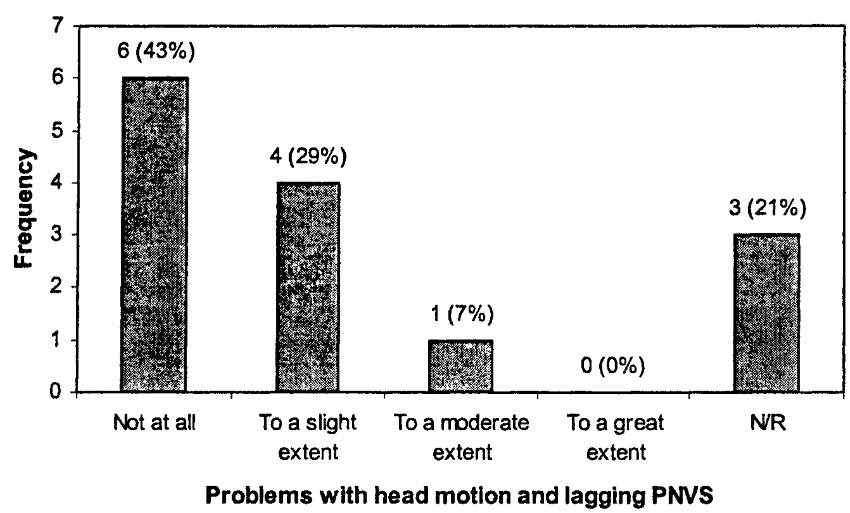
34. To what extent have you experienced problems with time lags associated with the symbology that made it difficult to correlate the symbol movement with the aircraft movement, and thus required some degree of compensation to fly the aircraft? (tick one box only)



If other than not at all, for what symbols does this occur? Please explain:

- Ground cushion wore, hover, and laterals. Note they have improved with time on the system

35. To what extent have you experienced problems with the PNVS image lagging behind your head motion? (tick one box only)



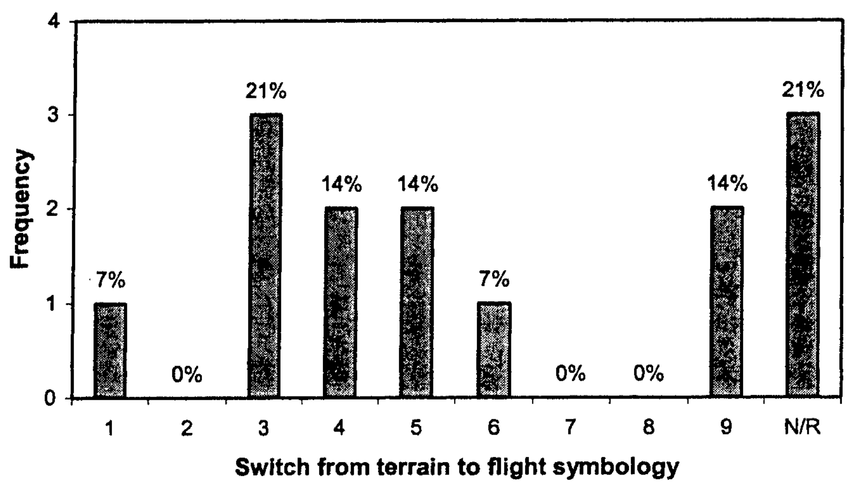
Please explain:

- Constantly aware that any panic movement of head will cause a slight delay.
- However, to a great extent when using TADS.
- TADs/PNVs not moving at head rate.
- Not a problem with PNVS however, slow rate of TADS only 60 seconds and can be a result of moving head to quickly.

36. When looking through the HDU, how frequently do you have to switch your visual attention from the terrain to the flight symbology when acquiring flight information?

Grade how frequently on a scale of 1 to 9. ______________

1 = never 5 = 50% of the time 9 = always.

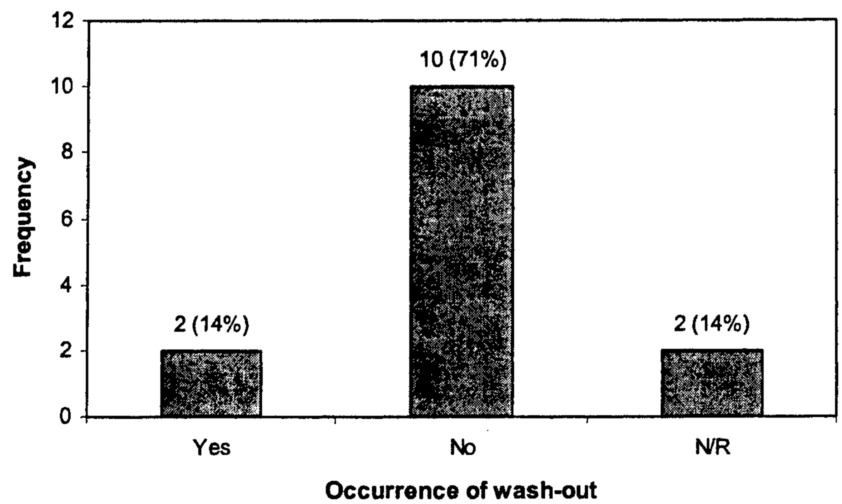


If other than never, please explain and estimate the duration.

- To scan the symbology. Less than 2 seconds.
- As a relative novice on the system it is easy to forget about the outside world and concentrate on the symbology. In the early stage you have to snap back to the terrain.
- For cross referencing purposes especially when FLIR picture is poor. Duration 2 seconds into 10 seconds
- Fifty-fifty.
- For interpretation of information for short periods.
- Most attention is paid to terrain with scan on symbology.

- The HDU replaces flight instruments.
- Not anticipating the rate. Moving head too quickly, in particular using TADS.

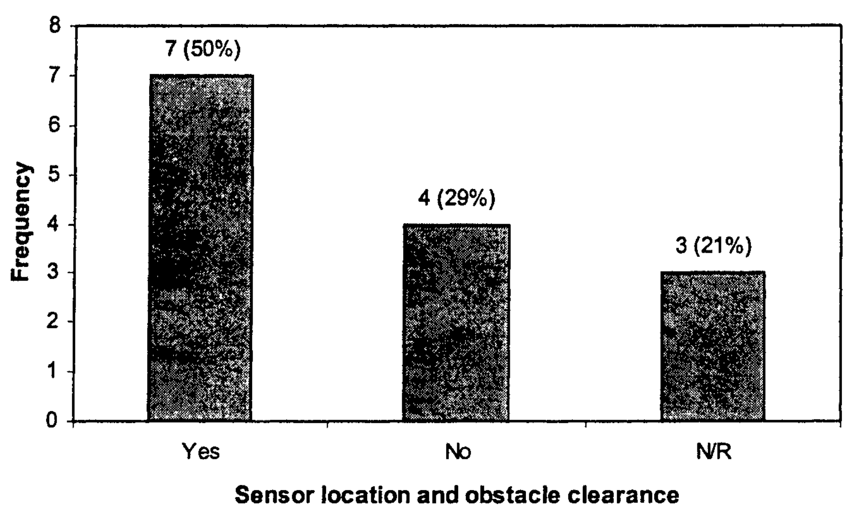
37. During night flight operations, have you ever experienced a situation in which flashes of light occurring in the left visual field tend to "wash-out" the information being presented on the HDU to the right eye?



If yes, please explain:

- Flashes of light tend to increase binocular rivalry.

38. Does the difference between sensor location (on the nose of the aircraft) and eye location create problems with obstacle clearance (to the sides of the aircraft and below the aircraft)?



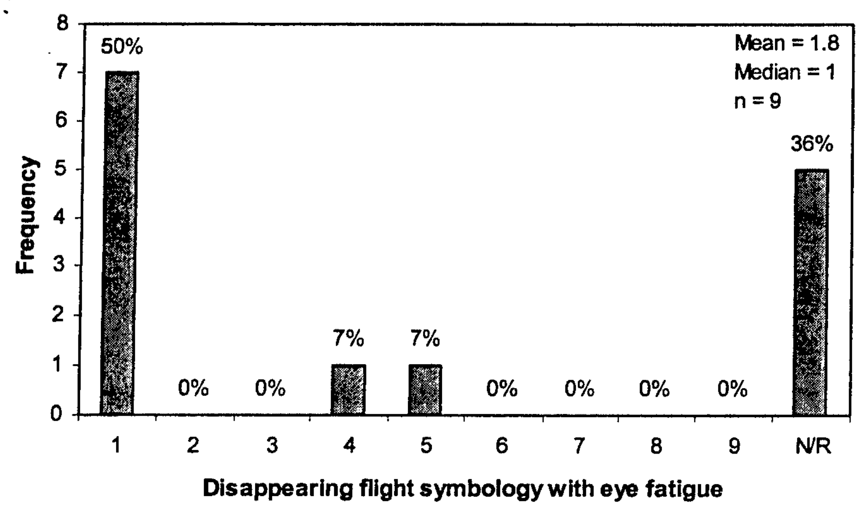
If yes, under what conditions and maneuvers do you most often experience this problem:

- Ground cushion work, the normal problems of eye and sensor location.
- Mainly during hover or hover taxi.
- Low level- Tree height and below generally slow.
- NOE flight moving into battle positions i.e. whenever low and slow.
- Hover and ground taxi.
- During NVS flight for NOE approach/takeoffs and confined area operation.
- Low level and 50 feet tactical flying.
- Entering confined areas and moving around in close proximity to obstacles.

39. During long duration flights (over 2 hours), how often do you experience problems with the flight symbology "disappearing" from view due to fatigue?

Grade how frequently on a scale of 1 to 9. ____________

1 = never 5 = 50% of the time 9 = always.



If other than never, please explain including how you compensate for this problem:

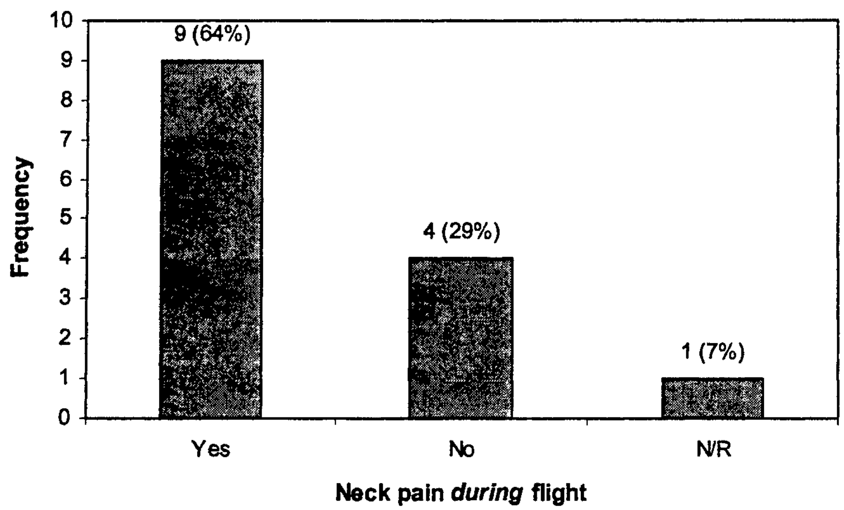
- Not flown greater than 2 hours.
- During a long "BAG" flight causes difficulty to maintain scan of symbology.

NECK PAIN

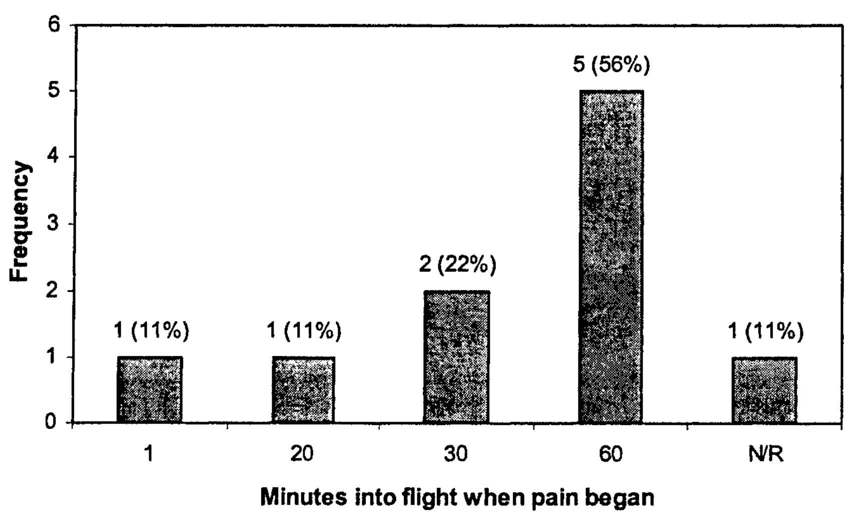
For the purposes of this survey, neck pain is pain ABOVE (but not including) the level of the shoulder blades. THERE ARE SEPARATE QUESTIONS ON NECK PAIN DURING AND AFTER FLIGHT.

40. Neck pain DURING flight

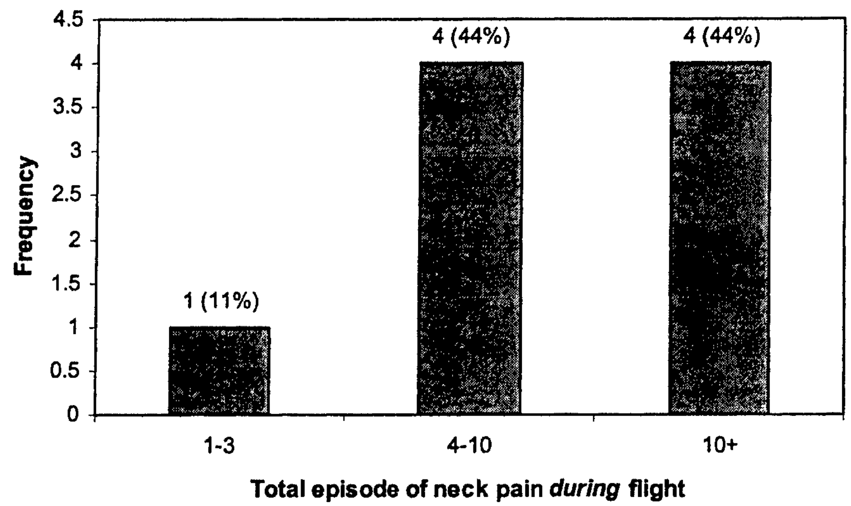
a. Have you ever experienced neck pain during a flight?



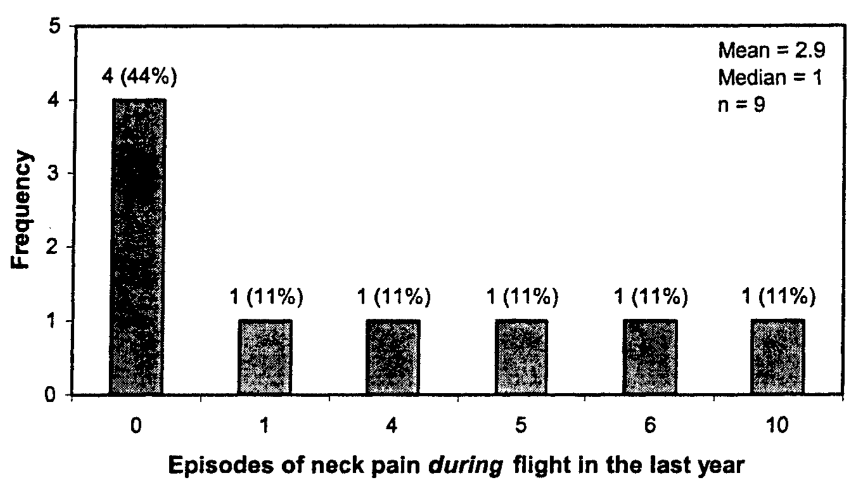
b. If you have experienced neck pain during flight, how long into the flight were you before the pain began? _______ minutes



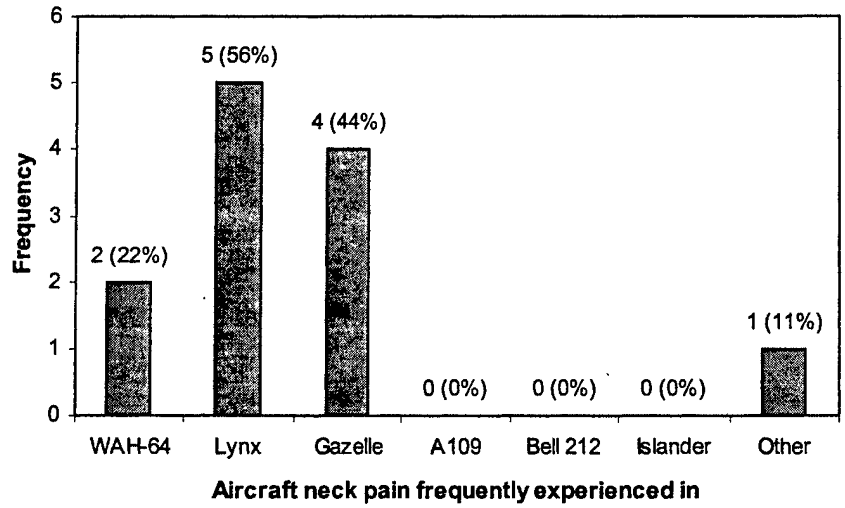
c. Please indicate the total number of episodes of neck pain you have experienced <u>during</u> flight. (Tick one box only)



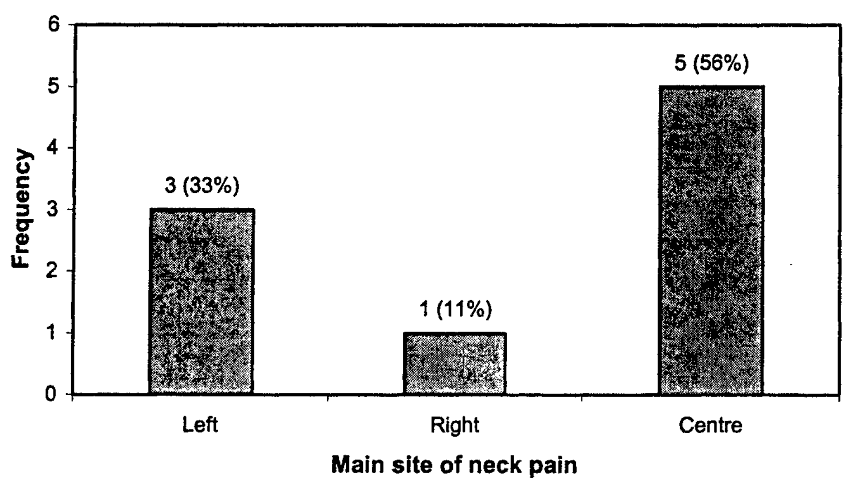
d. How many episodes of neck pain <u>during flight</u> have you had in the last year?___



e. In which aircraft have you experienced your most frequent neck pain (circle 1 or more)

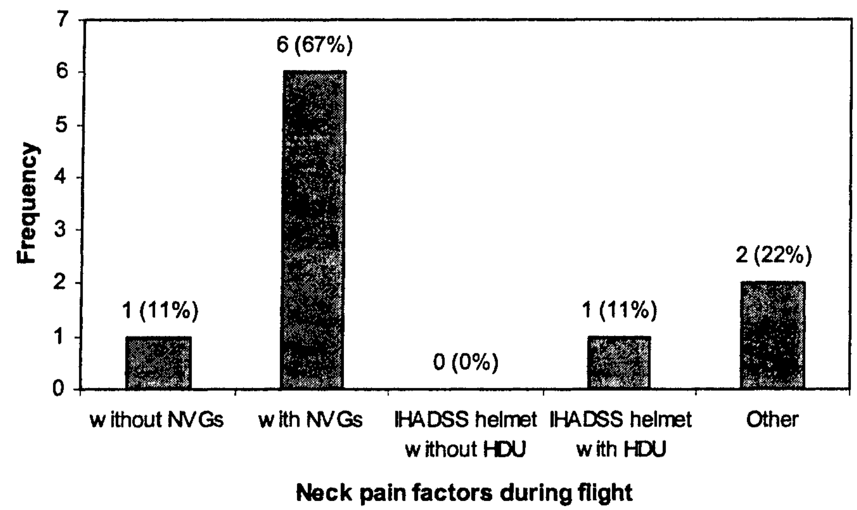


f. Where is the main site of your neck pain? (tick one only)

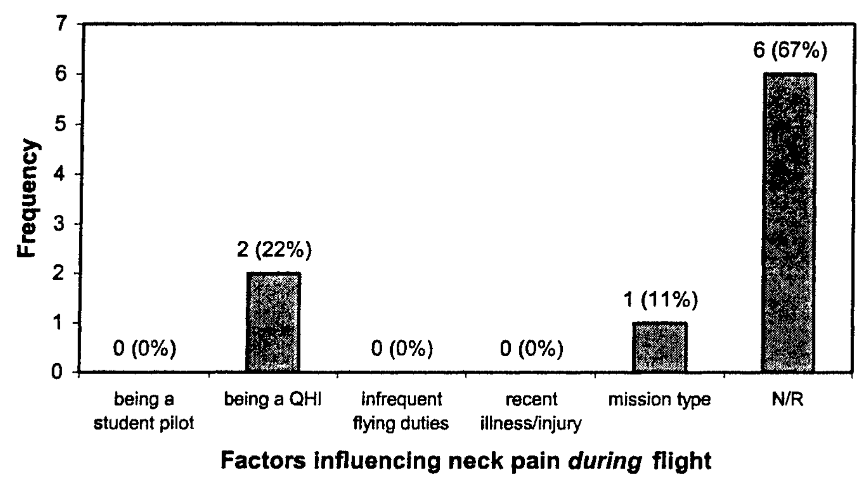


g. Which of the following factors resulted in your neck pain <u>during</u> flight?

- Poor helmet fit.
- Posture- leaning forward for extended duration.

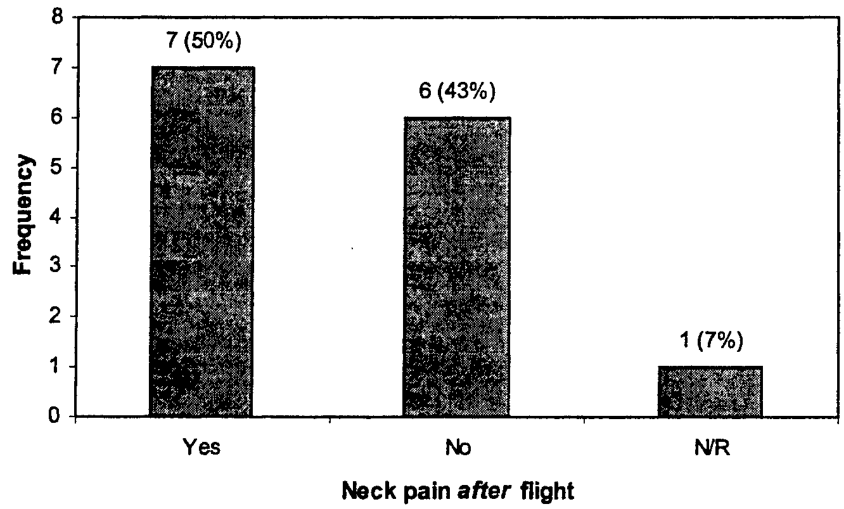


h. Indicate if any of the following factors may have influenced your neck pain <u>during</u> flight:

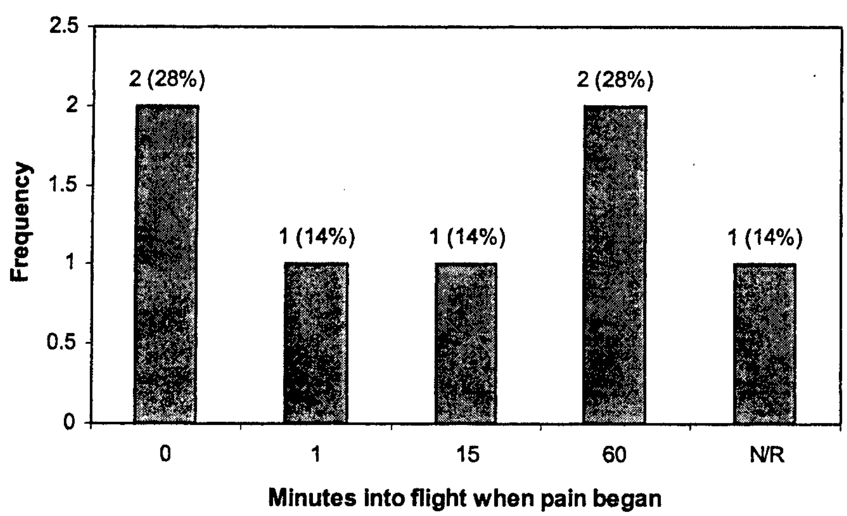


41. Neck pain AFTER flight

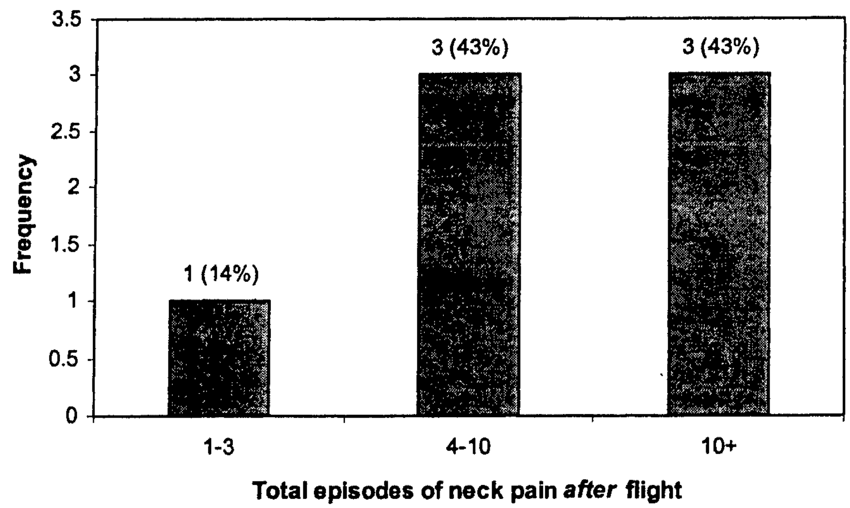
a. Have you ever experienced neck pain after a flight?



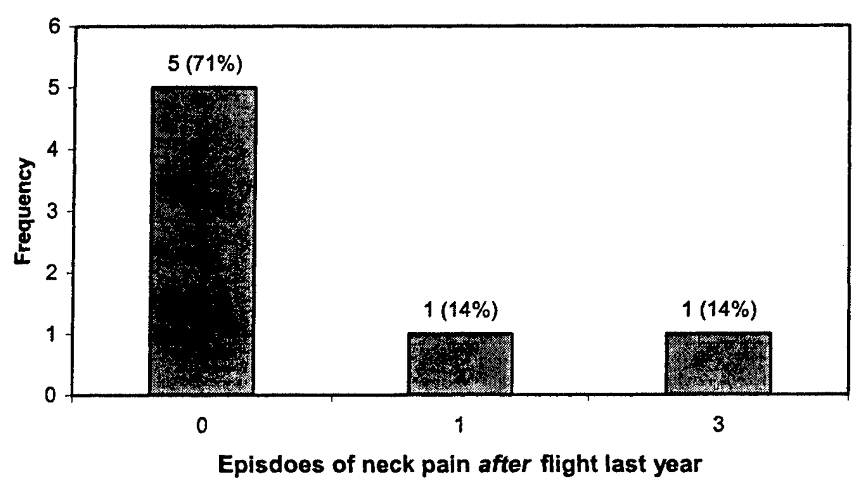
b. If you have experienced neck pain after flight, how long into the flight were you before the pain began?
_______ minutes



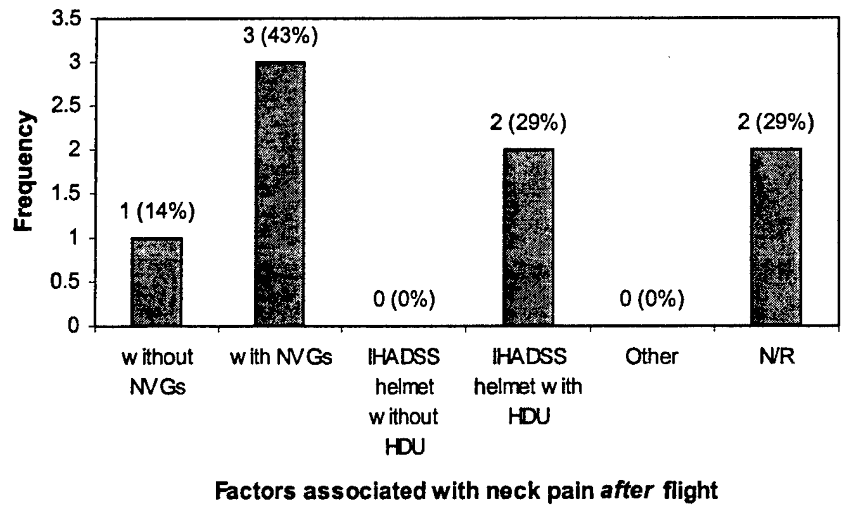
c. Please indicate the total number of episodes of neck pain you have experienced <u>after</u> flight. (Tick one box only)



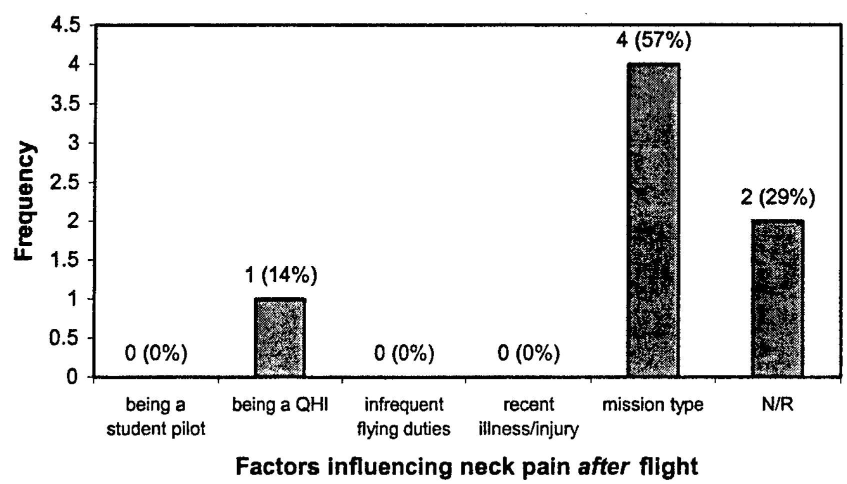
d. How many episodes of neck pain <u>after flight</u> have you had in the last year?___



e. Which of the following factors resulted in your neck pain <u>after</u> flight?



f. Indicate if any of the following factors may have influenced your neck pain <u>after</u> flight:

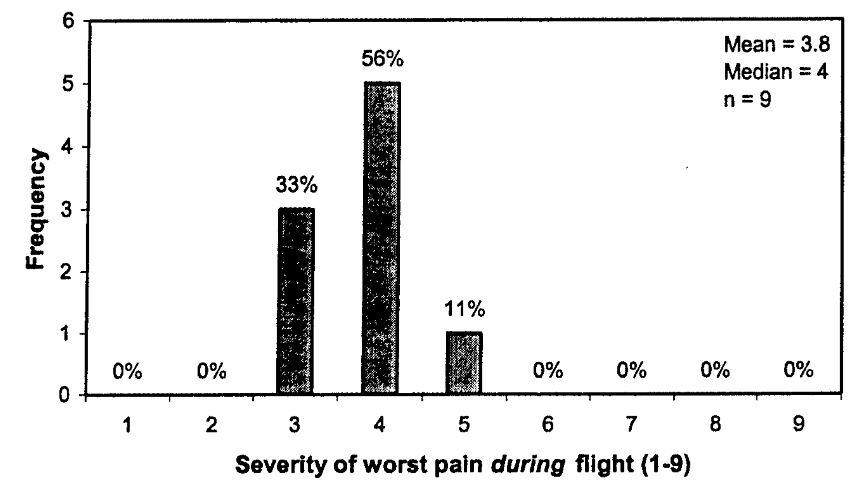


42. Indicate the severity of neck pain, for the <u>worst</u> episode of pain experience during flight and after flight.

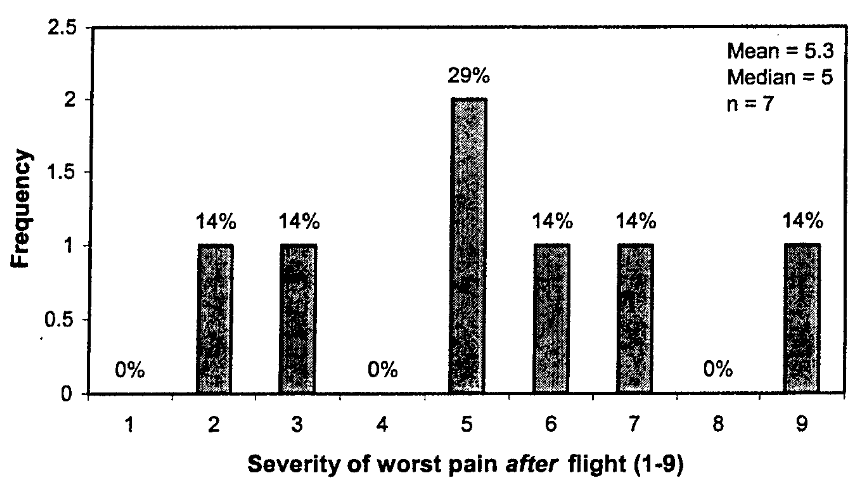
Grade the severity on a scale of 1 to 9.

1 = no pain 9 = incapacitating (e.g. resulting in handing over control or aborting the mission)

DURING FLIGHT ________



AFTER FLIGHT ________

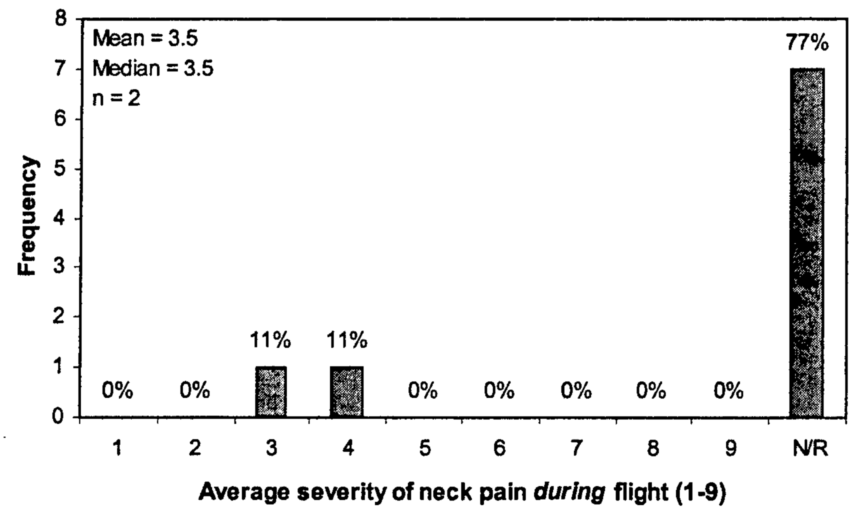


43. If you COMMONLY experience neck pain, please indicate an <u>average</u> severity of pain experienced.

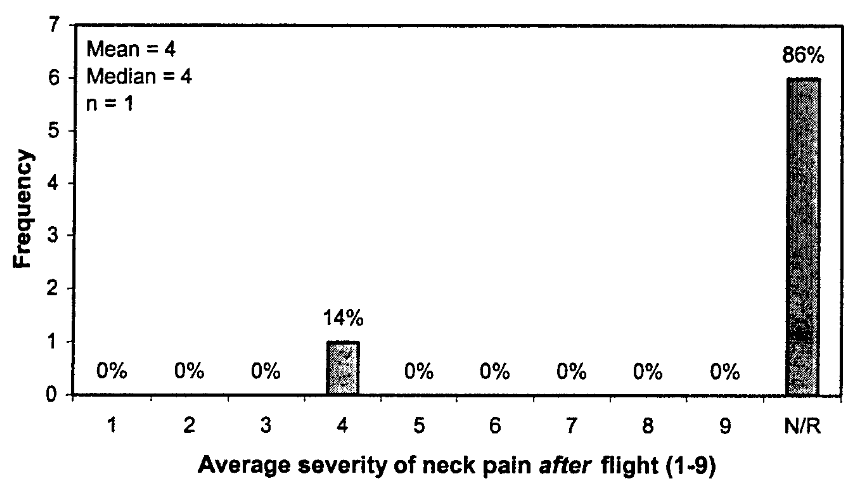
Grade the severity on a scale of 1 to 9.

1 = no pain 9 = incapacitating (e.g. resulting in handing over control or aborting the mission)

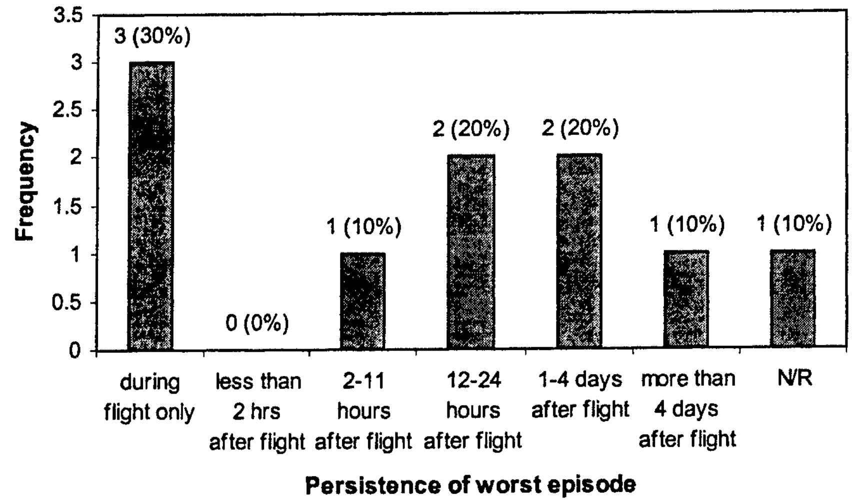
DURING FLIGHT ________



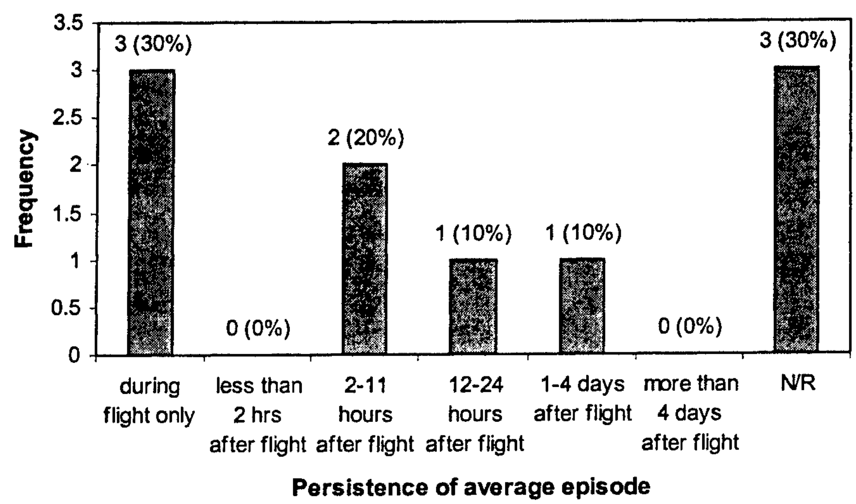
AFTER FLIGHT ________



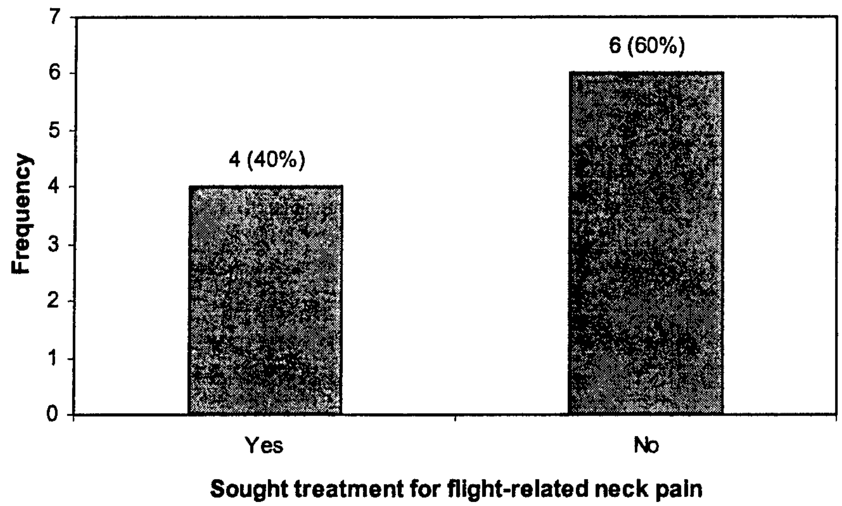
44. How long did the symptoms persist for the worst episode of neck pain?



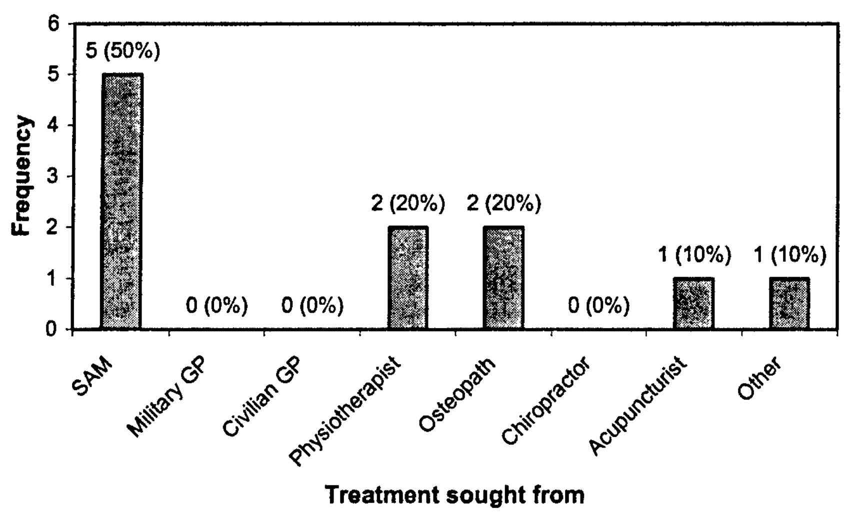
45. How long do the symptoms usually persist for the average episode of neck pain? (n=10)



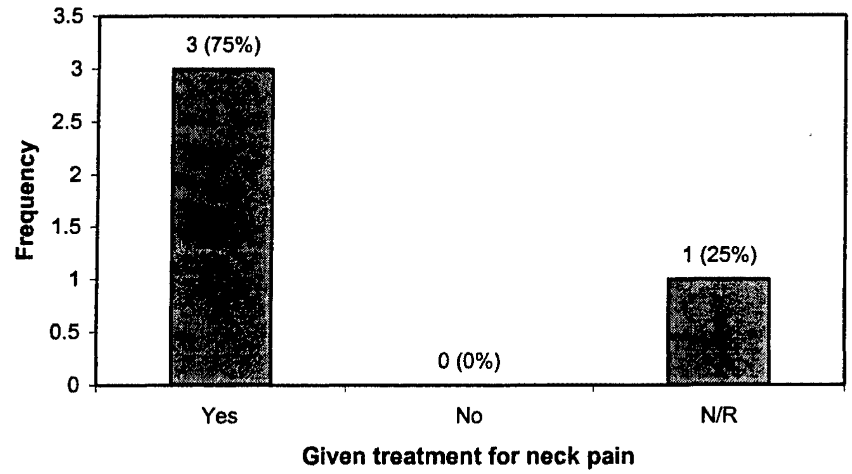
46a. Have your ever sought treatment for flight related neck pain?



46b. If yes, was the treatment sought from:



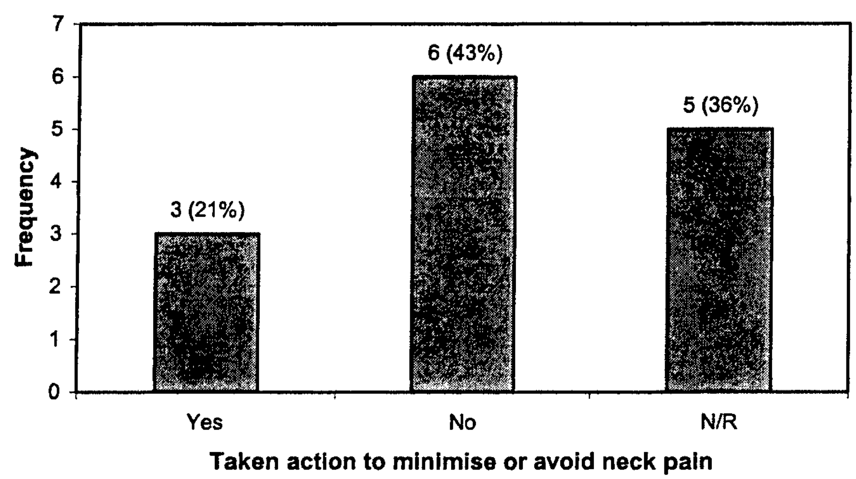
46c. Were you given any treatment for your neck pain?



46d. If 'YES', please describe briefly the treatment you received:

- A Course of neck and back correction in Salisbury.
- X ray and pain killers.
- Massage and heat treatment. Also electric pulse treatment.
- NI RAF pain killers.

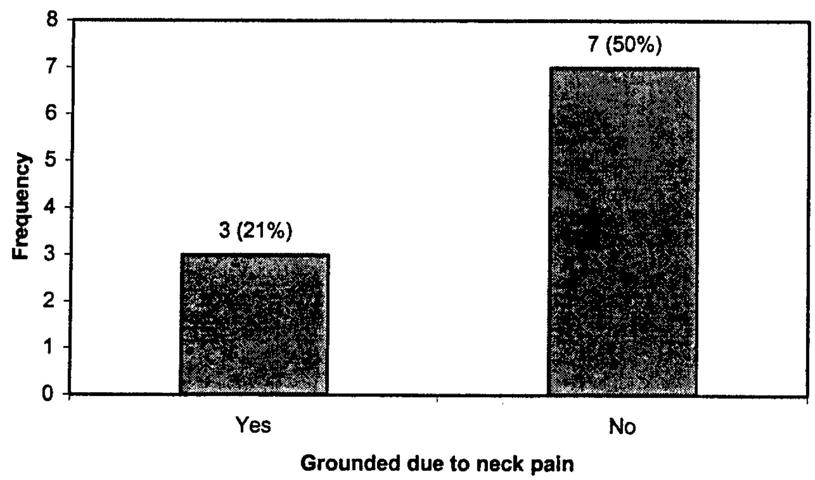
46e. Have you ever taken any action in order to minimize or avoid flight-related neck pain?



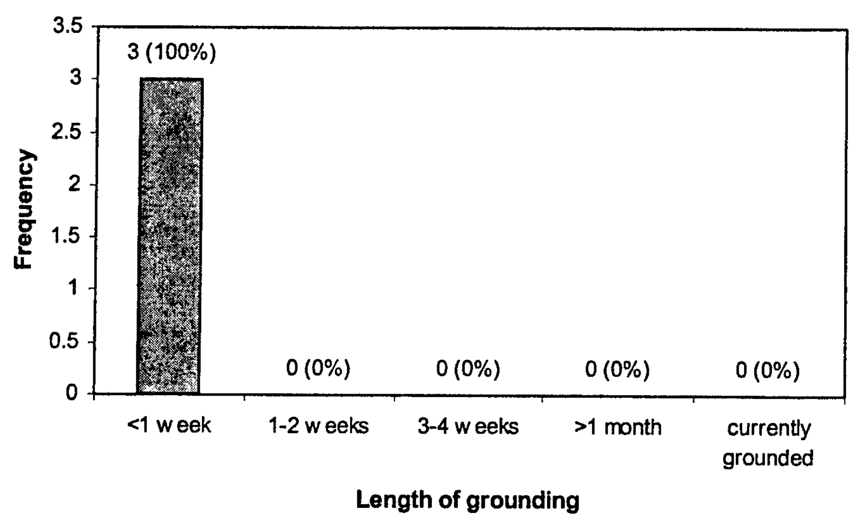
If 'YES', please describe the type of action taken and if the action taken was effective:

- Treat my neck with care i.e. correct sleeping posture.
- I took up Martial Arts in order to gain better flexibility. Since then the severity and frequency has been reduced significantly.
- US "PT"[Physical Therapist], session included pumpkin bobs to strengthen neck. No effect noticed.

47a. Have you ever been grounded as a result of flight-related neck pain?



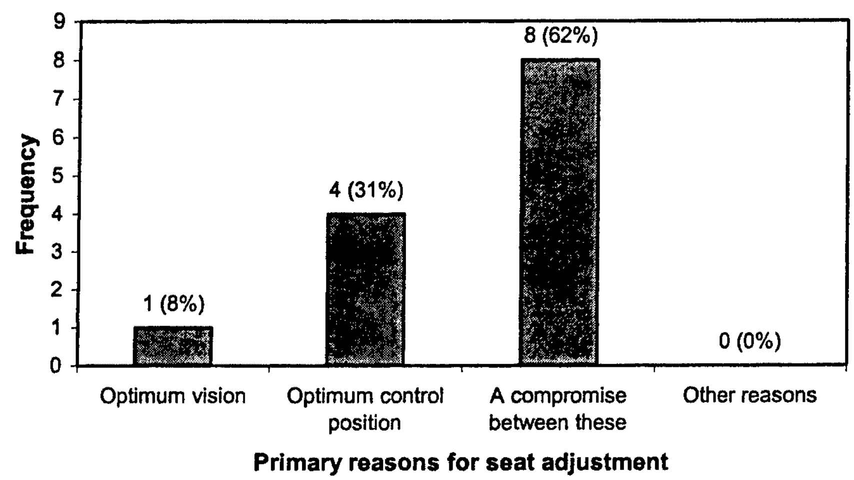
47b. If 'YES', please indicate how long you were grounded.



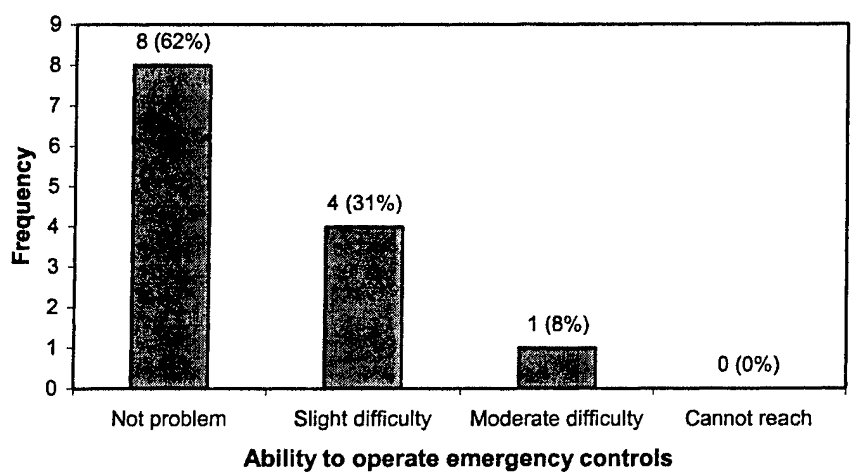
BACK PAIN

For the purposes of this survey, back pain is pain at or BELOW the level of the shoulder blades.
THERE ARE SEPARATE QUESTIONS ON BACK PAIN DURING AND AFTER FLIGHT.

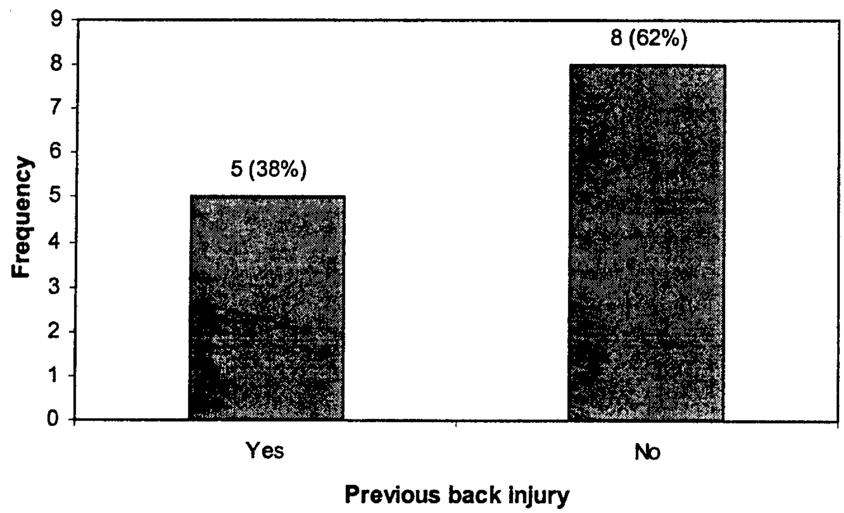
48. For which of the following reasons do you primarily adjust your seat? (tick one only)



49. With your seat in the normal position, and sitting in your normal flying posture with the harness inertia reel locked, how easily can you reach and fully operate the critical and emergency controls and switches?



50. Have you had a previous back injury?

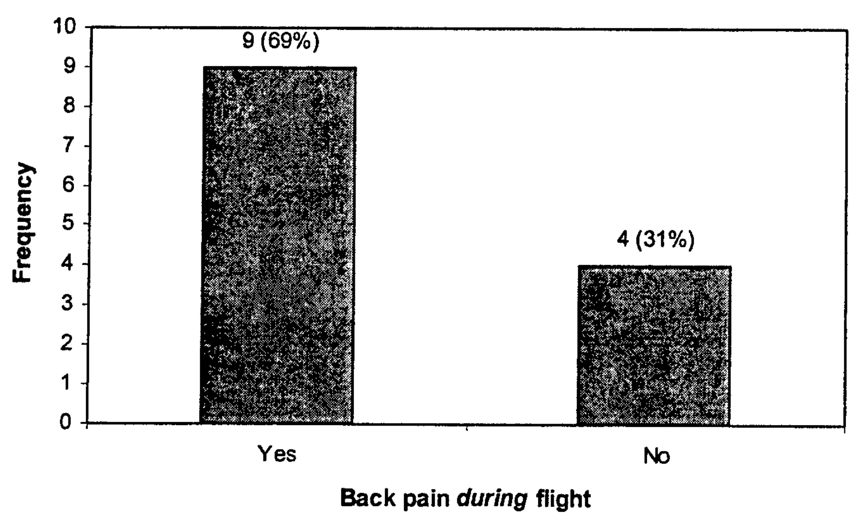


If yes please give the date and brief details:

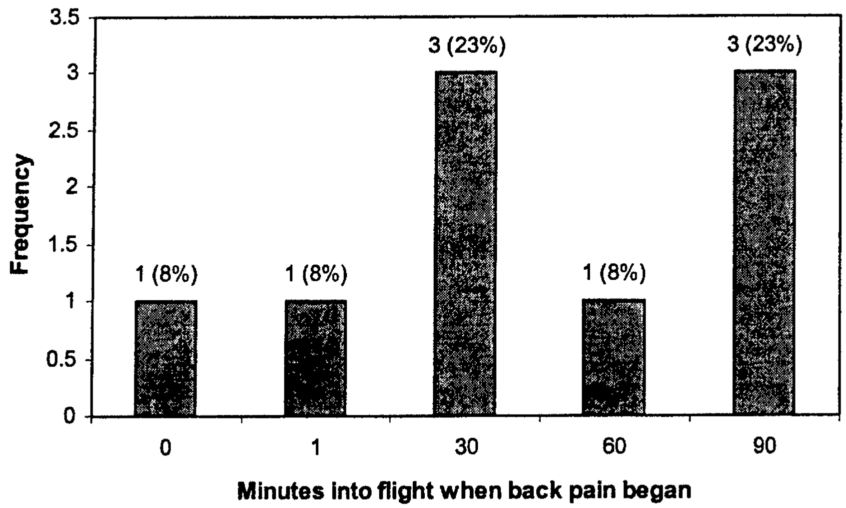
- This all relates to the neck pain which carries down through the shoulder blades.
- Fracture compression to lower vertebrae as a result of helicopter crash.
- Mild back pain.
- Torn ligament in right shoulder resulted in treatment by an Osteopath.

51. <u>Back pain DURING flight</u>

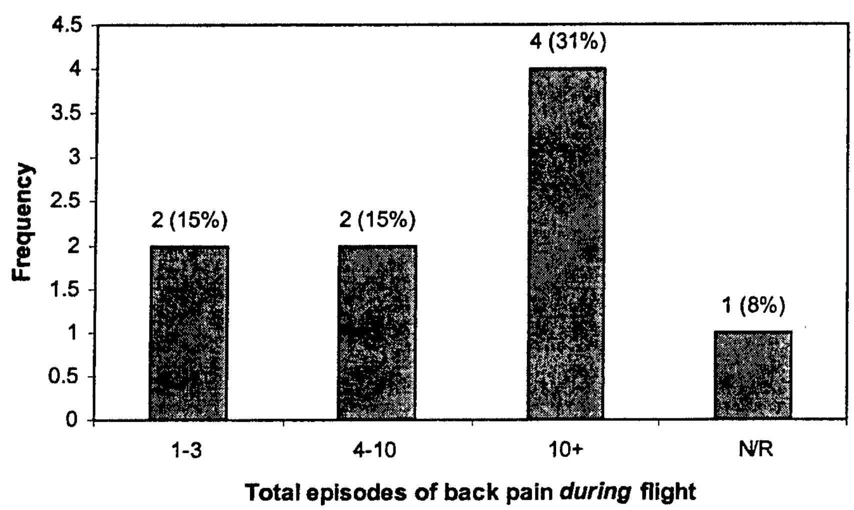
a. Have you ever experienced back pain <u>during</u> a flight?



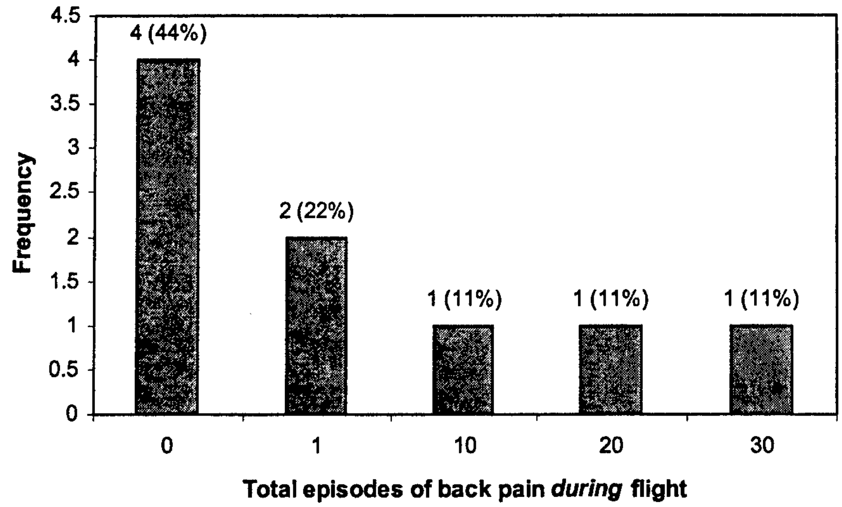
b. If you have experienced back pain <u>during</u> flight, how long into the flight were you before the pain began? _______ minutes



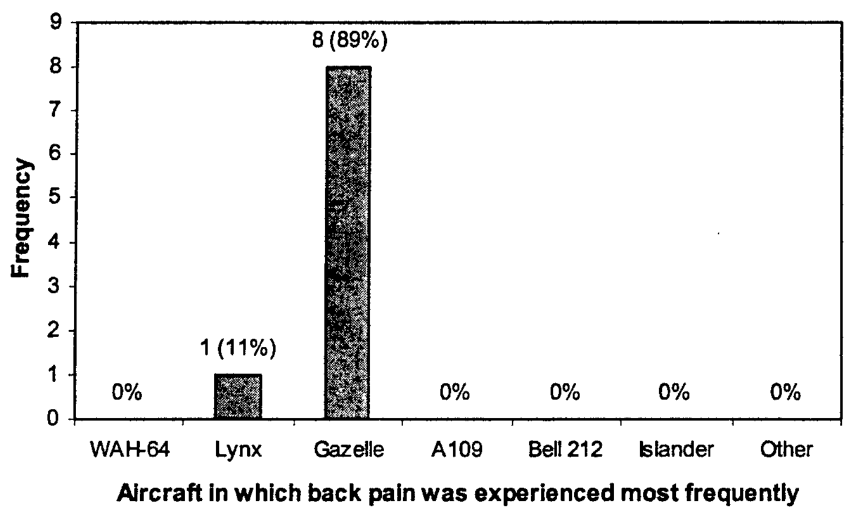
c. Please indicate the total number of episodes of back pain you have experienced <u>during</u> flight:



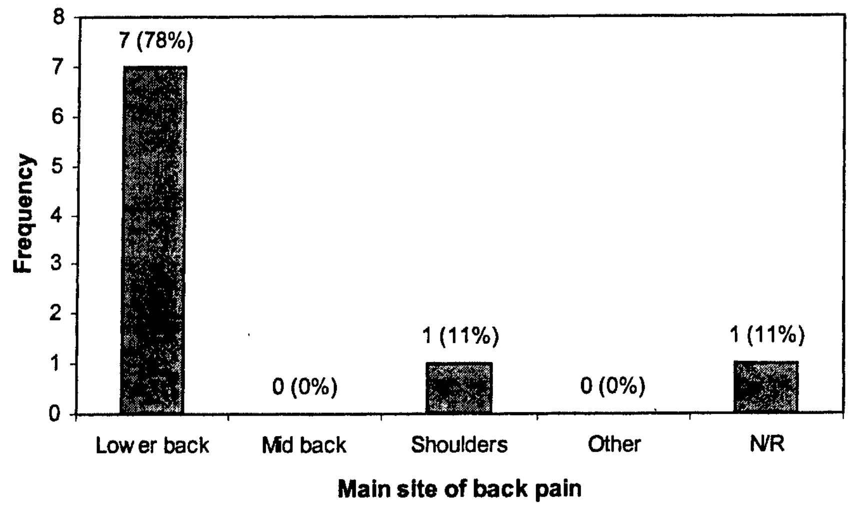
d. How many episodes of back pain <u>during flight</u> have you had in the last year?



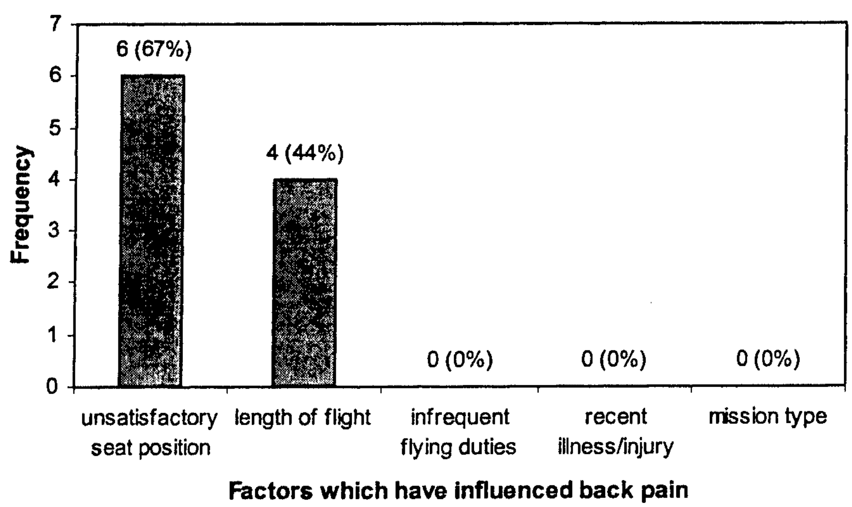
e. In which aircraft have you experienced your most frequent back pain (circle 1 or more)



f. Where is the main site of your back pain? (tick one only)



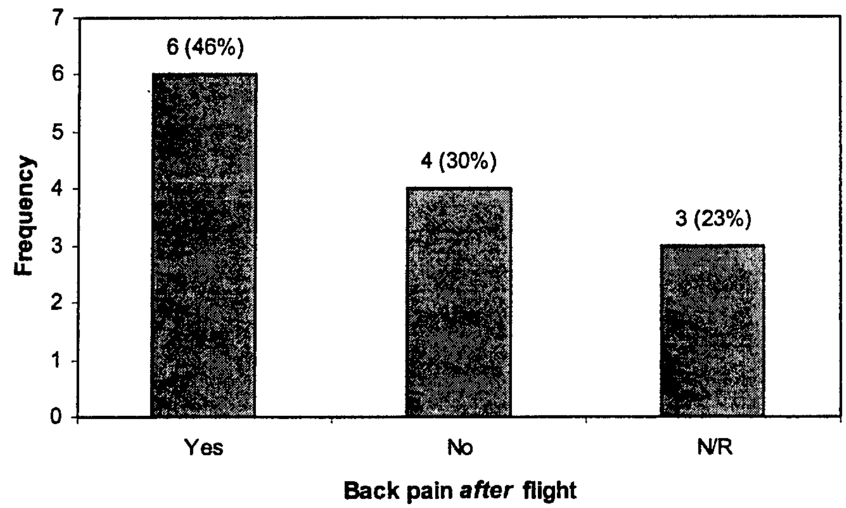
g. Indicate if any of the following factors may have influenced your back pain during flight:



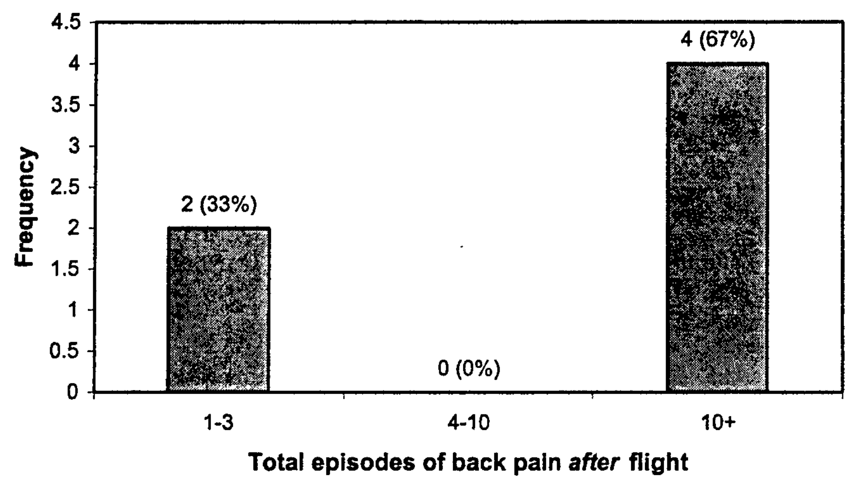
- Gazelle seat.
- I get very little pain if I consciously maintain posture.
- 90 minutes before pain began.
- Insufficient lumbar support.
- 30 minutes before pain began.

52. Back pain AFTER flight

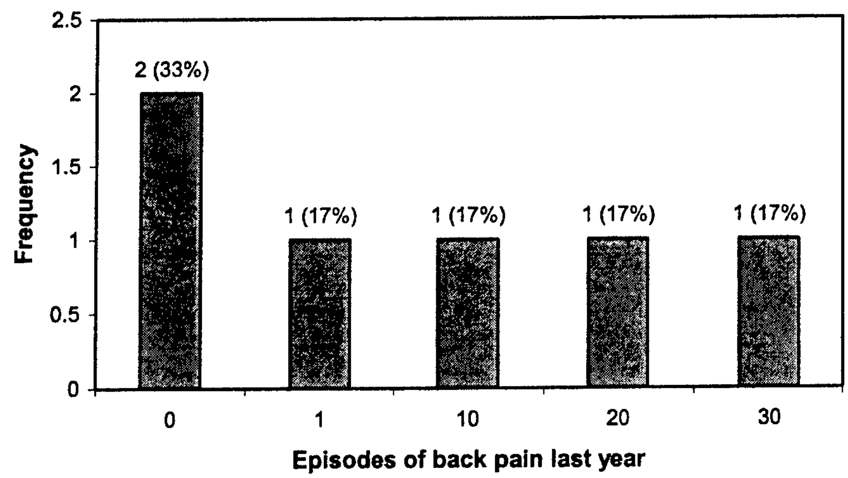
a. Have you ever experienced back pain after a flight?



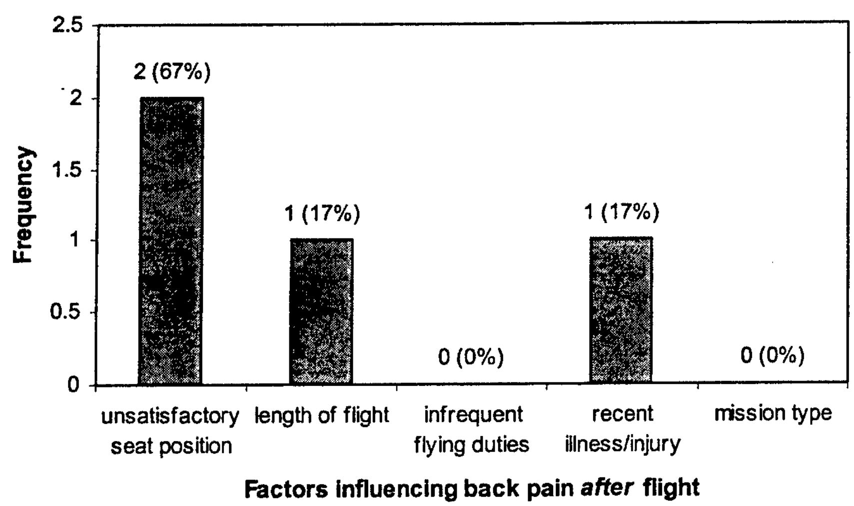
b Please indicate the total number of episodes of back pain you have experienced after flight:



c. How many episodes of back pain <u>after flight</u> have you had in the last year?



d. Indicate if any of the following factors may have influenced your back pain <u>during</u> flight:



Unsatisfactory seat position comment

- Gazelle seat.

Length of flight (how long before pain began? minutes) comment

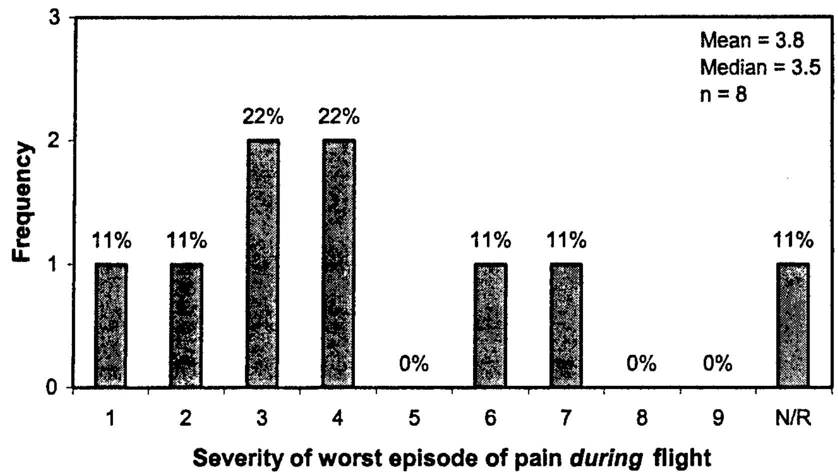
- 30 minutes.

53. Indicate the severity of back pain, for the worst episode of pain experience during flight and after flight.

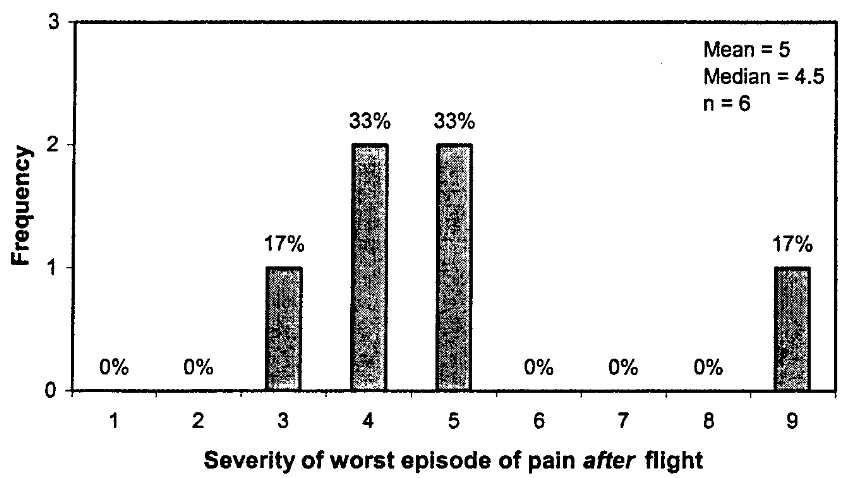
Grade the severity on a scale of 1 to 9.

1 = no pain 9 = incapacitating (e.g. resulting in handing over control or aborting the mission)

DURING FLIGHT __________



AFTER FLIGHT __________ change mean to 5

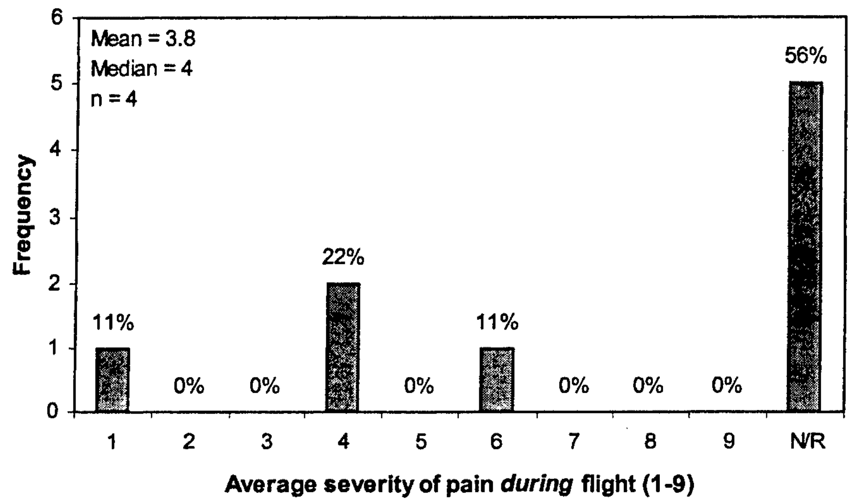


54. If you COMMONLY experience back pain, please indicate an <u>average</u> severity of pain experienced.

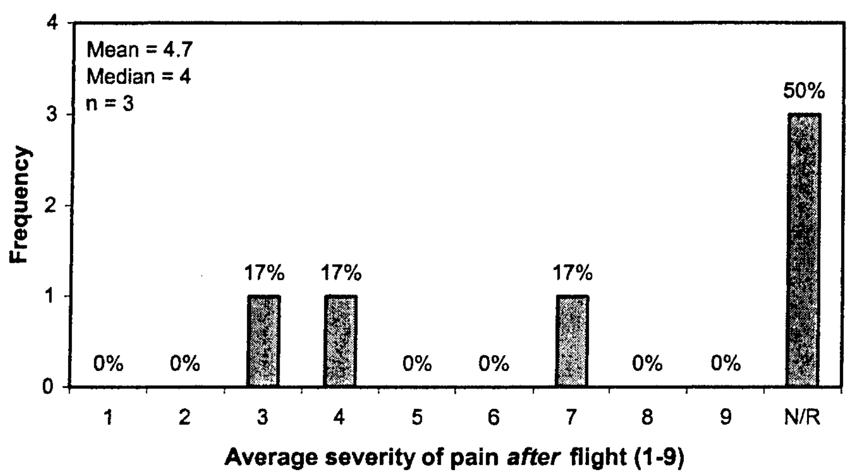
Grade the severity on a scale of 1 to 9.

1 = no pain 9 = incapacitating (e.g. resulting in handing over control or aborting the mission)

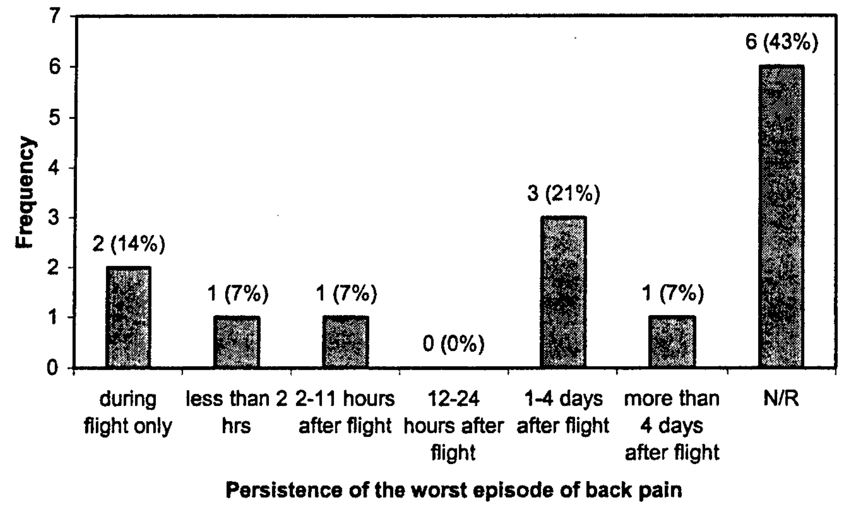
DURING FLIGHT __________



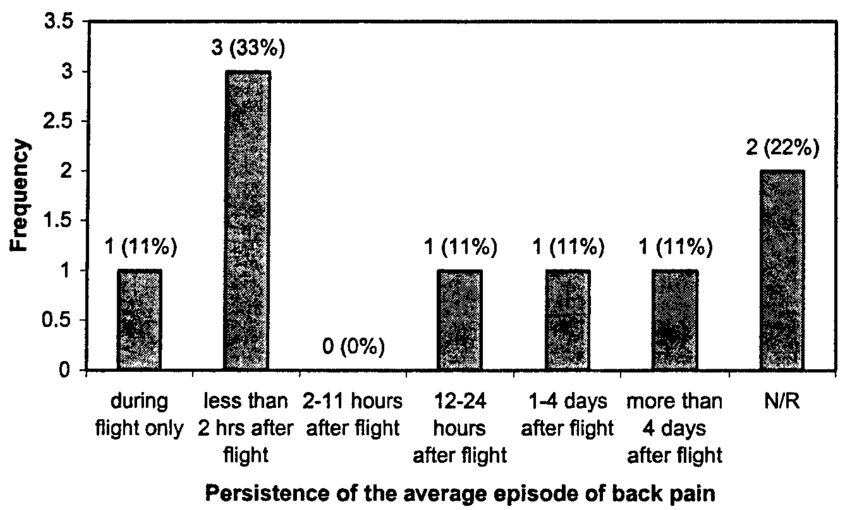
AFTER FLIGHT __________



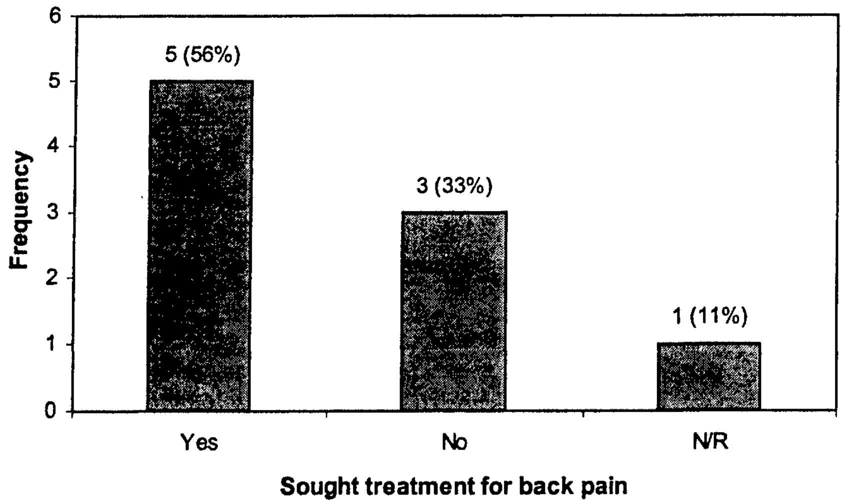
55. How long did the symptoms persist for the worst episode of back pain?



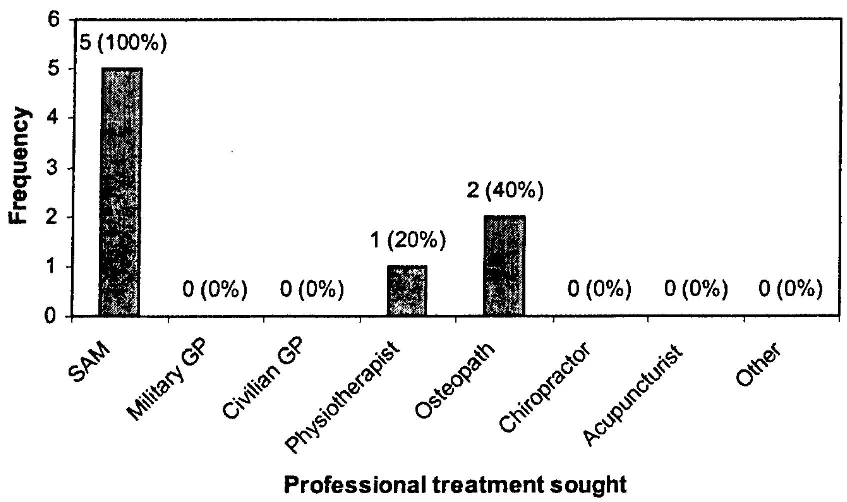
56. How long do the symptoms usually persist for the average episode of back pain?



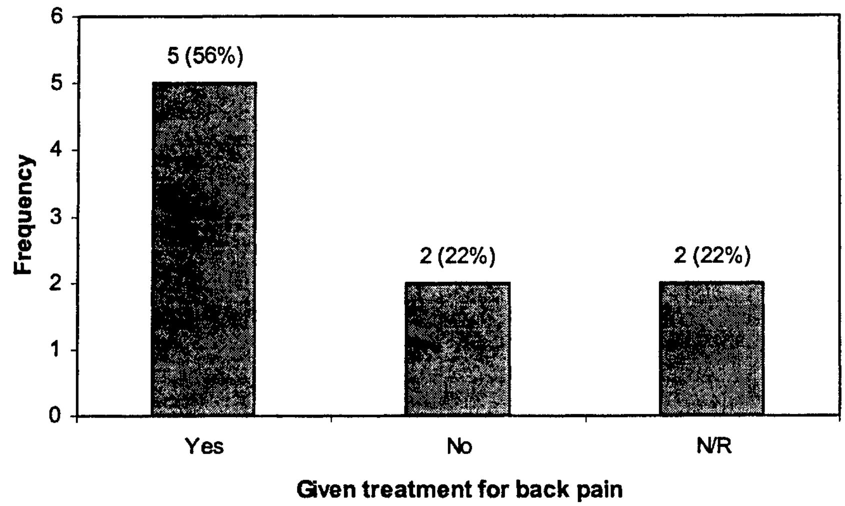
57a. Have your ever sought treatment for flight related back pain?



57b. If yes, was the treatment sought from:



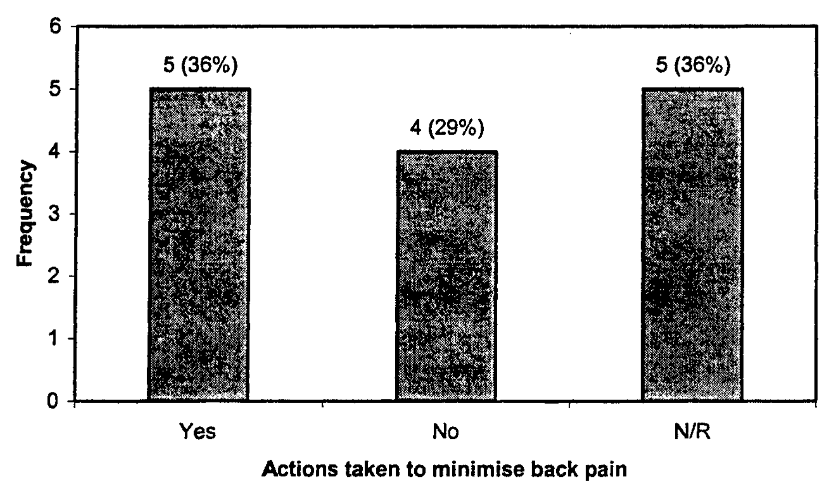
57c. Were you given any treatment for your back pain?



57d. If 'YES', please describe briefly the treatment you received:

- Pain relief. Exercises. Osteopathic treatment ongoing.
- A course of neck and back correction in Salisbury.
- Antiflammatories.
- Hospital for 3 weeks then rehab.
- Exercises to stretch the back.

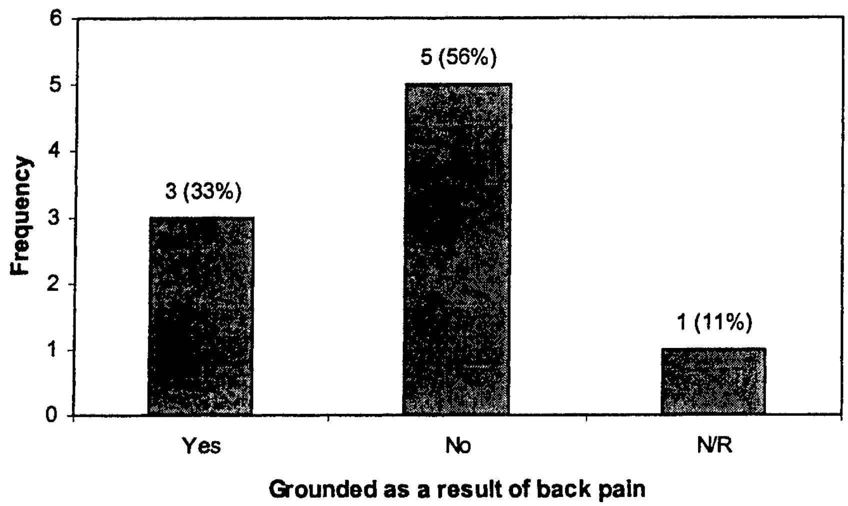
57e. Have you ever taken any action in order to minimise or avoid flight-related back pain?



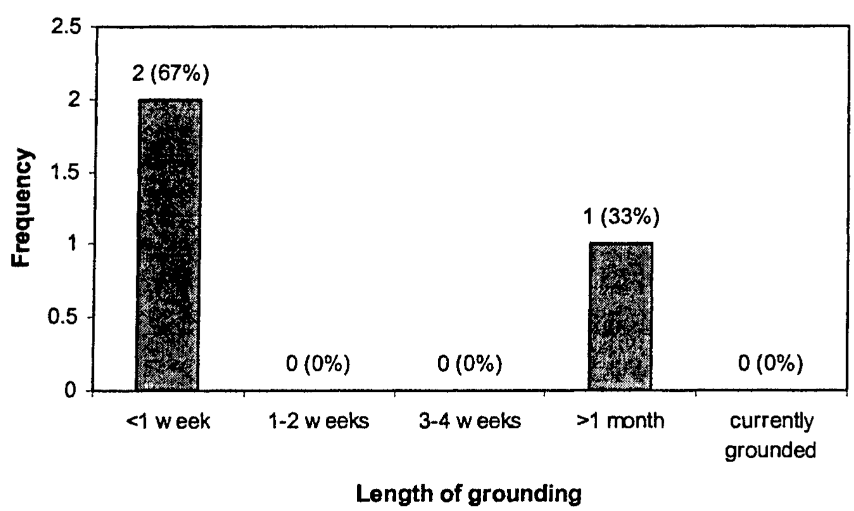
57f. If 'YES', please describe the type of action taken and if the action taken was effective:

- Lumbar support issued.
- Lumbar support cushion.
- Cushion was used but now not allowed.
- Change seating posture during flight in the Gazelle.
- Harness locked to force back into seat.

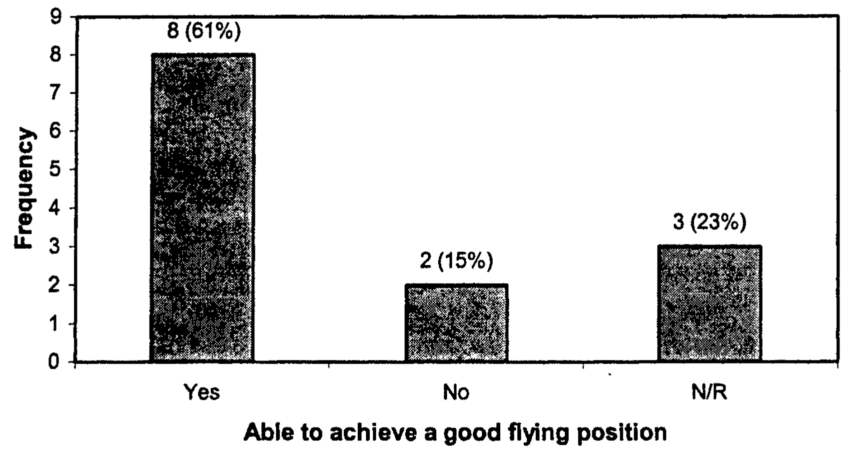
58a. Have you ever been grounded as a result of flight-related back pain?



58b. If 'YES', please indicate how long you were grounded:



59a. Do the standard procedures for adjusting the seat allow you to achieve a good flying position?



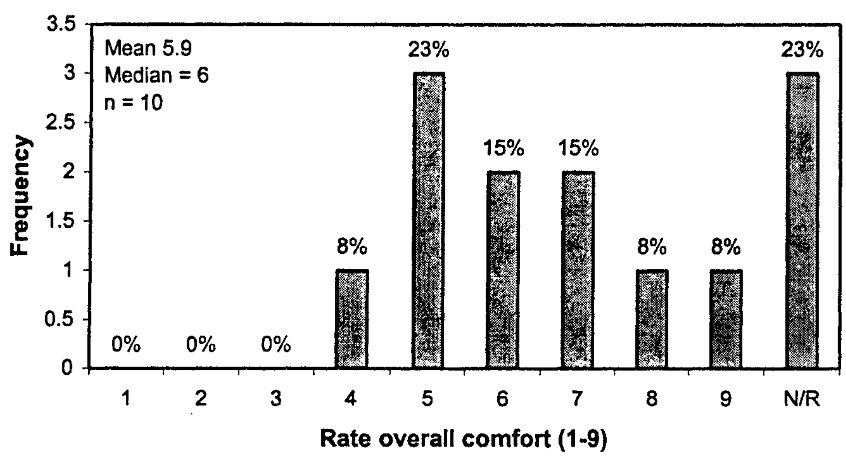
59b. If "NO", explain any difficulties you have with the seat adjustment mechanism. Include any additional methods you use to improve your flying position:

- I would like to be able to adjust the Rare (Back of seat).

60a. How would you rate the overall comfort of the seat on a scale of 1 to 9.

____

1 = extremely uncomfortable 5 = adequate 9 = extremely comfortable



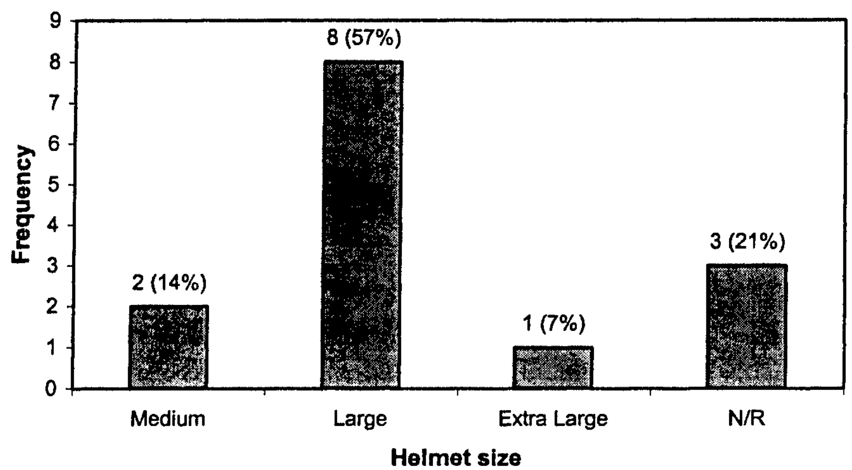
60b. If there is any discomfort, what causes it?

- Seat cushion.
- On longer flight painful backside. Lack of padding on seat.
- Sore or numb posterior during all flights in any aircraft where the duration exceeds 1.5-2 hours.
- No lumbar support.

<u>IHADSS HELMET USAGE</u>

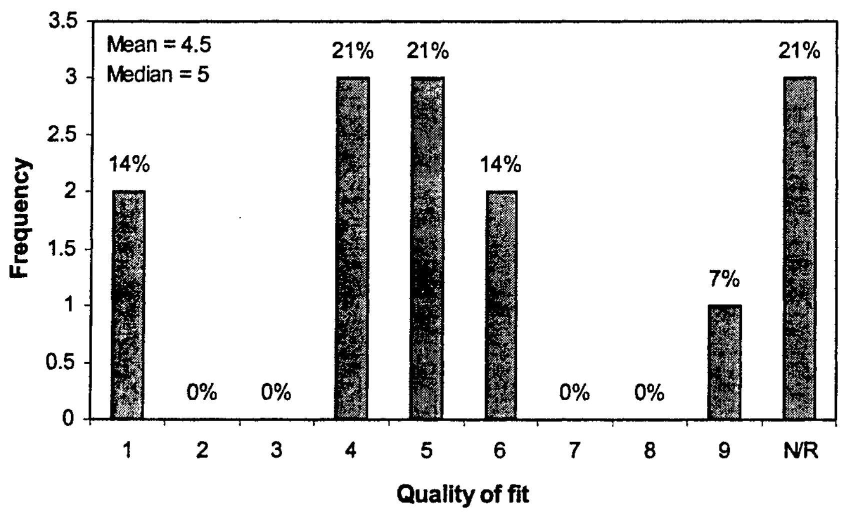
61. What helmet size do you wear? (tick one only) n=14

NR = 2(14%), MEDIUM = 2(14%), LARGE = 8(57%), EXTRA LARGE = 2(14%)



62a. Grade the quality current fit on a scale of 1 to 9. ______________

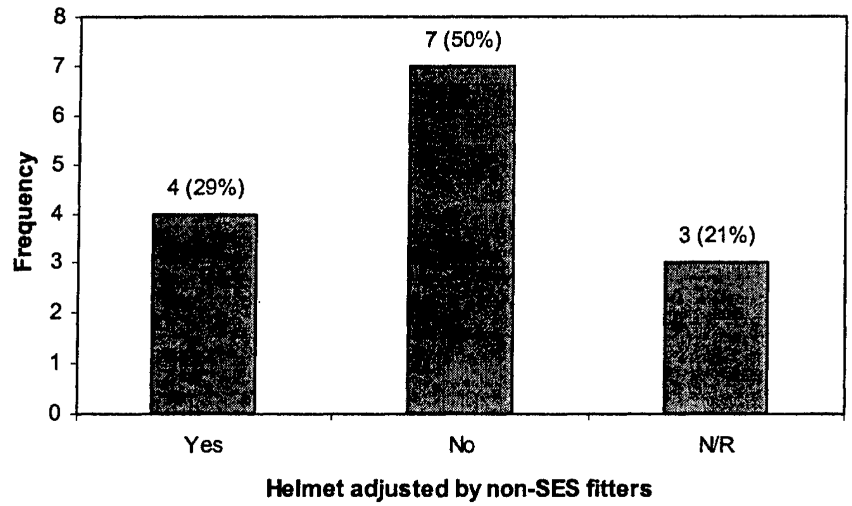
1 = unsatisfactory 5 = adequate 9 = excellent



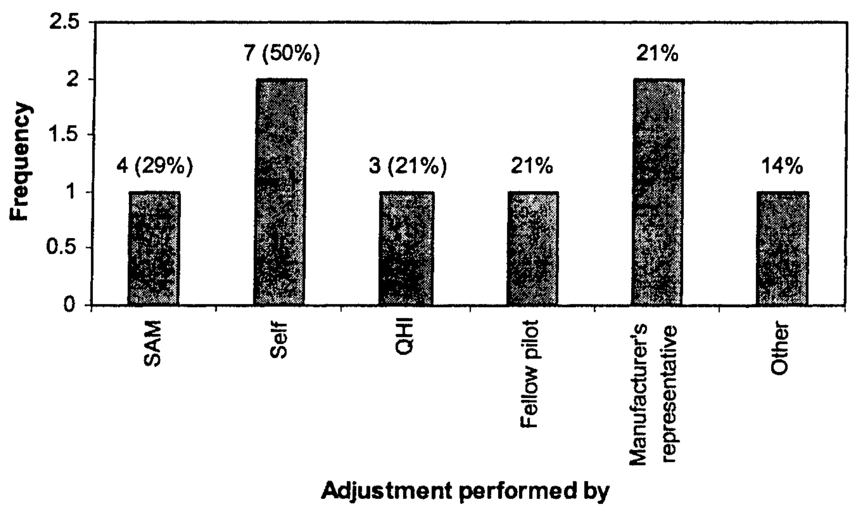
62b. If less than perfectly satisfied, please describe any problem the fit causes.

- Any poor fit will cause "hot spots" and difficulty reading all symbology.
- The RAF SE will not fit helmets.
- The helmet is fitted to the individual's head by building up velcro. These cause hot spots and pain.
- Helmet becomes very loose in its initial fit typically 1- 2 weeks.
- Loss of symbology as helmet occasionally moves during lead movements.
- Taken 3 attempts by ALSE to get correct fit. Unable to view symbology correctly or comfortably.
- Extra movement.
- Noise and chinstrap very poor quality.
- Pressure above and behind left ear.
- Occasional hot spots on the front of the head after prolonged wearing.

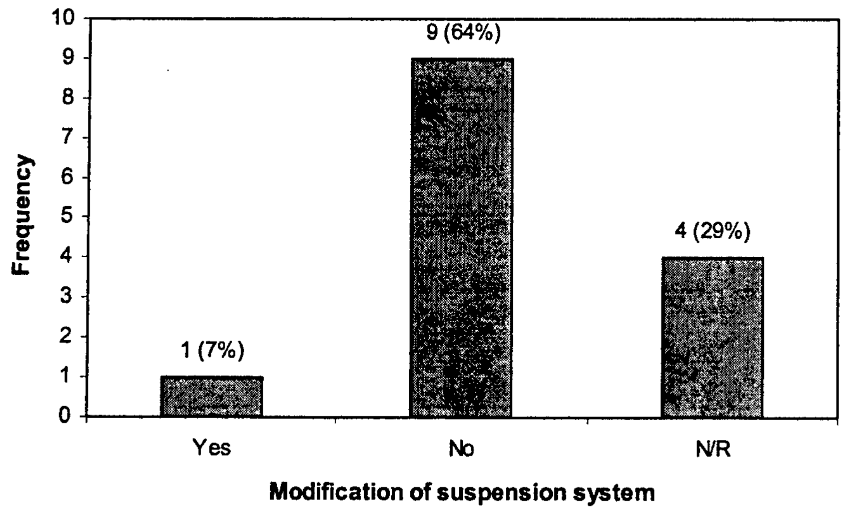
63a. Has your helmet been adjusted by anyone other than the Safety Equipment Section fitters?



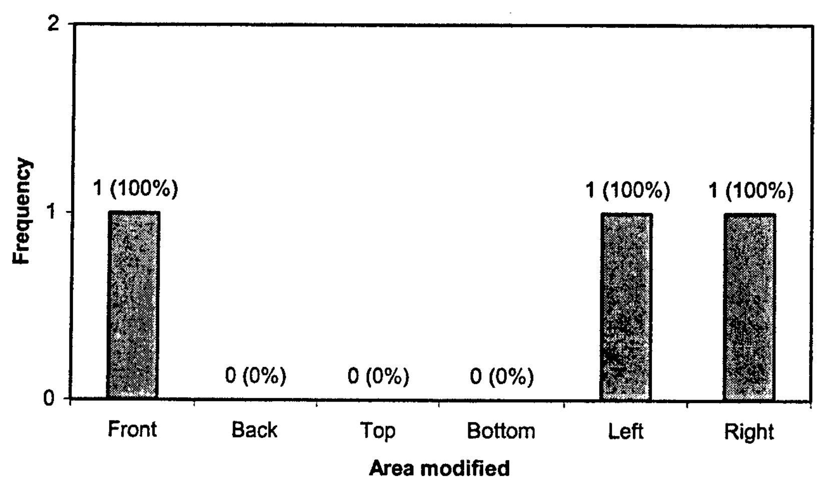
63b. If YES, by whom?



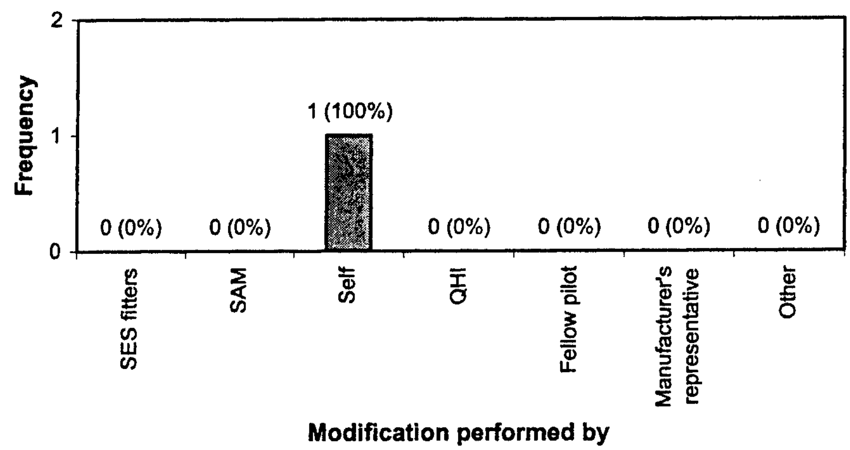
64a. Has the IHADSS suspension system rigid inner liner been modified in any manner? (Example; cut, ground, shaved, etc.)



64b. If YES, please tick below: (More than one may apply.)



64c. If YES, by whom (no names)?



65. Have you experienced any breakage, binding, slipping, or other malfunction with any of the following? (circle one in each row)

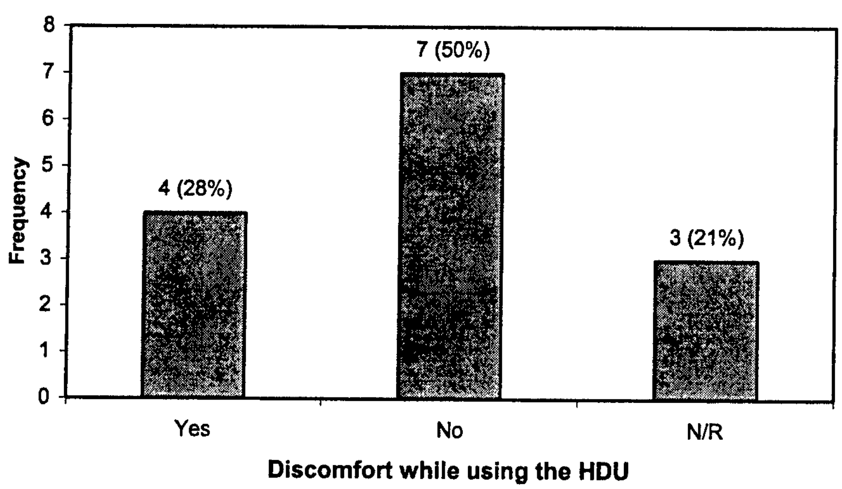
Visors	No [ ]	Yes [ ]
Visor activators	No [ ]	Yes [ ]
Chinstrap	No [ ]	Yes [ ]
Suspension assembly	No [ ]	Yes [ ]
Microphone	No [ ]	Yes [ ]
Microphone Boom	No [ ]	Yes [ ]
Earcups	No [ ]	Yes [ ]
Helmet internal speakers	No [ ]	Yes [ ]
HDU mounting bracket	No [ ]	Yes [ ]
Communication cable	No [ ]	Yes [ ]
Electronics cable	No [ ]	Yes [ ]

	Yes	No	N/R
Visors	1(8%)	8(67%)	3(25%)
Visor activators	2(17%)	7(58%)	3(25%)
Chinstrap	1(8%)	8(67%)	3(25%)
Suspension assembly	2(17%)	7(58%)	3(25%)
Microphone	4(33%)	6(50%)	2(17%)
Microphone Boom	3(25%)	7(58%)	2(17%)
Earcups	1(8%)	7(58%)	4(33%)
Helmet Internal speakers	3(25%)	7(58%)	2(17%)
HDU mounting bracket	1(8%)	8(67%)	3(17%)
Communication cable	4(33%)	6(50%)	2(17%)
Electronics cable	3(25%)	6(50%)	3(25%)

Remarks:

- Chinstrap difficult to fasten releases when new. Microphone boom often loose requires confirmatory tightening prior to every flight. Communication cable loss or degradation of audio. Electronic cable degradation of IR sensors on right side harness changed. Breakage of IR sensor (replaced).
- Chinstrap buckle difficult to do up.
- Occasional snagging during head movements.
- Comms [communication] cable fail with single loss of earcups.
- Locking system on electronics cable is poor.

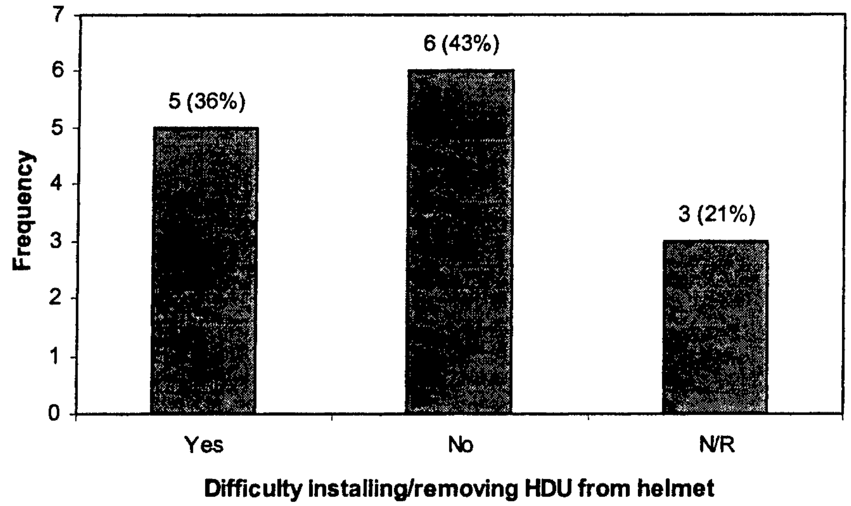
66. Have you experienced any discomfort while using the HDU?



Remarks:

- Newly fitted helmet at Fort Rucker.
- In USA post fitting- severe pain centre of forehead until re-adjusted (took 2 or 3 attempts to achieve satisfaction).
- Hot spots.
- Resting too heavily on cheek or pressure point on brow piece.
- Pressing onto cheek bones.

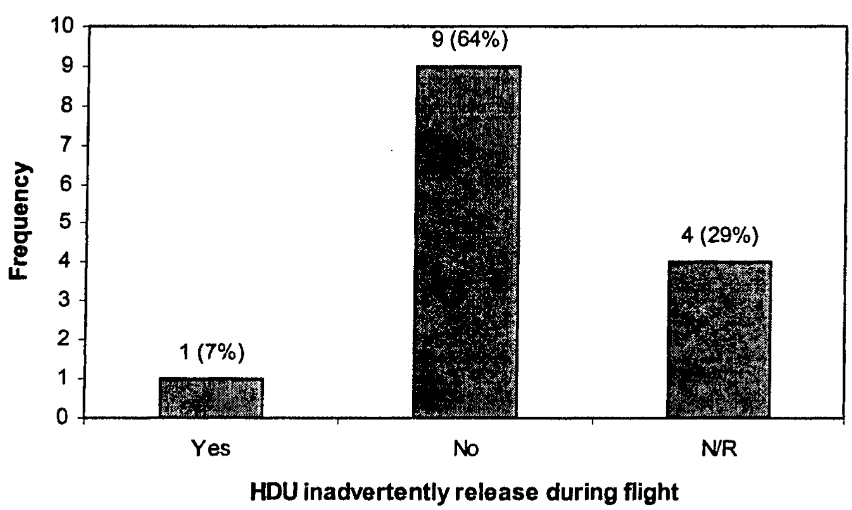
67. Have you experienced any difficulty installing or removing the HDU from the helmet?



Remarks:

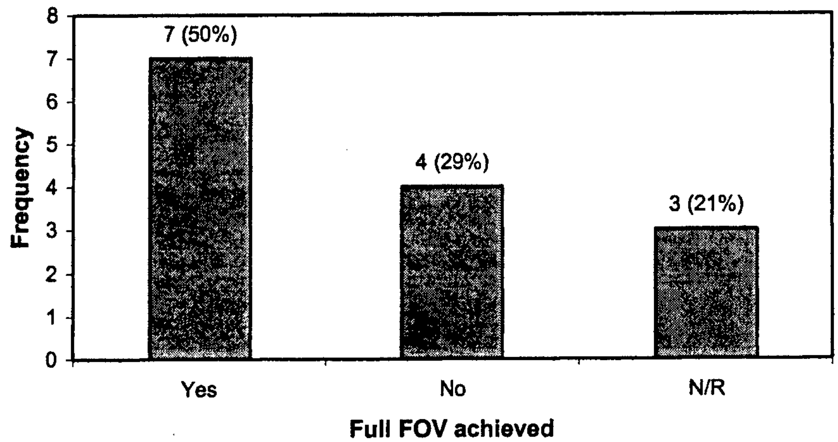
- It takes time to locate receiving bracket.
- Installing only improved with practice.
- Initially difficult to locate until muscle memory kicks in.
- Takes a while to find the correct installation position.
- Unfamiliarity with fitting primary cause.

68a. Has the HDU ever inadvertently released during flight?



68b. If yes, how many times has this happened? [2 (100%)]

69a. Do you currently achieve a full field of view?

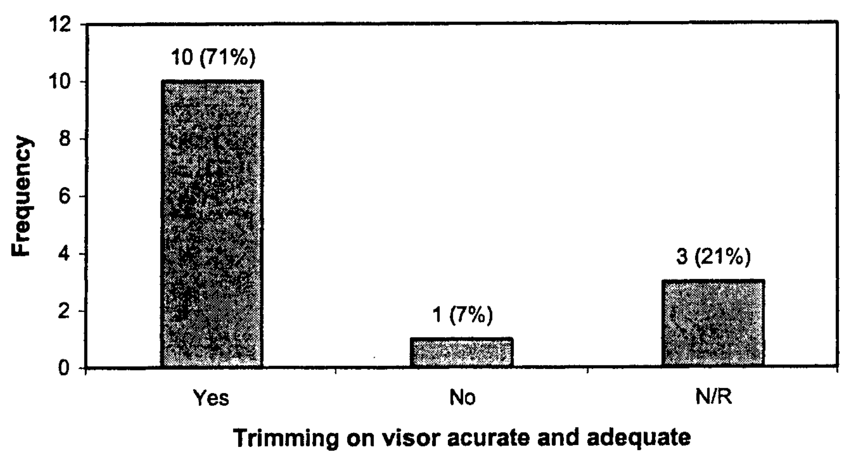


69b. If NO, assess which items of information you are not seeing:

- Varies depending on positioning of HDU (still experimenting).

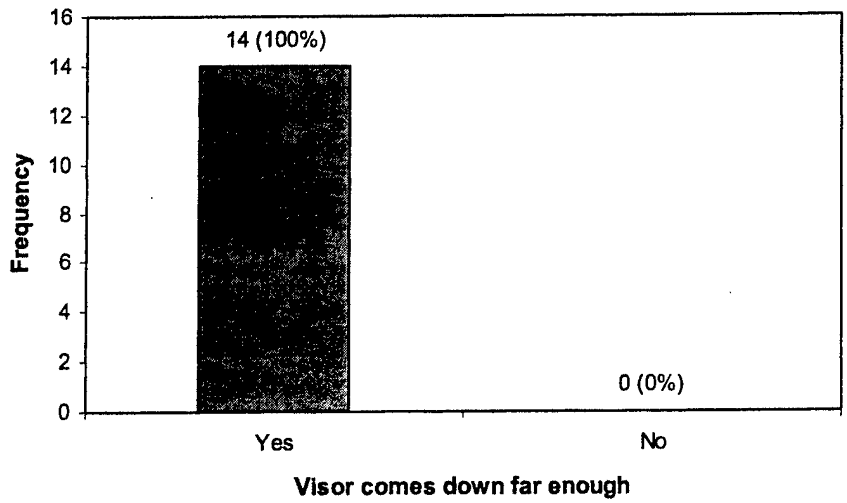
70. Was the custom trimming of the visor accurate and adequate?

YES [ ] NO [ ]



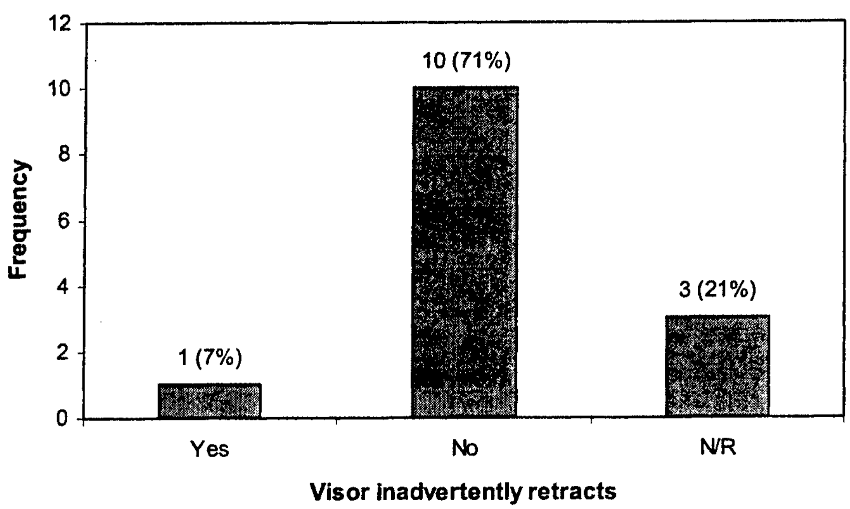
Remarks:

71. Does the visor come down far enough?



Remarks:

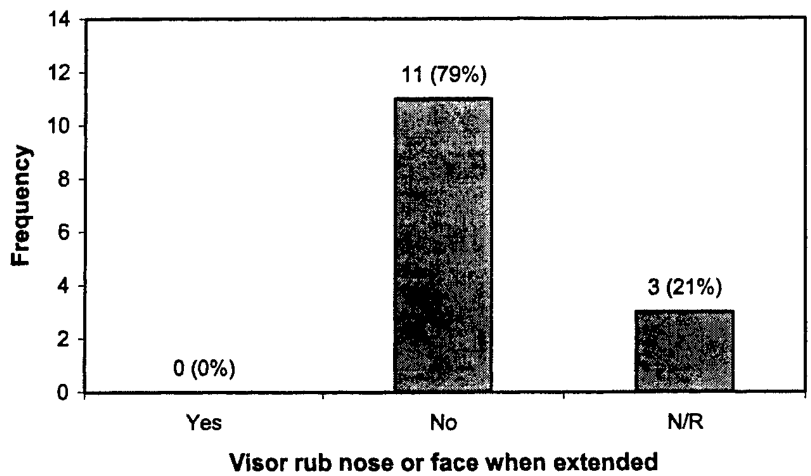
72. Has the visor ever inadvertently retracted?



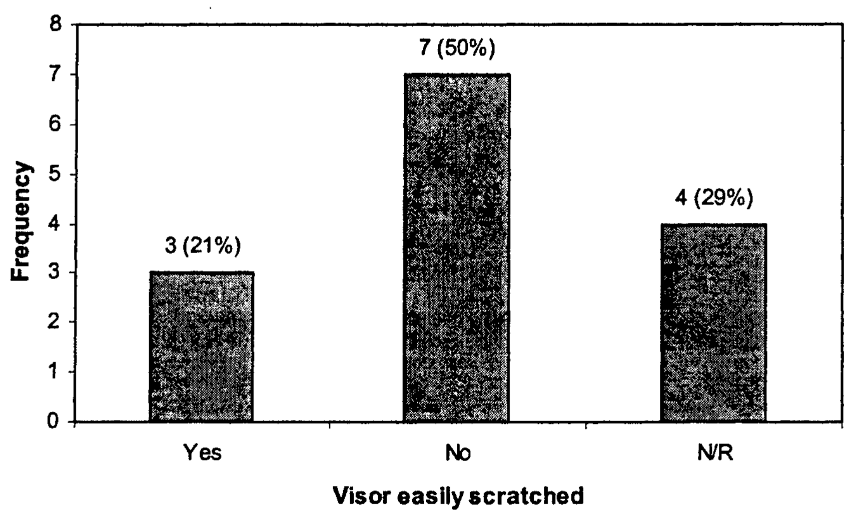
Remarks:

- On second hand helmet issued at Fort Rucker. No problems with new helmet issued in UK.

73. Does the visor rub your nose or face when extended?



74. Is the visor easily scratched?

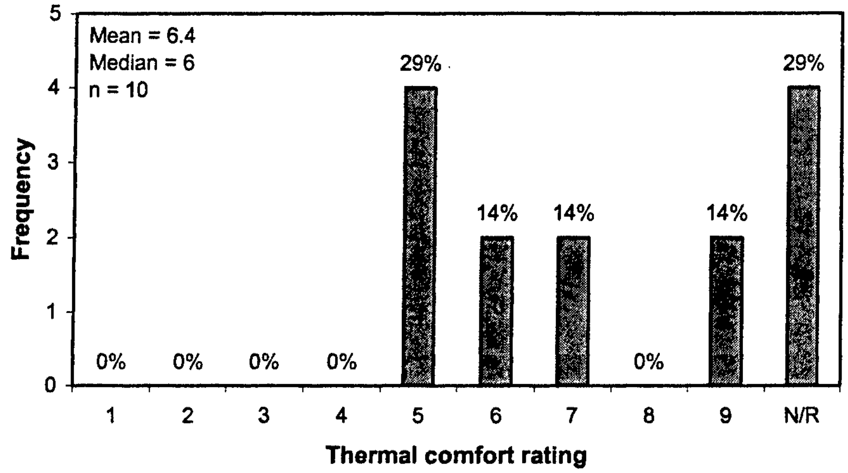


Remarks:

- Retraction system protects well.

75a. How would you rate the THERMAL comfort of the IHADSS helmet on a scale of 1 to 9 _________

1 = extremely uncomfortable 5 = adequate 9 = extremely comfortable

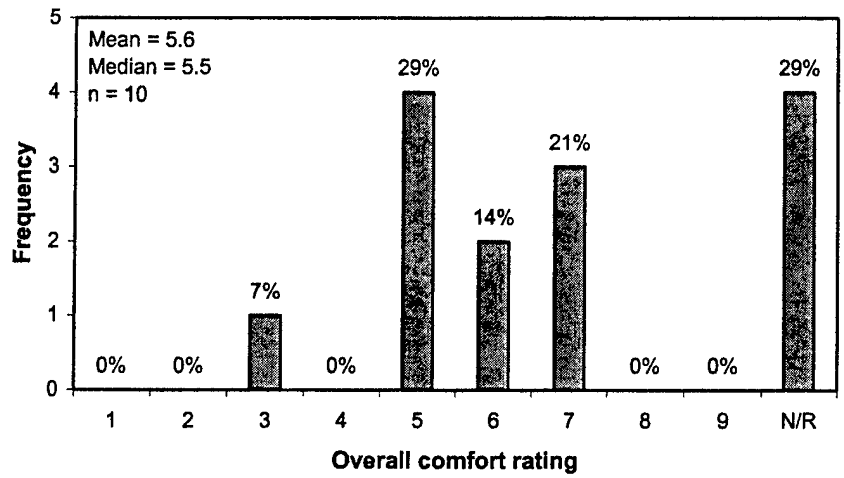


75b. If there is any discomfort, what causes it?

- Not using the TPL (Thermo Plastic Liner) . I always have it fitted.
- Lack of professional fitting.

76a. How would you rate the overall comfort of the IHADSS helmet on a scale of 1 to 9 ___

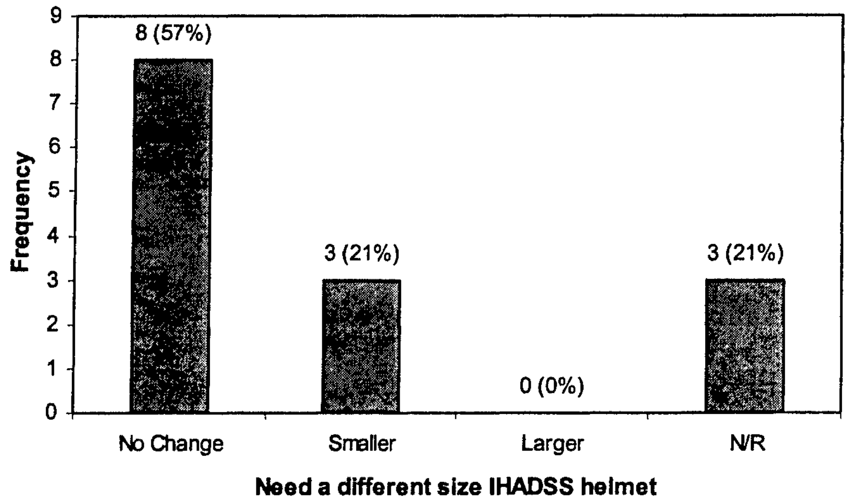
1 = extremely uncomfortable 5 = adequate 9 = extremely comfortable



76b. If there is any discomfort, what causes it?

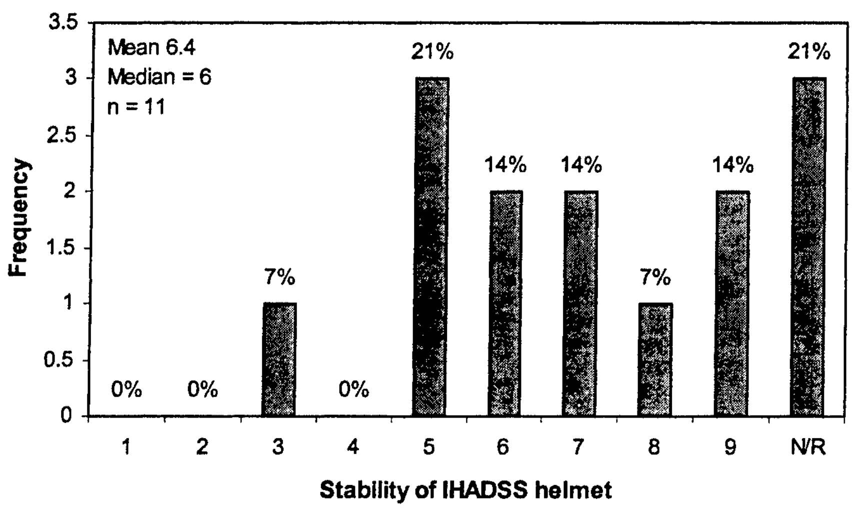
- Once fitted correctly the helmet is adequate.
- Bad fit.
- Takes a while to find the correct installation position.
- Fit is very critical therefore, helmet comfort can range widely.
- Hot spots.

77. Do you feel that you currently need a different size IHADSS helmet? (TICK ONE ONLY)



78a. How would you rate the STABILITY of the IHADSS helmet on a scale of 1 to 9 ____________

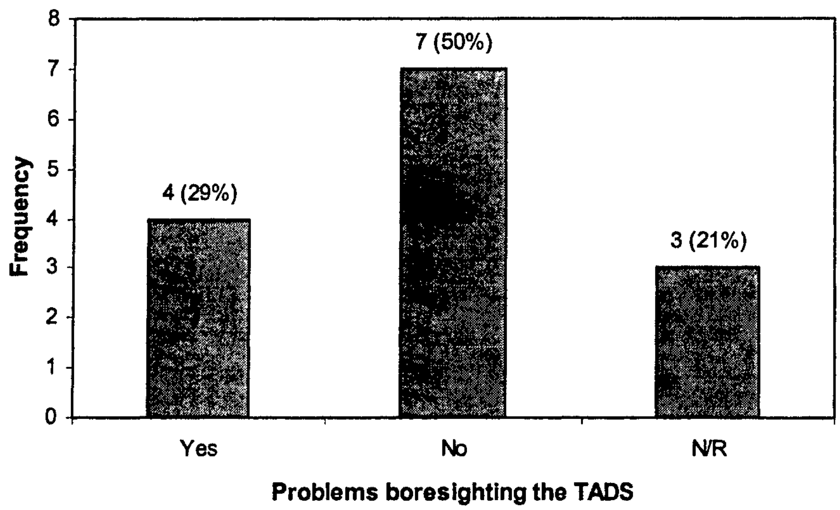
1 = extremely unstable 5 = adequate 9 = extremely stable



78b. If there is any instability, what causes it?

- Wear and tear. Regular fitting will prevent any instability.
- Designed only to fit points on the head and not the whole shape.
- Fit.
- Helmet being slightly too large.

79a. Have you had any problems boresighting the TADS?



79b. If YES, what was the problem?

- Seat height - have to boresight then adjust to correct flying position.
- Warped head shell.
- A/C problem.
- Seat position, IHADSS cable unlatched.

79c. What was done to correct the problem?

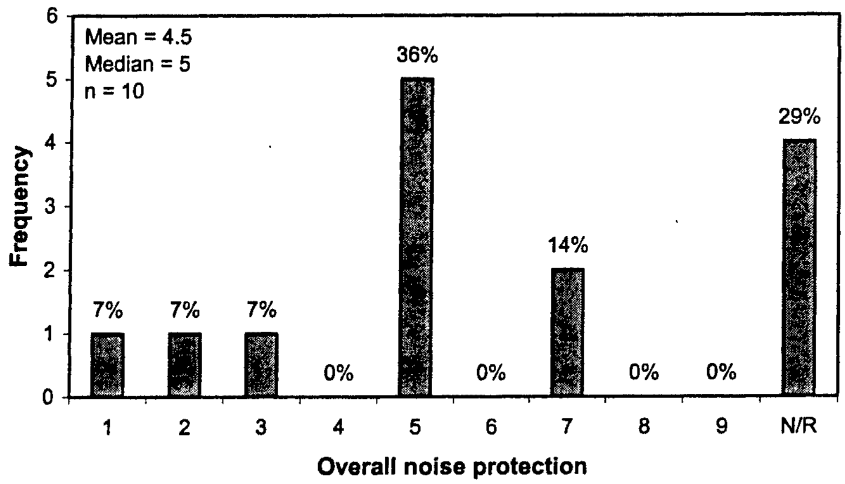
- Adjust seat height.
- Replace shell.
- Change seating position and check IHADSS cable locking device.

79d. Do you have any suggestions on how to better correct this problem?

- Modify locking device on IHADSS cable.

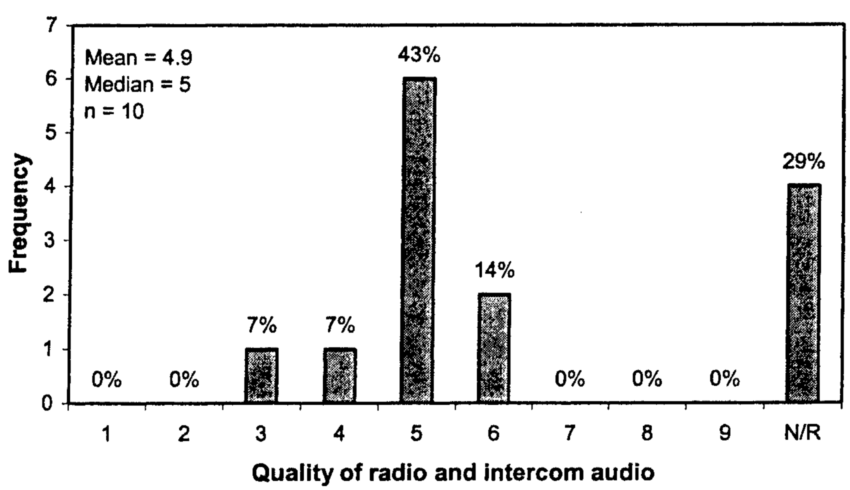
80. How would you rate the overall noise protection that you have experienced in flight on a scale of 1 to 9? _____

1 = extremely noisy 5 = adequate 9 = extremely quiet



81. How would you rate the overall quality of radio and intercom audio that you have experienced in flight on a scale of 1 to 9 _____________

1 = extremely poor 5 = adequate 9 = extremely good



82. Are the capabilities of the IHADSS system sufficient to allow you to safely meet all mission requirements?

YES [7(50%)] NO [2 (14%)] N/R [5(36%)]

If you would like to make additional comments on the capabilities or limitations of the IHADSS system, which have not been fully addressed by this survey, please do so below.

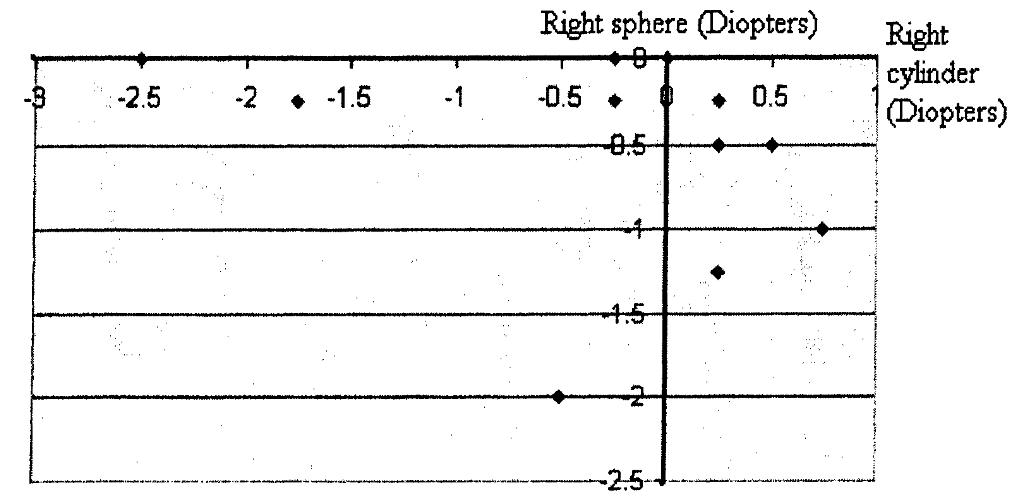
THANK YOU

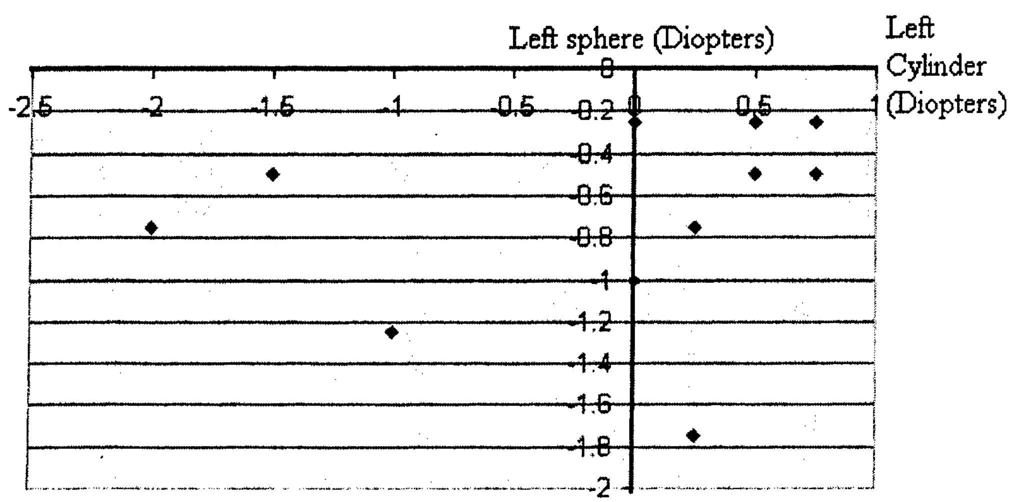
Appendix E.

Apache AH Mk 1 pilot eye examination.

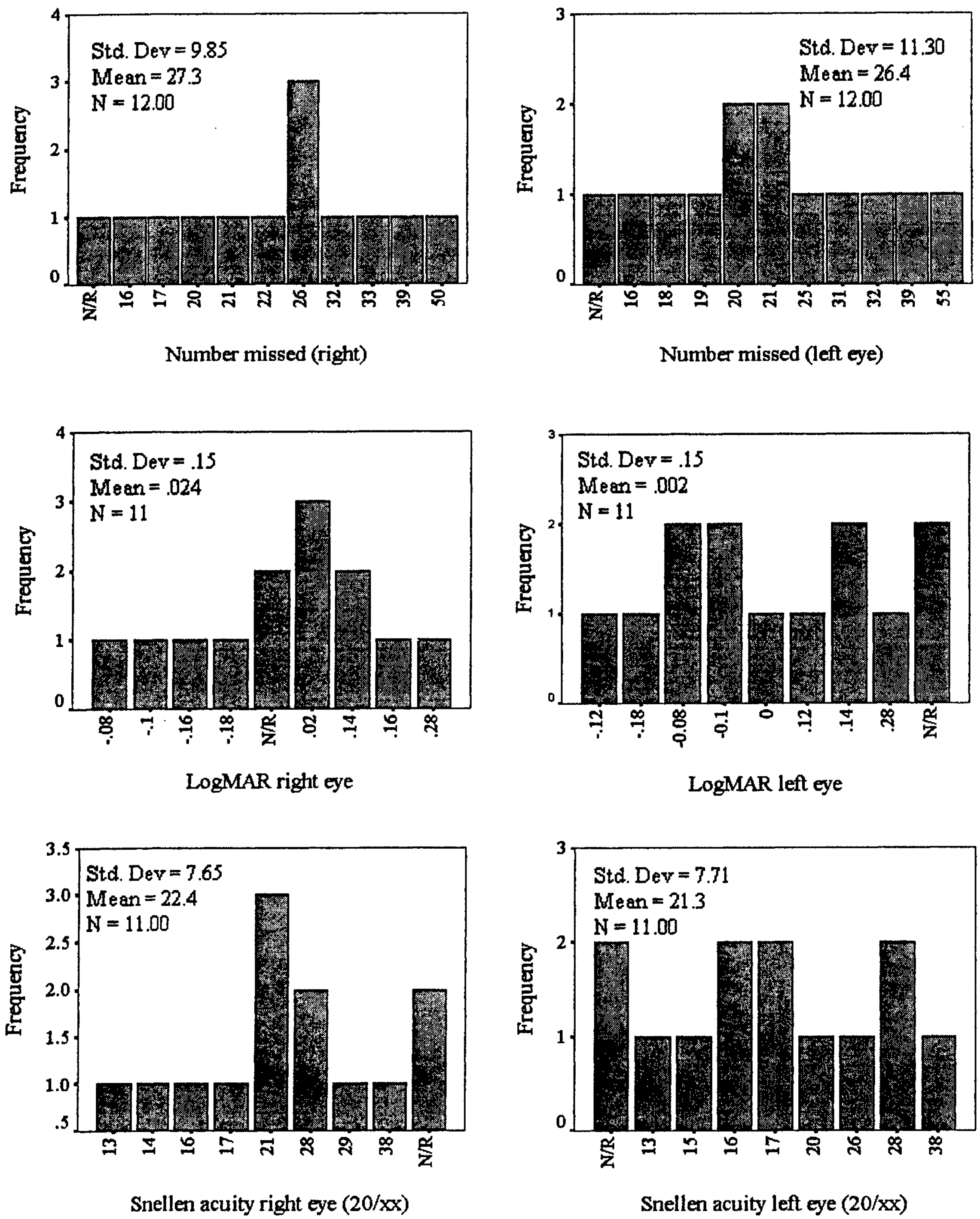
Exposed

Manual Refraction:
OD: Sphere _____ Cylinder ______ Axis ______
OS: Sphere _____ Cylinder ______ Axis ______

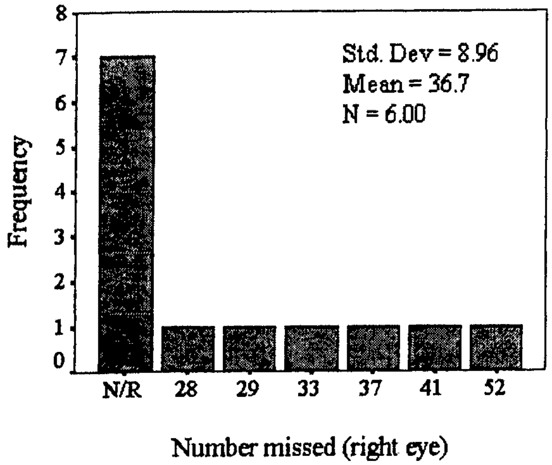


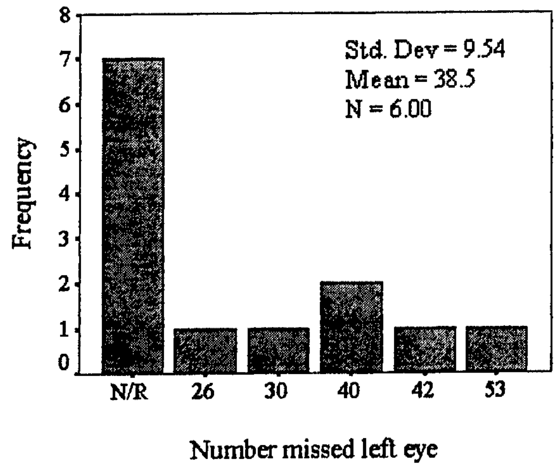


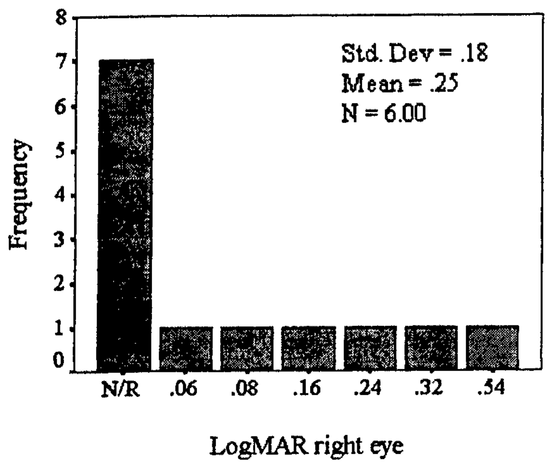
Bailey-Lovie High Contrast Visual Acuity
Total number missed for:
Right Eye: ______ Left Eye: ______

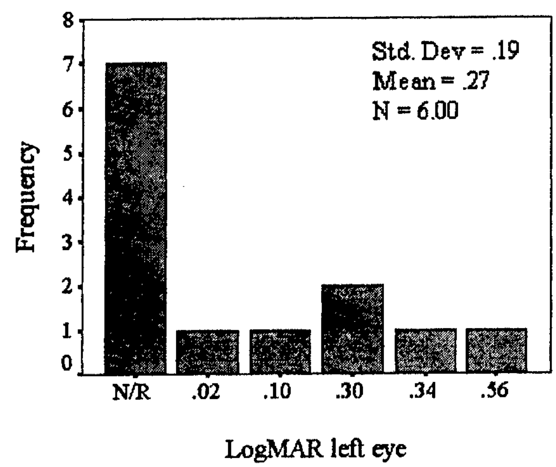


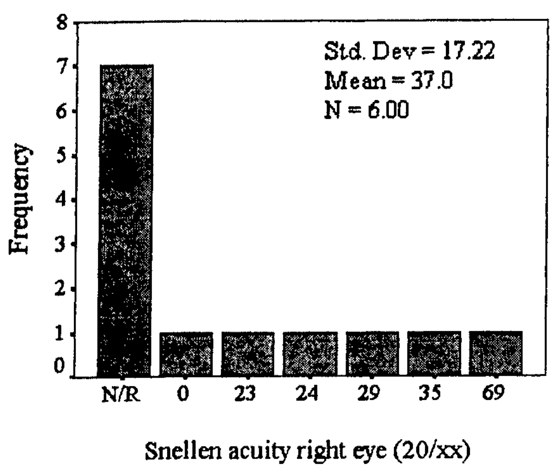
Bailey-Lovie Low Contrast Visual Acuity
Total number missed for:
Right Eye: ______ Left Eye: _______

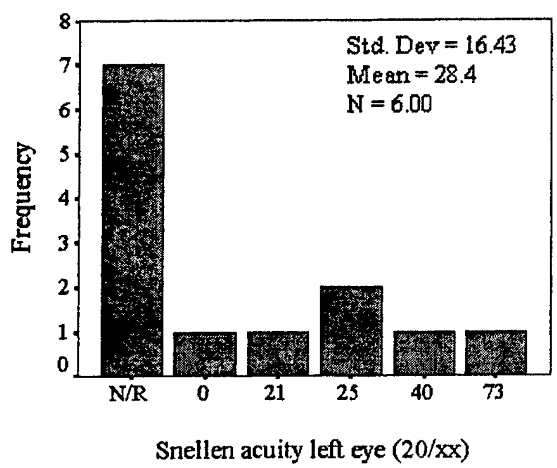








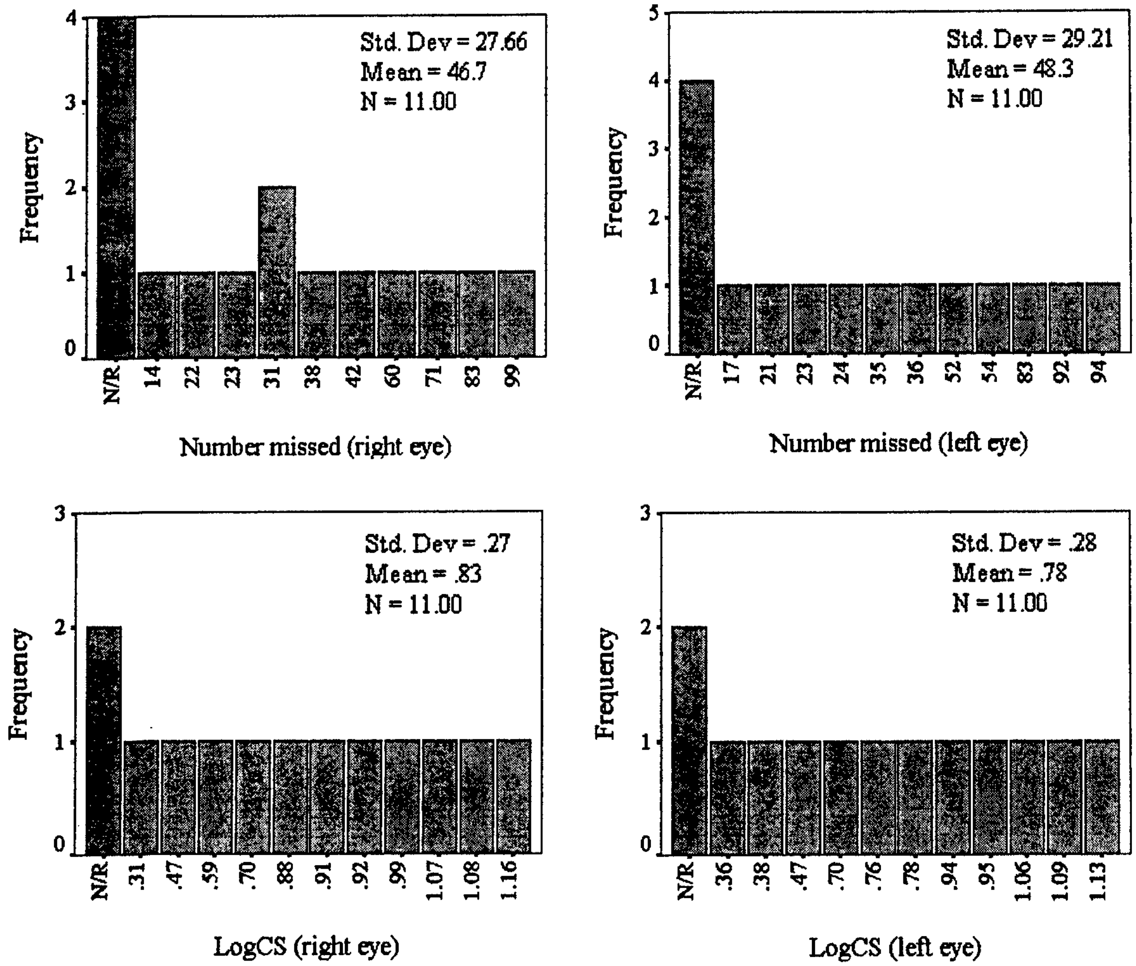




Small Letter Contrast

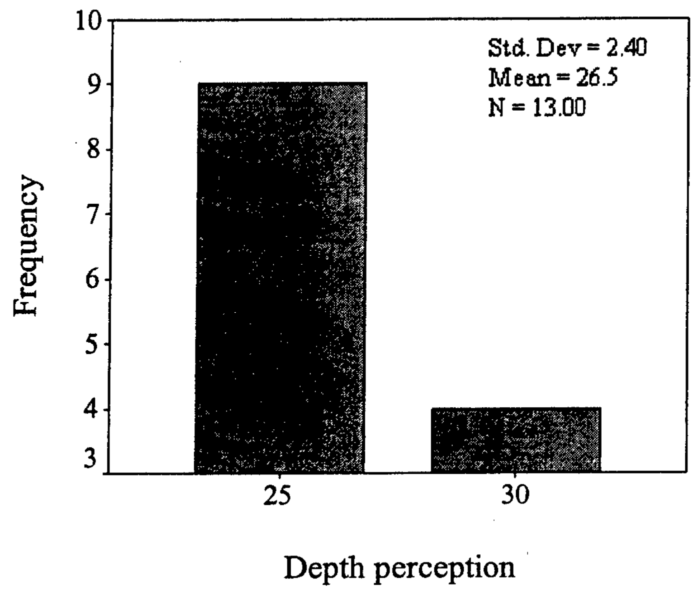
Total number missed for:

Right Eye: ______ Left Eye: _______



Depth Perception

Minimum angle of stereopsis:



Color Perception

Right eye:

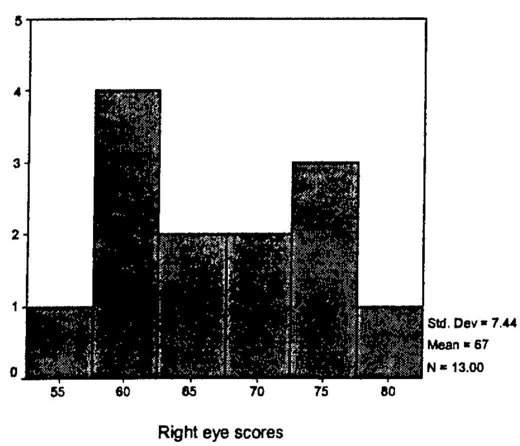
_____ No reversal

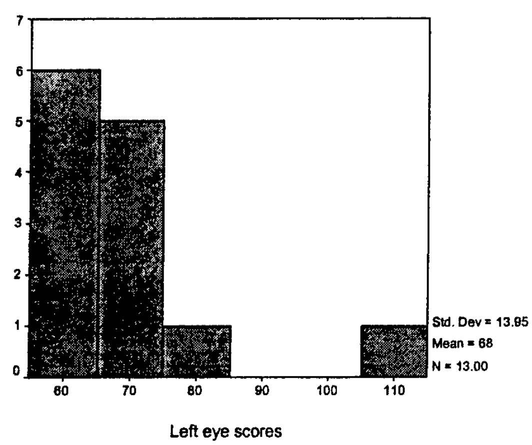
__ 1 __ 2 __ 3 __ 4 __ 5 __ 6 __ 7 __ 8 __ 9 __ 10 __ 11 __ 12 __ 13 __ 14 __ 15

Left eye:

___ No reversal

__ 1 __ 2 __ 3 __ 4 __ 5 __ 6 __ 7 __ 8 __ 9 __ 10 __ 11 __ 12 __ 13 __ 14 __ 15

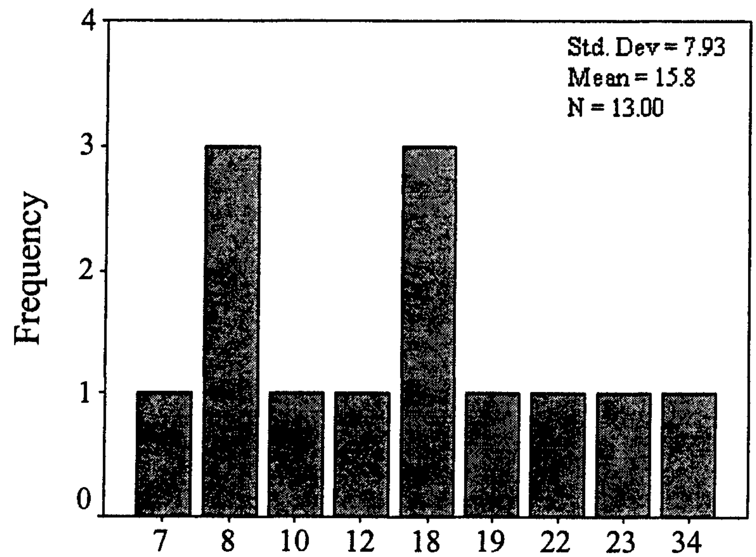




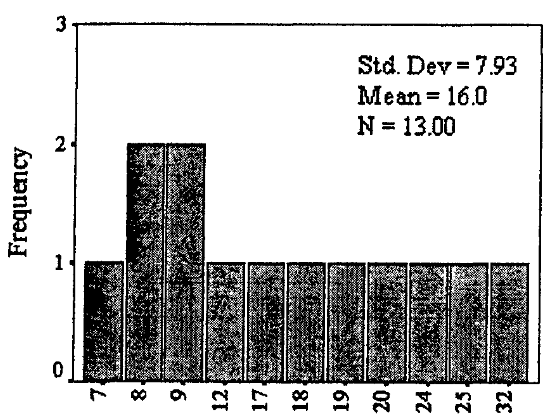
Accommodation

Without spectacles:

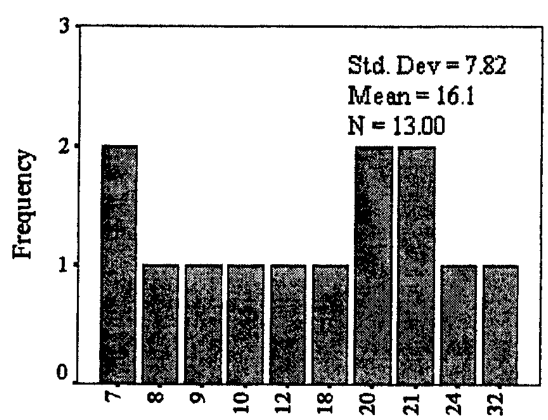
Both eyes: ____cm
Right eye: ____ cm
Left eye: ____ cm



Accommodation without spectacles both eyes



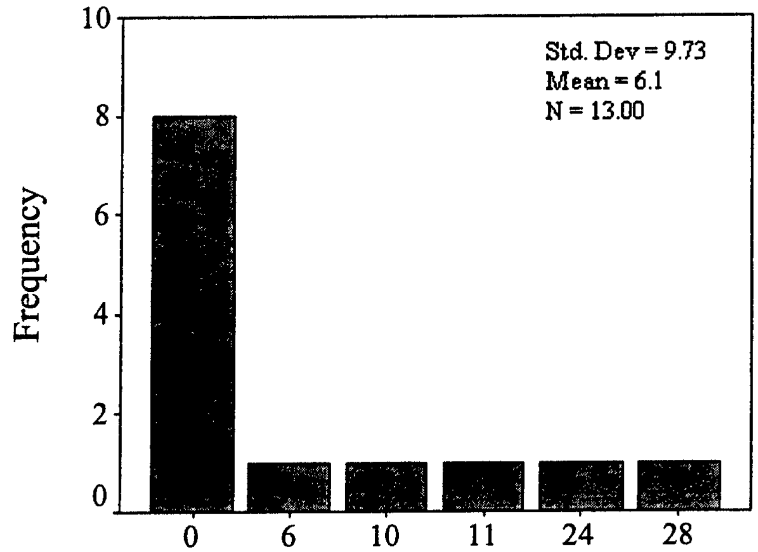
Accommodation without spectacles right eye



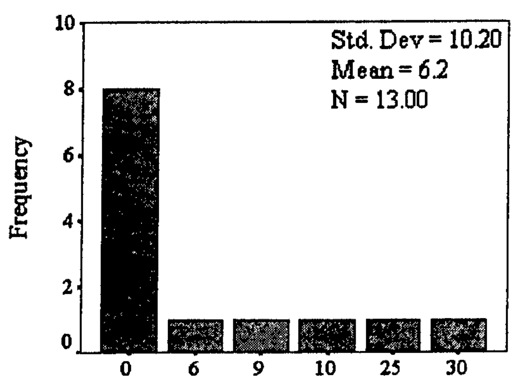
Accommodation without spectacles left eye

With spectacles

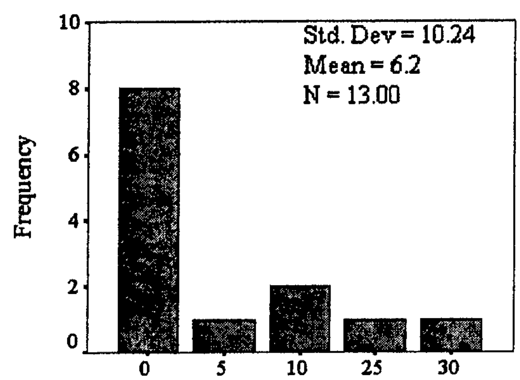
Both eyes: _____cm
Right eye: _____ cm
Left eye: _____ cm



Accommodation with spectacles both eyes



Accommodation with spectacles right eye



Accommodation with spectacles left eye

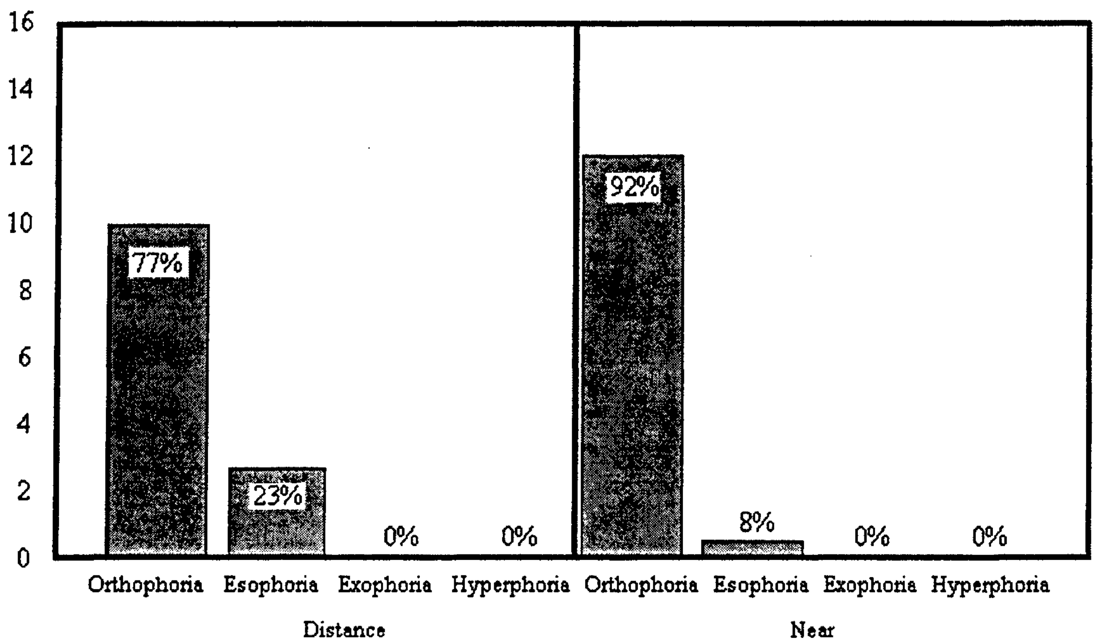
Eye Muscle Balance

Distance

Orthophoria: _____ Yes _____ No
Heterophoria: _____ Exophoria _____
Hyperphoria: Right: ____ Left eye ____

Near

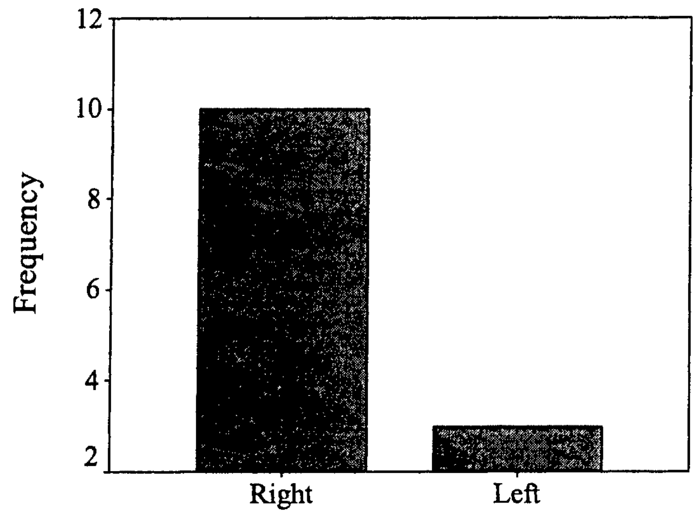
Orthophoria: _____ Yes _____ No
Heterophoria: _____ Exophoria _____
Hyperphoria: Right eye: ____ Left eye



Eye muscle balance

Eye preference

Right eye: ______ Left eye: _____



Eye preference

Additional Comments:

Exposed Refraction Values

Subject Number	Right			Left		
	Sphere + Cylinder X Axis			Sphere + Cylinder X Axis		
1	0.50	-0.50	0.00	0.75	-0.25	3
2	0.25	-0.25	73	0.50	-0.25	108
3	0.00	0.00	0.00	0.50	-0.50	76
4	0.02	-1.25	176	0.00	-1.00	85
5	-1.75	-0.25	29	-1.50	-0.50	45
6	0.75	-1.00	10	0.25	-1.75	141
33	-2.50	0.00	112	-2.00	-0.75	67
51	0.50	-0.50	6	0.75	-0.50	176
58	-0.50	-2.00	106	-1.00	-1.25	76
89	-0.25	0.00	0.00	0.00	-0.25	19
101	0.25	-0.25	11	0.75	-0.25	112
102	0.25	-0.50	93	0.00	-0.25	108
103	-0.25	-0.25	1	0.25	-0.75	80
Mean	-0.19	-0.52	47	-0.06	-0.63	84
SD	0.94	0.58	58	0.89	0.46	47

Appendix F.

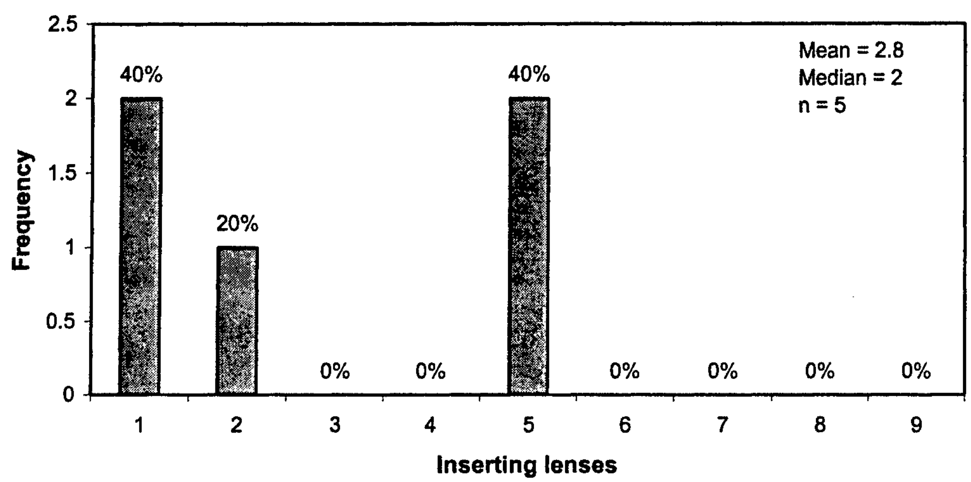
Contact lens users survey.

EXPOSED

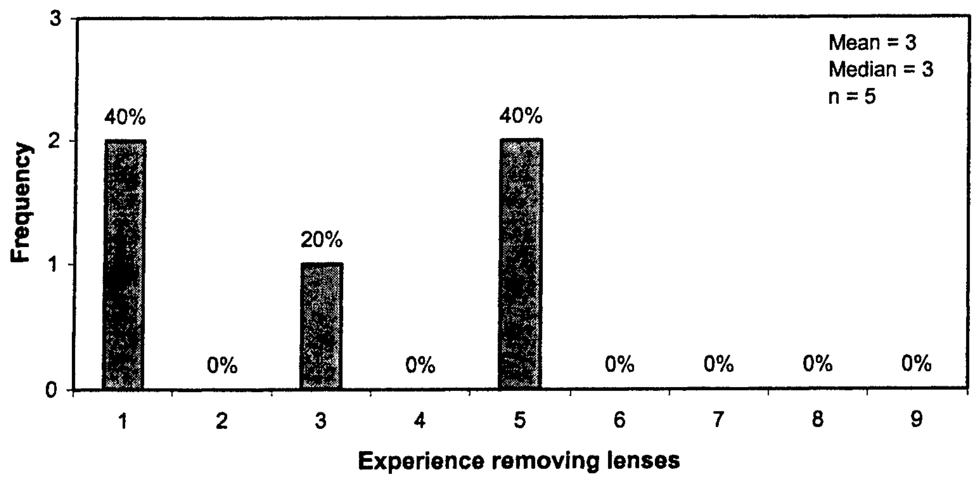
Date questionnaire completed: ____________ **See Appendix A.**

a. If contact lens wear was discontinued within the last year, please give the reason.
NO ANSWER TO THIS QUESTION

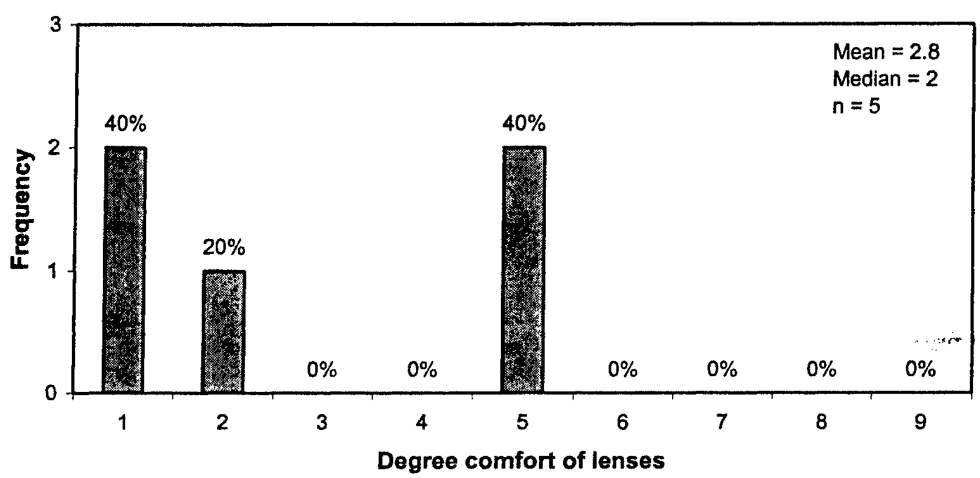
b. Please rate your experiences in inserting your lenses. (1-9)______
1 = No problems what-so-ever
5 = Minor problems
9 = Severe problems



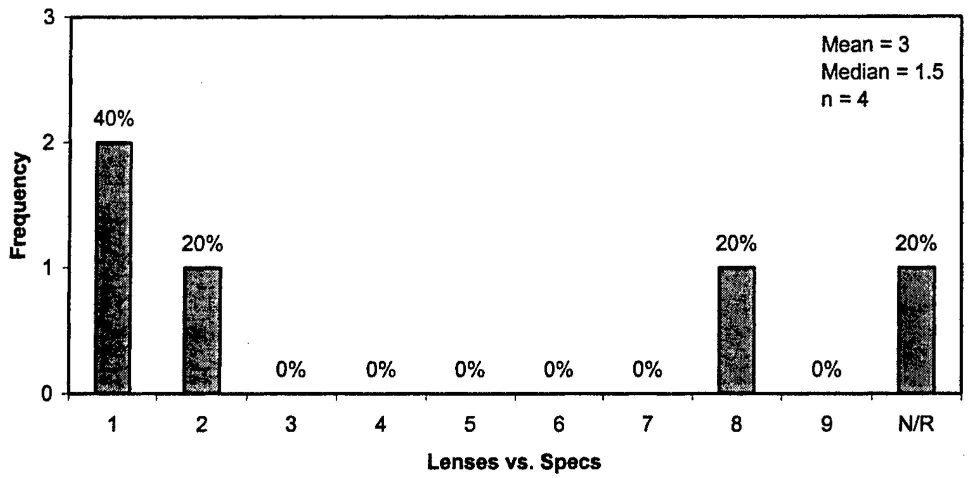
c. Please rate your experiences in removing your lenses. (1-9)______
1 = No problems what-so-ever
5 = Minor problems
9 = Severe problems



d. In general, how comfortable are your contact lenses? (1-9)______
1 = Very comfortable
5 = Neither comfortable nor uncomfortable
9 = Very uncomfortable



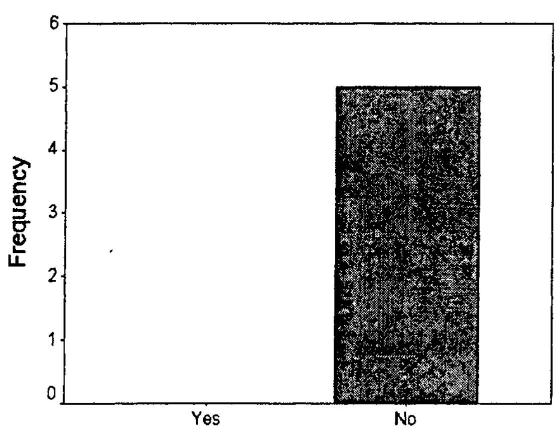
e. How do you rate your vision with contact lenses as opposed to your vision with spectacles? (1-9)______
1 = Much better with contact lenses
5 = No difference between contact lenses and glasses
9 = Much better with glasses



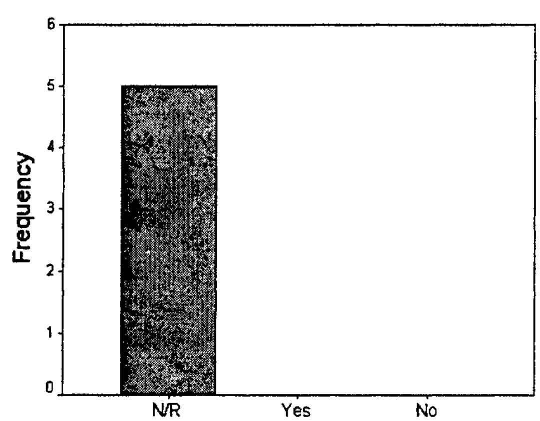
f. Have you experienced any difficulty maintaining your contact lenses?

At home/in barracks	Yes [0 (0%)]	No [5 (100%)]	N/R [0 (0%)]
In the field	Yes [0 (0%)]	No [0 (0%)]	N/R [5 (100%)]

If yes, please explain:



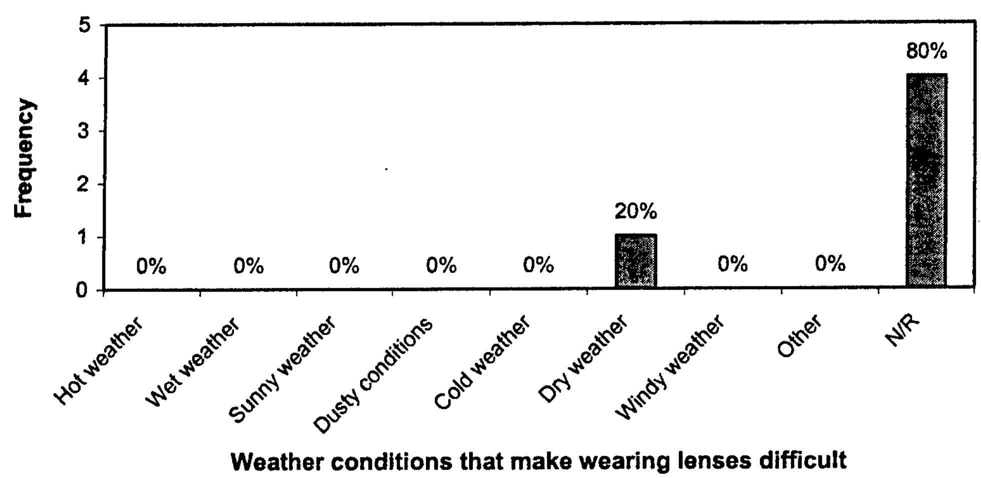
Difficulty maintaining lenses at home/barracks



Difficulty maintaining lenses in field

g. Did any of the following weather conditions make the wearing of contact lenses difficult? (Check all that apply.)

Conditions that makes contact lens wear difficult	Number of respondents
Hot Weather	0 (0%)
Wet Weather	0 (0%)
Sunny	0 (0%)
Dusty conditions	0 (0%)
Cold Weather	0 (0%)
Dry Weather	1 (20%)
Windy Weather	0 (0%)
Other	0 (0%)
N/R	4 (80%)



h. Since your last contact lens review, have you experienced any of the following problems while flying? Tick only those that apply.

FREQUENCY

	Never	Rarely	Occasionally	Often	N/R
Eye irritation	2 (40%)	1 (20%)	1 (20%)	0 (0%)	1 (20%)
Eye pain	4 (80%)	0 (0%)	0 (0%)	0 (0%)	1 (20%)
Blurred vision	3 (60%)	0 (0%)	1 (20%)	0 (0%)	1 (20%)
Dry eye	1 (20%)	2 (40%)	0 (0%)	1 (20%)	1 (20%)
Light sensitivity	4 (80%)	0 (0%)	0 (0 %)	0 (0%)	1 (20%)

i. If any of the above occurred, how bothersome was it?

SEVERITY

	Minor	Moderate	Severe	N/R
Eye irritation	1(20%)	1(20%)	0(0%)	3(60%)
Eye pain	0(0%)	0(0%)	0(0%)	5(100%)
Blurred vision	0(0%)	0(0%)	1(20%)	4(80%0
Dry eye	2(40%)	1(20%)	0(0%)	2(40%)
Light sensitivity	0(0%)	0(0%)	0(0%)	5(100%)

j. Since your last contact lens review, did you experience any of the following problems while on the ground? Tick only those that apply.

FREQUENCY

	Never	Rarely	Occasionally	Often	N/R
Eye irritation	3(60%)	1(20%)	1(20%)	0(0%)	0(0%)
Eye pain	5(100%)	0(0%)	0(0%)	0(0%)	0(0%)
Blurred vision	4(80%)	0(0%)	1(20%)	0(0%)	0(0%)
Dry eye	1(20%)	3(60%)	0(0%)	0(0%)	1(20%)
Light sensitivity	5(100%)	0(0%)	0(0%)	0(0%)	0(0%)

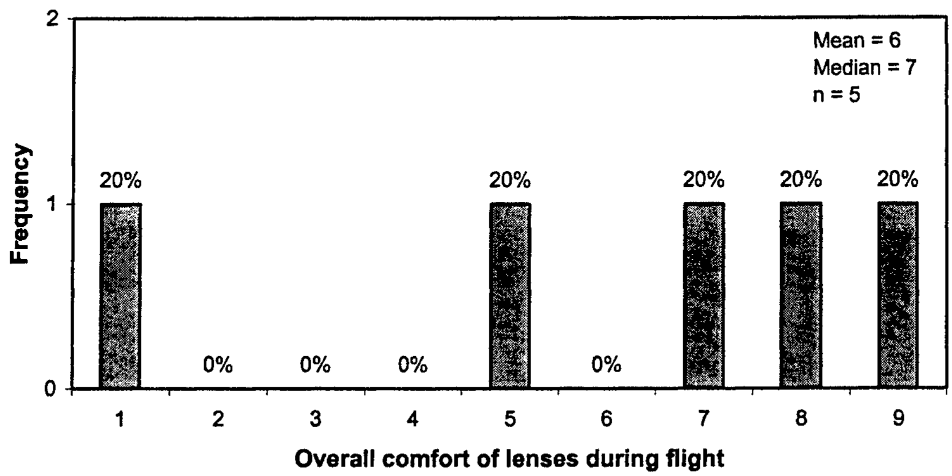
k. If any of the above occurred, how bothersome was it?

SEVERITY

	Minor	Moderate	Severe	N/R
Eye irritation	1(20%)	1(20%)	0(0%)	3(60%)
Eye pain	0(0%)	0(0%)	0(0%)	5(100%)
Blurred vision	0(0%)	0(0%)	1(20%)	4(80%)
Dry eye	3(60%)	1(20%)	0(0%)	1(20%)
Light sensitivity	0(0%)	0(0%)	0(0%)	5(100%)

l. If you use contact lenses during flight, how would you rate their overall comfort? (1-9) ___________

1 = unsatisfactory
5 = adequate
9 = excellent
Comments:



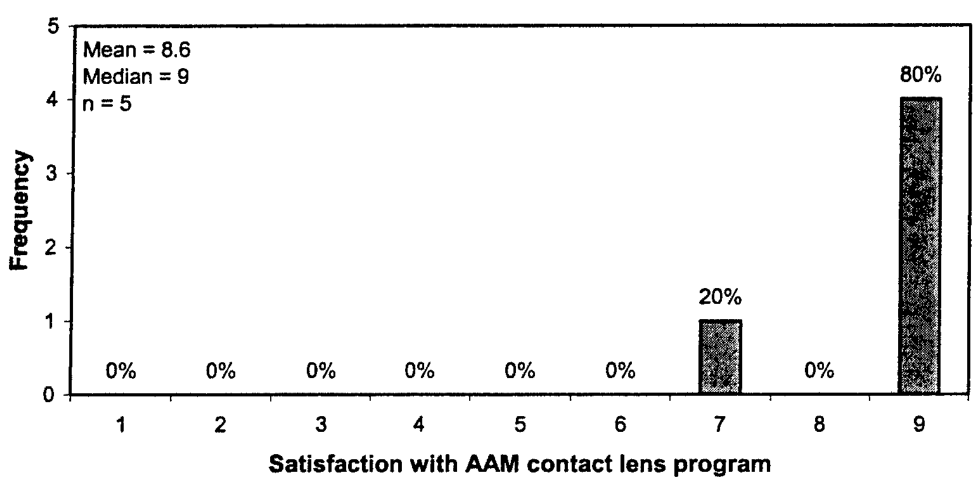
m. If you use contact lenses during flight, have difficulties with the lenses caused you to: (tick all that apply)

	Yes	No
Reschedule or cancel flights	0(0%)	5(100%)
Deviate from flight plan	0(0%)	5(100%)
Hand over controls in flight	1(20%)	4(80%)
Remove lens in flight	0(0%)	5(100%)
Use eye drops in flight	0(0%)	5(100%)

n. If this is your first year wearing lenses, please evaluate the training that you have received in the following aspects:

	Application	Removal
Ineffective	0(0%)	0(0%)
Poor	0(0%)	0(0%)
Fair	0(0%)	0(0%)
Good	2(40%)	2(40%)
Excellent	1(20%)	1(20%)
N/R	2(40%)	2(40%)

o. Overall, how would you rate the Army Aviation Medicine support of the contact lens programme? (1-9)______
1 = Ineffective
5 = Fair
9 = Excellent



p. Finally, please comment on how the support for AH MK 1 pilots who use contact lenses could be improved:

- Concern over provision of lenses in field conditions using two disposables weekly appears to be a waste. Are there cheaper daily disposables that would be more appropriate? Also cleanliness of fingers in field condition when putting them in or out.
- Get more up to date on the lenses available.
- I believe that there are better contact lenses now available.

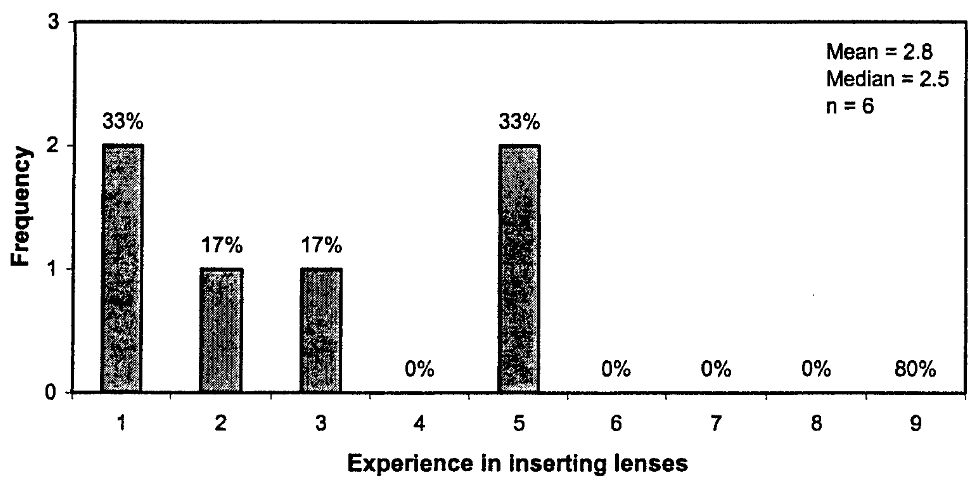
CONTROL

Date questionnaire completed: ____________

a. If contact lens wear was discontinued within the last year, please give the reason.

NO ANSWER TO THIS QUESTION

b. Please rate your experiences in inserting your lenses. (1-9) _____
1 = No problems what-so-ever
5 = Minor problems
9 = Severe problems

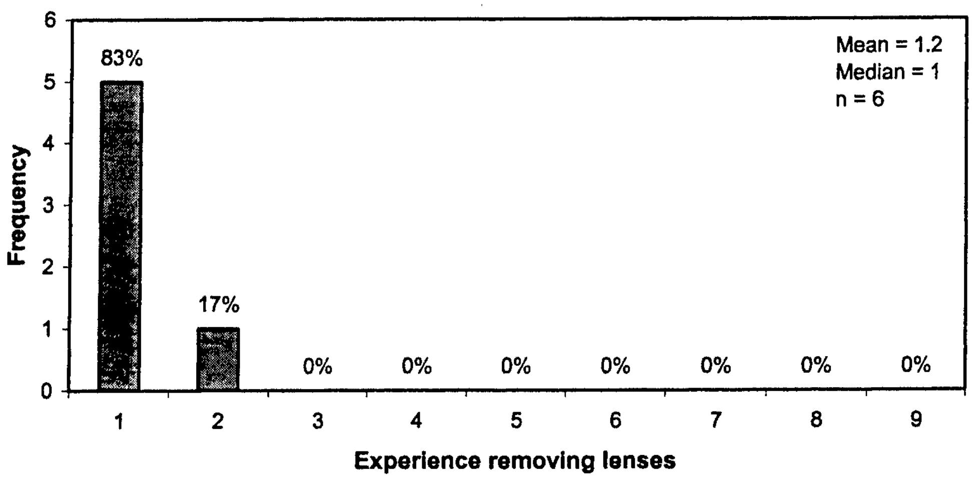


c. Please rate your experiences in removing your lenses. (1-9)______

1 = No problems what-so-ever

5 = Minor problems

9 = Severe problems

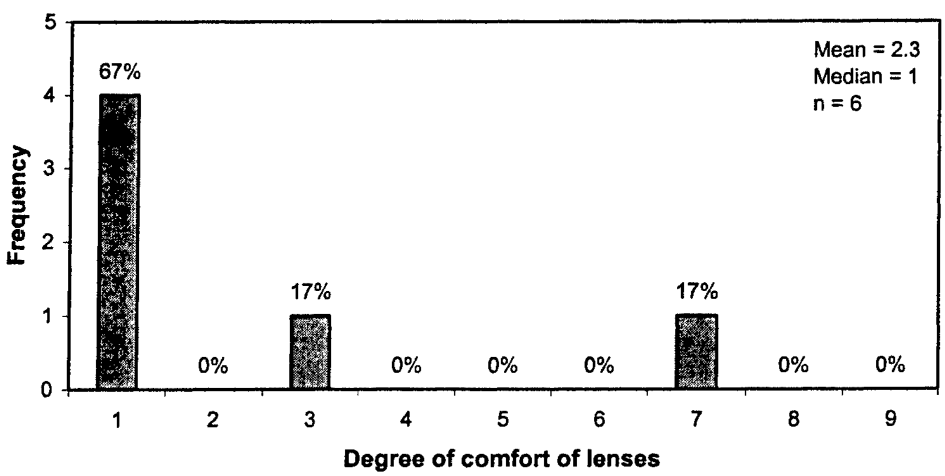


d. In general, how comfortable are your contact lenses? (1-9)______

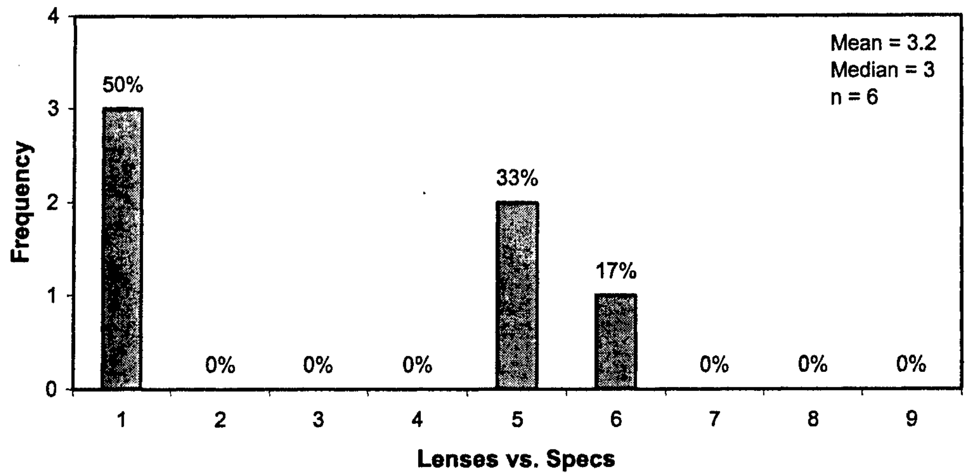
1 = Very comfortable

5 = Neither comfortable nor uncomfortable

9 = Very uncomfortable



e. How do you rate your vision with contact lenses as opposed to your vision with spectacles (1-9)______
1 = Much better with contact lenses
5 = No difference between contact lenses and glasses
9 = Much better with glasses



f. Have you experienced any difficulty maintaining your contact lenses?

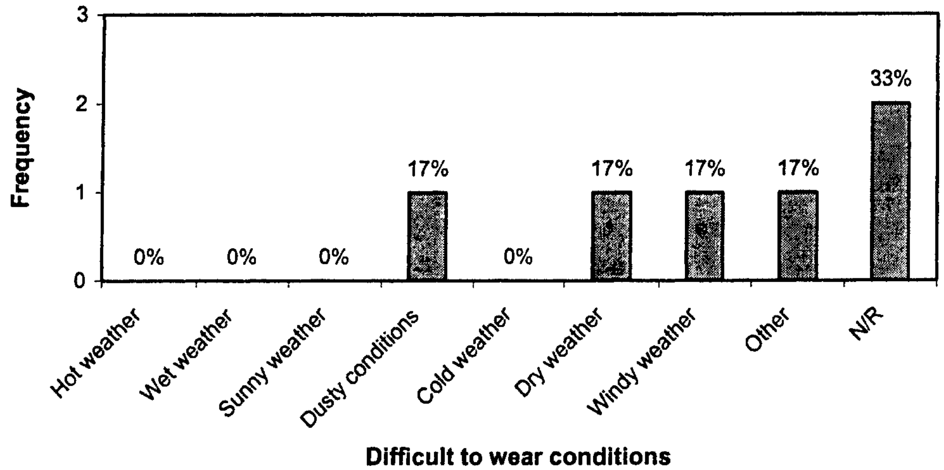
At home/in barracks	YES [0 (0%)]	NO [6 (100%)]
In the field	YES [1 (17%)]	NO [5 (83%)]

If yes, please explain:

____

- Hygiene and light to insert/remove

g. Did any of the following weather conditions make the wearing of contact lenses difficult? (Check all that apply.)



- Extended periods in the field dirty hands

h. Since your last contact lens review, have you experienced any of the following problems while flying? Tick only those that apply.

FREQUENCY

	Never	Rarely	Occasionally	Often	N/R
Eye irritation	3 (50%)	2(33%)	0(0%)	0(0%)	1(17%)
Eye pain	4(67%)	0(0%)	0(0%)	0(0%)	2(33%)
Blurred vision	4(67%)	0(0%)	0(0%)	0(0%)	2(33%)
Dry eye	2(33%)	1(17%)	0(0%)	0(0%)	3(50%)
Light sensitivity	3(50%)	0(0%)	0(0%)	0(0%)	3(50%)

i. If any of the above occurred, how bothersome was it?

SEVERITY

	Minor	Moderate	Severe	N/R
Eye irritation	2(33%)	0(0%)	0(0%)	4(67%)
Eye pain	0(0%)	0(0%)	0(0%)	6(100%)
Blurred vision	0(0%)	0(0%)	0(0%)	6(100%)
Dry eye	1(17%)	0(0%)	0(0%)	5(83%)
Light sensitivity	0(0%)	0(0%)	0(0%)	6(100%)

j. Since your last contact lens review, did you experience any of the following problems while on the ground? Tick only those that apply.

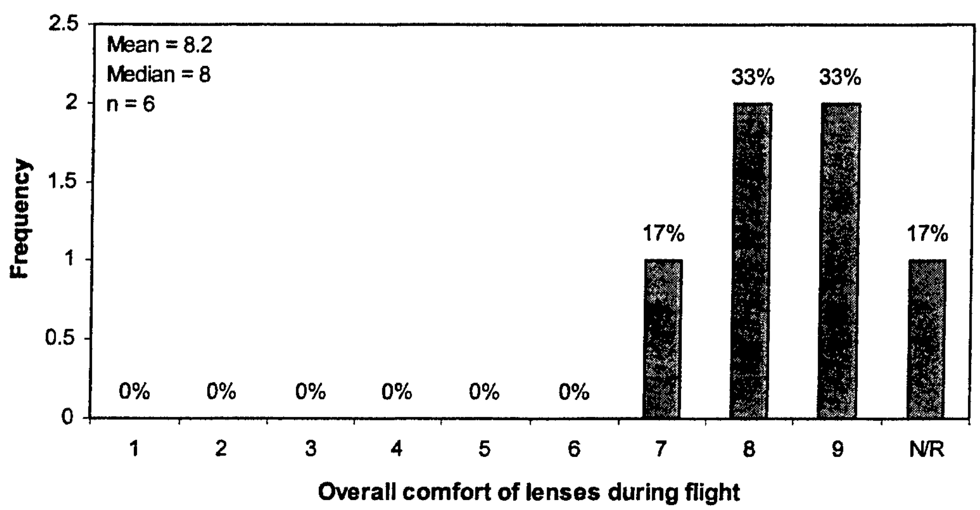
FREQUENCY

	Never	Rarely	Occasionally	Often	N/R
Eye irritation	3(50%)	1(17%)	0(0%)	0(0%)	2(33%)
Eye pain	4(67%)	0(0%)	0(0%)	0(0%)	2(33%)
Blurred vision	3(50%)	1(17%)	0(0%)	0(0%)	2(33%)
Dry eye	3(50%)	1(17%)	0(0%)	0(0%)	2(33%)
Light sensitivity	4(67%)	0(0%)	0(0%)	0(0%)	2(33%)

k. If any of the above occurred, how bothersome was it?

	SEVERITY			
	Minor	Moderate	Severe	N/R
Eye irritation	1(17%)	0(0%)	0(0%)	5(83%)
Eye pain	0(0%)	0(0%)	0(0%)	6(100%)
Blurred vision	1(17%)	0(0%)	0(0%)	5(83%)
Dry eye	1(17%)	0(0%)	0(0%)	5(83%)
Light sensitivity	0(0%)	0(0%)	0(0%)	6(100%)

l. If you use contact lenses during flight, how would you rate their overall comfort? (1-9) ___________
1 = unsatisfactory
5 = adequate
9 = excellent
Comments:



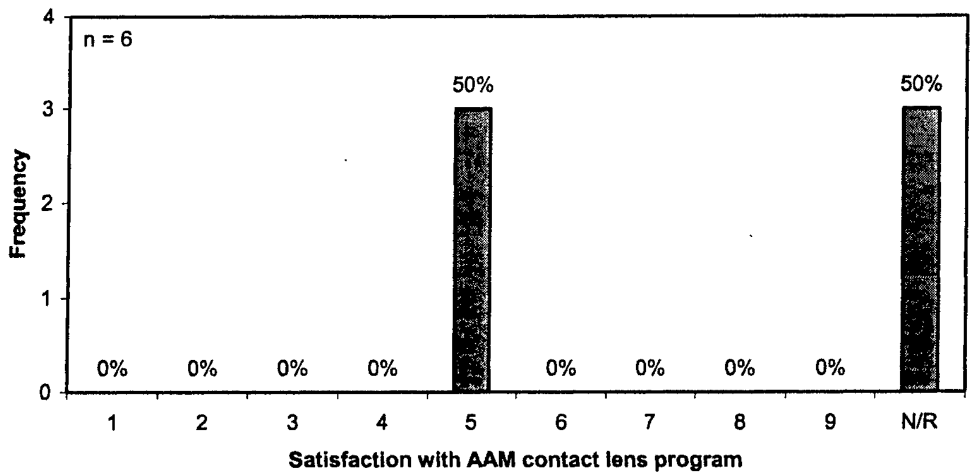
m. If you use contact lenses during flight, have difficulties with the lenses caused you to:

	Yes	No	N/R
Reschedule or cancel flights	0(0%)	5(83%)	1(17%)
Deviate from flight plan	0(0%)	5(83%)	1(17%)
Hand over controls in flight	0(0%)	5(83%)	1(17%)
Remove lens in flight	0(0%)	5(83%)	1(17%)
Use eye drops in flight	0(0%)	5(83%)	1(1%)

n. If this is your first year wearing lenses, please evaluate the training that you have received in the following aspects:

	Application	Removal
Ineffective	0(0%)	0(0%)
Poor	0(0%)	0(0%)
Fair	0(0%)	0(0%)
Good	2(33%)	2(33%)
Excellent	0(0%)	0(0%)
N/R	4(67%)	4(67%)

o. Overall, how would you rate the Army Aviation Medicine support of the contact lens programme (1-9)______
1 = Ineffective
5 = Fair
9 = Excellent



p. Finally, please comment on how the support for AH MK 1 pilots who use contact lenses could be improved:

- The army should pay for them.

Appendix G.

The Edinburgh Handedness Inventory.

NAME:______________________________(Surname, First, MI)

DATE:______________________________ (YYMMDD)

Please indicate your preferences in the use of hands in the following activities by putting a "+" in the appropriate column. Where the preference is so strong that you would never try to use the other hand unless absolutely forced to, put "++". If in any case you are really indifferent, put "+" in both columns.

Some of the activities require both hands. In these cases, the part of the task, or object, for which hand preference is wanted, is indicated in brackets.

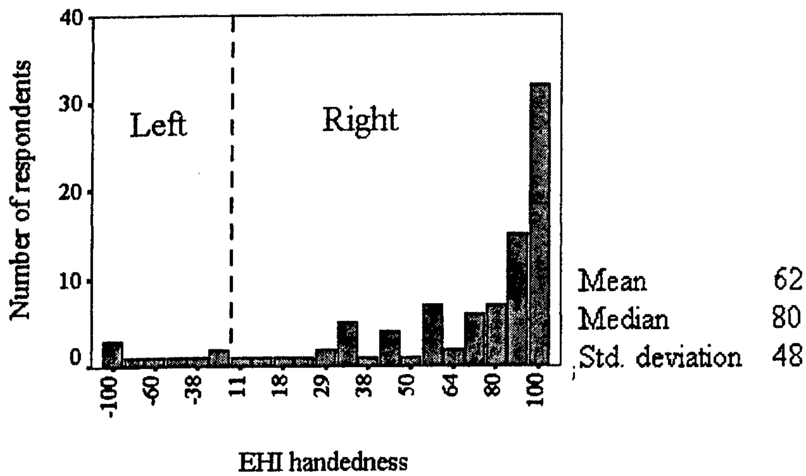
Please try to answer all the questions, and only leave a blank if you have no experience at all with the object or task.

Number of respondents   Control ___95___   Exposed ___13___

TASK OR OBJECT	Control Left	Control Right	Control Either	Exposed Left	Exposed Right	Exposed Either
1. Writing	11 (12%)	83 (87%)	1 (1%)	3 (23%)	10 (77%)	0 (0%)
2. Drawing	11 (12%)	84 (88%)	0 (0%)	3 (23%)	10 (77%)	0 (0%)
3. Throwing	5 (5%)	87 (92%)	3 (3%)	3 (23%)	10 (77%)	0 (0%)
4. Scissors	3 (3%)	80 (84%)	12 (13%)	2 (15%)	11 (85%)	0 (0%)
5. Toothbrush	10 (11%)	73 (77%)	12 (13%)	1 (8%)	10 (77%)	1 (8%)
6. Knife (without fork)	9 (10%)	82 (86%)	4 (4%)	2 (15%)	9 (69%)	2 (15%)
7. Spoon	10 (11%)	73 (77%)	12 (13%)	0 (0%)	11 (85%)	2 (15%)
8. Broom (upper hand)	12 (13%)	63 (66%)	20 (21%)	3 (23%)	7 (54%)	3 (23%)
9. Striking match (match hand)	11 (12%)	70 (74%)	14 (15%)	2 (15%)	10 (77%)	1 (8%)
10. Opening box (lid)	13 (14%)	42 (44%)	39 (41%)	2 (15%)	7 (54%)	4 (31%)
EHI=[(#R - #L) / (#R + #L)] X 100	See following table for EHI scores			See following table for EHI scores		

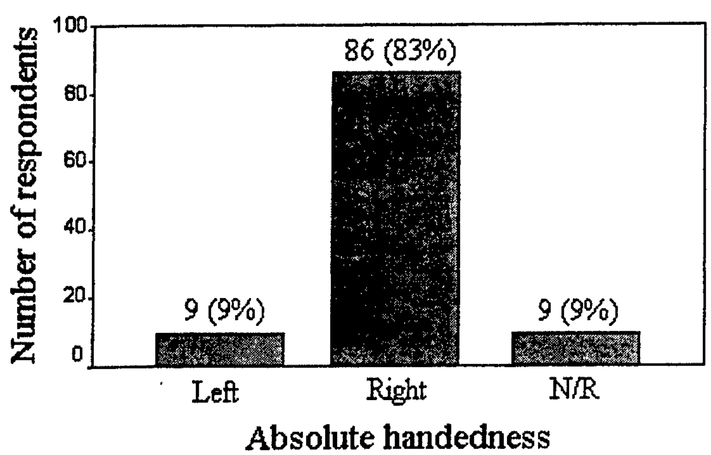
Control:

Relative scores:



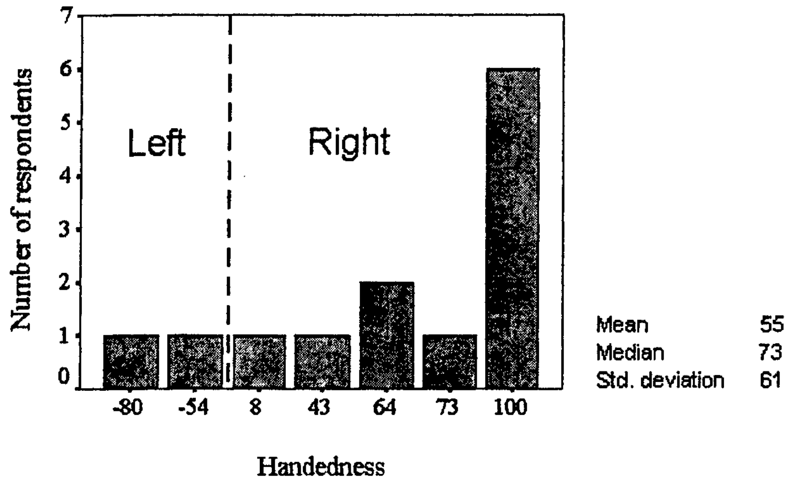
EHI number	-100	-60	-38	11	18	29	38	50	64	80	100
Number of respondents	3	1	1	1	1	2	1	1	2	7	32

Absolute scores:



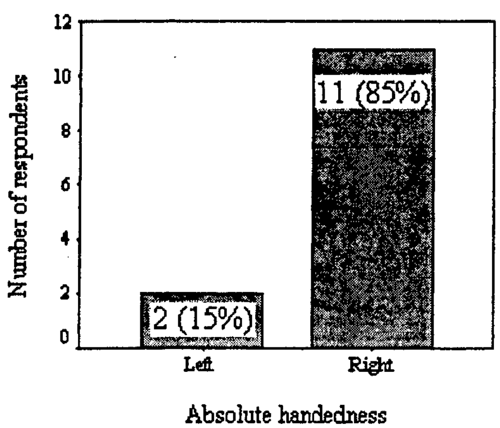
Exposed:

Relative scores:



EHI number	-80	-54	8	43	64	73	100
Number of respondents	1	1	1	1	2	1	6

Absolute scores:



Appendix H.

List of acronyms.

ACRONYM	DEFINITION
AAC	Army Air Corps
ANVIS	Aviator's Night Vision Imaging System
CA	Consultant Advisor
CFS	Corrective Flying Spectacles
CHS	Centre for Human Sciences
CRT	cathode ray tube
CS	contrast sensitivity
DAAvn	Director of Army Aviation
DERA	Defence Evaluation and Research Agency
EHI	Edinburgh Handedness Inventory
FOV	field-of-view
HDU	helmet display unit
HMD	helmet-mounted display
IHADSS	Integrated Helmet and Display Sighting System
MAR	minimum angle resolved
NVG	night vision goggles
PNVS	Pilot's Night Vision System
QHI	Qualified Helicopter Instructor
SAM	Specialist in Aviation Medicine
SCL	soft contact lens
SD	spatial disorientation
SLCT	small letter contrast test

TADS	Target Acquisition and Designation System
USAARL	United States Army Aeromedical Research Laboratory
USXO	United States Army exchange officer