Original Article

Aeromedical evaluation protocol in low backache (LBA) and cervicalgia in 41 aircrew (1996 - 1998)

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A total of 32 non-ejection cases of cervicalgia, low backache (LBA), asymptomatic and traumatic spinal disorders were assessed aeromedically at IAM, IAF by the authors between 1996 and 1998. Nine post-ejection cases who continued to be symptomatic/positive on protocol investigations beyond a period of two years were also included in the study sample. The test protocol followed by authors in the evaluation of these cases is presented and analysed in the light of the available literature. The clinical and investigative correlates of the series of cases are discussed. The subgroup of helicopter pilots is focussed. The need for use of CT scan, vibration exposure and psychometric assessment in doubtful and borderline cases of spinal disorders is emphazised.

Keywords: Aircrew evaluation, spinal disorders, flying fitness

Various aviation stresses are known to be detrimental to the spinal hygiene. Non-specific low backache (LBA) in helicopter aircrew is a well-documented phenomenon [1,2,3]. Delahaye has reviewed the incidence of LBA as between 21% to 95% in different air forces of the world. Studies carried out in the IAF have also shown a high incidence [4]. A survey of helicopter pilots in UK by Sheared in 1996 has shown that the symptoms of non-specific LBA are the commonest (72%), followed by pain in the mid-back (42%), shoulders (19%) and across the buttocks in 12% cases [5]. A variety of causes, such as poor posture, in-flight vibrations, poor ergonomics of controls, poor seat, use of back-pack survival packs etc. have been implicated. Crew of certain helicopters (e.g. Chetak in the IAF) have been found to have more tendency to develop LBA [1,4]. LBA in helicopter pilots may present clinically as follows:

a) A small population that suffers chronic pains similar to idiopathic LBA.

b) A large population that experiences pain during and immediately after flight only.

Spondylolysis and spondylolisthesis have been reported to be commoner amongst helicopter pilots by Froom et al and are considered a bar to flying in view of poor tolerance to crash forces [6].

Cervicalgia and disorders of the cervical spine

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are uncommon in helicopter crew but have been reported in fighter aircrew exposed to high G environment. Neck movements required for in-flight scanning (e.g. 'Check 6' position) have precipitated the onset of pain. Varied degrees of soft tissue damage, including damage to the intervertebral discs (IVD) have been found [8].

Epidemiologically, LBA and cervicalgia have shown an increase and it is estimated that >60% of industrial work force suffers from LBA at least once in their work career [9]. It accounted for 60% of all occupational diseases in industries in a study in Japan [9] and for 49.3% of absenteeism from work in a survey done in Poland [10]. One year incidence and prevalence rate of LBA in working population in New Jersey, has been found to be 5.6 and 6.3% respectively and resulted in 10.5% of annual loss of wages paid [11]. Higher incidence of LBA has also been reported in tractor, truck and bus drivers, and similar aetiological factors as in helicopter aircrew with LBA have been implicated [1].

Epidemiological cohort studies in work-related low back pain have shown that both acute and cumulative exposures should be assessed as risk factors for low back pain [12]. Smoking also correlates positively with LBA [13]. The incidence of LBA amongst industrial workers has been reported to be high in cold meteorological conditions [14]. Obesity has been implicated in the aetiology of LBA and often forms a vicious cycle in which the patient with LBA fails to exercise and puts on weight and with increased weight, the antigravity load on the spine increases to cause more LBA. In a recent study including a random sample of 5,887 men and 7,018 females, no such association has been found for the males; however, incidence of LBA was found to be higher in overweight women with large waists [15].

Mcfarlane has brought out that short-term spinal stress influences may be more important in the occurrence of new episodes rather than cumulative lifetime exposure and has emphasised that avoidance of short-term exposures may prevent the morbidity due to LBA [16]. Aircrew, also need to be medically evaluated on the basis of these principles. This may warrant change of flying environment of the aircrew to a different aircraft/stream despite the well-known need to conserve the trained aircrew in their specialised types of aircraft.

Psychological aspects of LBA have gained importance in view of the ambiguity of symptoms and clinical profile. Psychosomatic aetiology of LBA has been found to be significant in industrial workers who are dissatisfied with their work and social status. On the contrary, anxiety, depression and minor personality changes have been shown to occur in chronic cases of LBA. Specialised questionnaires for LBA, taking into consideration various psycho-ergonomic correlates of LBA, have been developed. There is also a lack of acceptance of this psychological component of LBA in general and medical community leading to further misery to patients [17, 18].

Assessment of spinal disabilities in relation to flying has always posed a challenge to the aeromedical community due to their wide variety in spectrum of symptoms and their possible anatomical locations. Clinical and functional tests have shown large variability and hence significant false positivity and false negativity in the occupational disposal of such cases.

Gupta et al reviewed all the spinal cases evaluated at IAM in the period 1969-1979. The study sample included 52 cases of spinal disorders referred to IAM. Ejection related vertebral fractures formed 59.6% of cases. 13 cases of scoliosis and 3 cases of spina bifida were reported. There was one case each of spondylolisthesis, hemi-vertebra and sacralisation and 2 cases of cervical spondylosis [19]. Significant standardisation has been achieved world over in determining ejection fitness criteria for fighter aircrew. However, non-specific spinal pain disorders still need a fresh look in light of the above mentioned significant research findings of the recent past.

With the advent of CT scan and MRI techniques, diagnosis and aeromedical disposal of the hitherto nonspecific cases of LBA have been facilitated due to more specific and sensitive delineation of soft tissue damage. However, all over the world, these techniques are also raising their share of issues and controversies such as the following:

a) There are no studies to correlate the degrees of various changes observed in CT Scan/MRI and the acceptable abnormalities for flying duties.

b) High inter-observer and intra-observer errors have been noted in the interpretation of the results, especially in MRI. In a MRI study of 149 working men, it was found that 32% of asymptomatic subjects had spinal abnormalities whereas 47% of all the subjects who had definitely experienced LBA were reported to have normal spines [20].

Biodynamic assessment of the cases of LBA has also been used as an indicator of the severity of the disease. At IAM, similar studies have also been carried out [21]. However, there are no tangible results which can be used as guidelines to determine fitness for flying. Our experience at IAM has not shown biodynamic testing as a reliable tool of assessment for the following reasons:

a) The biodynamic test protocols are dissimilar to the aircrew ergonomic environment.

b) Biodynamic testing serves as a tool to assess rehabilitative progress in a subacute or post-acute setting in the cases of LBA when used on a day to day basis in conjunction with physiotherapy. The results are not contributory when evaluation is done at prolonged periods at 3 to 6 months interval. Nonetheless, biodynamic testing of the back gives sufficient clue to the mobility status of the back.

Electromyography has been attempted as a tool of assessment of non-specific spinal symptoms [22, 23]. EMG response of the erector spinae muscle to sudden loading of the spine was tested and the reaction time was reduced after rehabilitation in 45% of cases [23]. Our experience at IAM with Fast Fourier Transform analysis of EMG of erector spinae muscles did not reveal it as a reliable tool in periodic assessment of LBA/cervicalgia cases. Moreover, a large number of physiological variables, sophistication of data acquisition techniques required and large individual variations interfered with dependability of the data acquired. Moreover, results achieved, when weighed against the above mentioned difficulties, revealed EMG to be of limited use as a predictor of flying fitness [24].

This paper presents the findings of the study of 41 aircrew with LBA and cervicalgia who were evaluated at IAM, with the following aims:

a) To highlight the clinical and investigative correlates.

b) To present the protocol for assessment of LBA/cervicalgia; bringing out the strengths and weaknesses of the tools of evaluation.

Material and method

32 aircrew with non-ejection spinal disorders who had presented with non-specific low backache (LBA) and neck pain were evaluated aeromedically

by the authors at the Human Engineering Department of IAM during 1996-'98. Nine post-ejection cases, who continued to be symptomatic for prolonged period for unexplained reasons, were also included in the evaluation protocol.

A standardised protocol for the assessment of LBA and cervicalgia was laid down. The protocol is shown briefly in figures 1 and 2. The evaluation was preceded by thorough clinical examination of the pilot with special reference to the spine. Measurement of the static range of spinal movements was done on the special platforms devised at IAM [21]. In otherwise asymptomatic and clinically normal pilots, spinal tolerance to stretch and shock was assessed clinically by the 'Jump', 'Jog' and 'Squat' tests.

The pilots were subjected to simulated vibrations in accordance with the advocated protocol [25]. Clinical examination was repeated at the end of the run or on reporting of symptoms. Static spinal range of motion was evaluated after the run. The cases, which were positive on the first run, were given another run on the subsequent day at about 75% of acceleration amplitude. Vibration run was repeated in every case that was positive on previous assessment at IAM. Cases of cervicalgia were assessed while wearing suitable helmet-mask assembly and for higher frequency levels.

Simulated G exposure was given to all the fighter stream cases in the Human Centrifuge at IAM, IAF. The centrifuge trials were usually spread over 2 days; the first day being used for centrifuge familiarisation, determination of relaxed G tolerance and AGSM retraining and the second day for exposure with G suit to +6 Gz for 15 seconds. Elicitation of symptoms during the run and clinical evidence of spasm of the paraspinal muscles, were set as signs of positivity.

Those pilots, in whom the onset, diagnosis, progress and disposal of the spinal pain remained in doubt for whatever reasons, were subjected to the following:

a) Psychometric evaluation at AFPRC, IAM was done using the following personality testing tools:
   i. Roscharch test
   ii. Interview technique
b) CT Scan / MRI

The data so gathered was analysed for the following correlates:

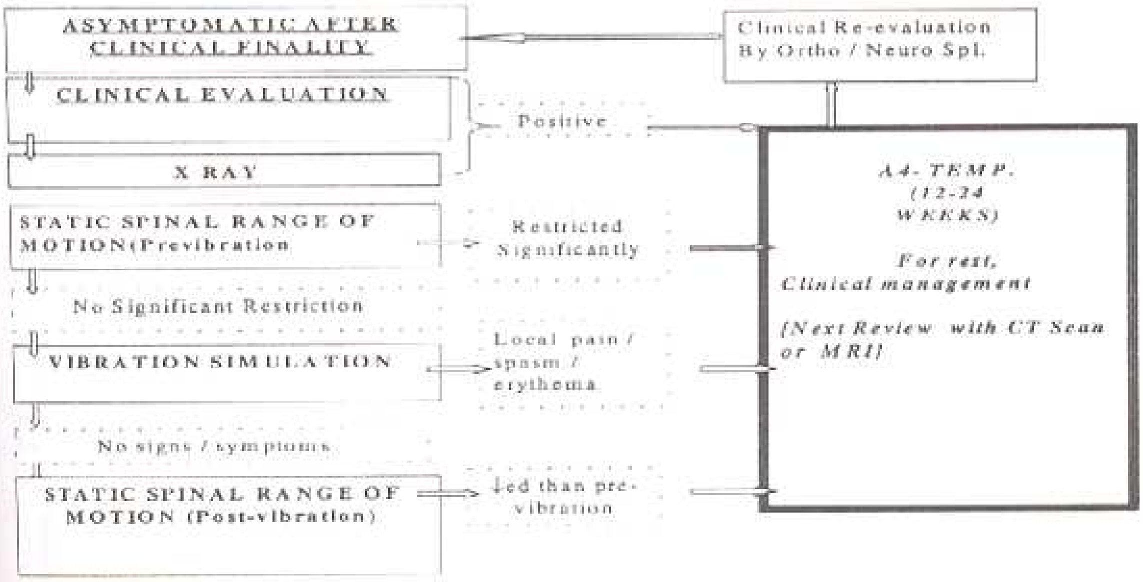
a) Aetiological distribution
b) Aircraft fleet-wise distribution with special emphasis on helicopter crew.
c) Use of investigative tools (X-Ray, CT Scan, MRI, Vibration and Psychometry).
d) Clinical correlates in helicopter aircrew.

Results

A total of 407 aircrew reported for Human Engineering evaluation at IAM, IAF. 102 cases out of these were spinal disorders (25.06%).

41 pilots in whom spinal pain was predominant were identified. All the pilots under study were males. The age distribution of the total and helicopter pilots in the sample is shown in table 1. Mean history of onset of disability was found to be 18.5 months ± 19.6 months (n=21). The range was variable. One of the cases evaluated was suffering since 1978 with ankylosing spondylitis and cervical spondylitis. One high +Gz-related case of acute lumbago and one case of LBA, were evaluated within one month of onset. History of

Figure 1: First review



First review (Contd.)

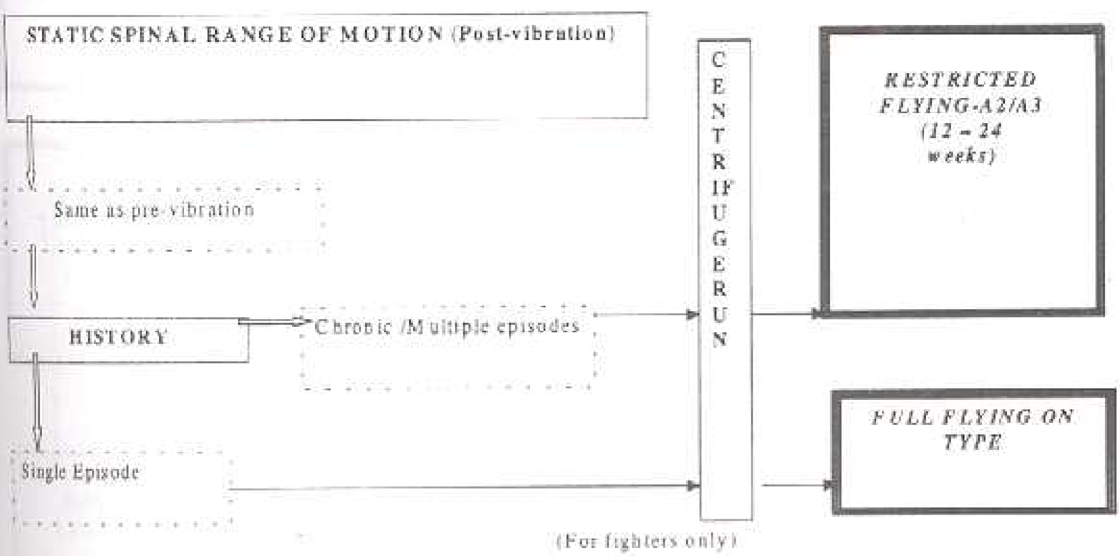
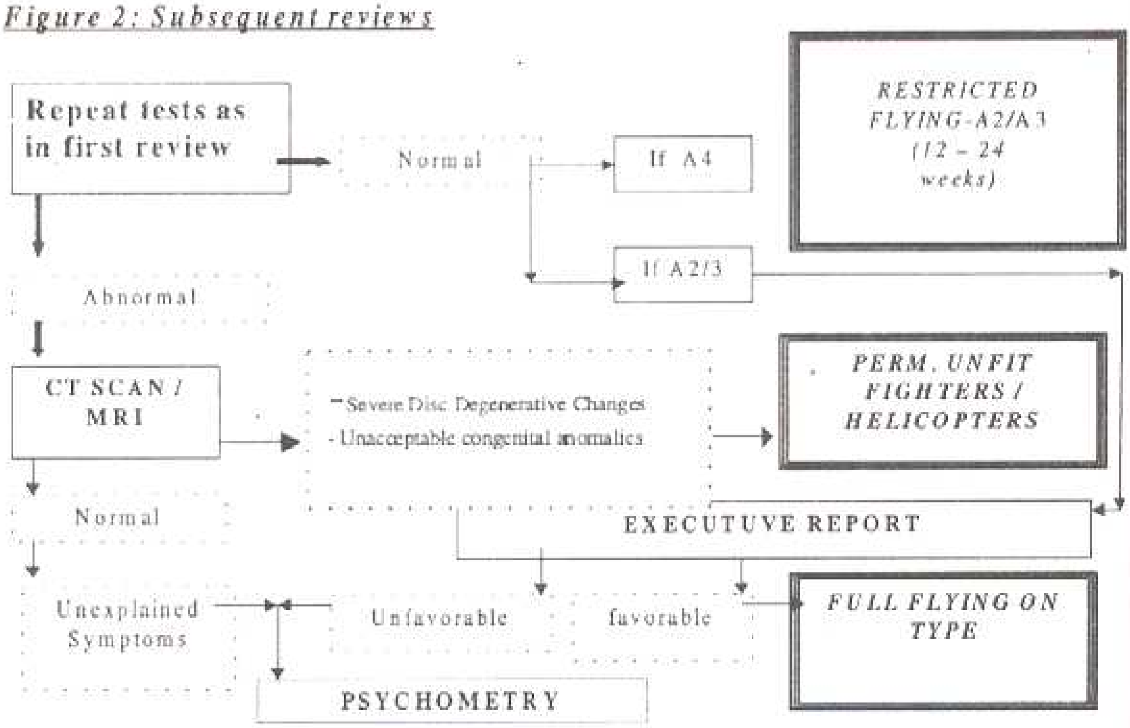
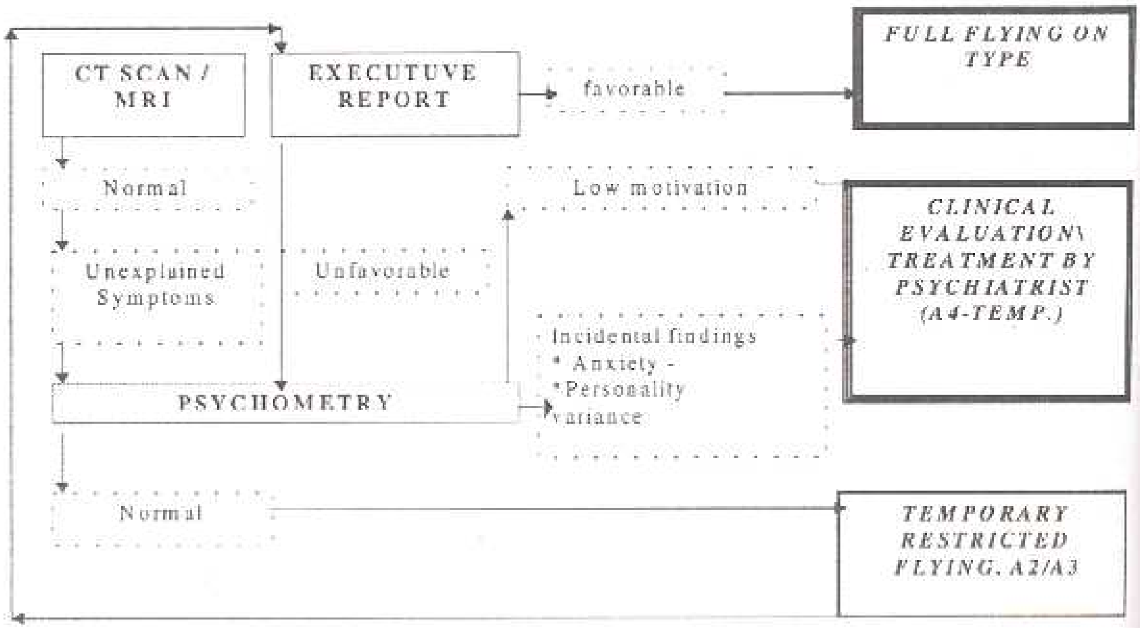


Figure 2: Subsequent reviews



SUBSEQUENT REVIEWS (Contd)



onset of symptoms in helicopter crew was found to be conspicuously ambiguous. The aircraft fleet-wise distribution of the sample cases under study; is shown in table 2. The aetiological distribution is shown in table 3.

Table 1: Age distribution

	Helicopter (n = 16)	Non-helicopter (n = 23)	Total (n = 39)
Mean	32.3	30.7	30.8
S.D.	5.7	8.0	6.9
20-30 yr (%)	20.0	62.5	48.7
30-40 yr (%)	66.6	16.7	35.9
40-50 yr (%)	13.3	20.8	15.4
Range (yr)	24.5 - 45	21 - 49	22 - 49

Table 2: Aircraft Fleet-wise distribution

Aircraft Type	Frequency of Cases (n=41)
Fighters	17 (41.5%)
Helicopters	15 (36.6%)
Tpts {F(P) / F(N) / Observers}	3
Training Aircraft	3
Gliders	1
Administrative Appointments	1
Ab Initio	2

Table 3: Aetiologic Distribution

Aetiology	Frequency of Cases (%)		
	Helicopters (n=15)	Non-helicopters	Total (n=41)
Post Ejection	NA	34.6	24.4
High G Stress	NA	11.5	7.3
Idiopathic/unknown*	73.3	30.8	46.3
Traumatic**	26.7	15.4	19.5
Congential Anomalies	-	One Case	One Case

* Includes helicopter flying stress as aetiology, cases of spondylolysis and spondylolisthesis of unknown aetiology and cases of spondylosis of old age.

** Includes trivial trauma like lifting of weights / prolonged bus journey and RTA.

Table 4: Diagnostic distribution: Lumbo-sacral disorders

Diagnosis	Frequency of Cases (%)		
	Helicopters (n = 15)	Non-helicopters (n = 26)	Total (n = 41)
LBA	46.7	31.3	39.0
Ac Lumbago	–	One case	One case
Lumbar Spondylosis	One case	–	One case
Sacro-ileitis	One case	–	4.9
PIVD: Optd.	–	11.5	7.3
PIVD: Not optd.	26.7	7.5	17.1
Spondylolysis/ Spondylolisthesis	Two case	One case	7.3
Vertebral #	–	23.1	14.6
Congenital Anomalies	–	3.8	7.3
Cervicalgia	One case	15.4	9.8
Cervical Spondylosis	One case	One case	4.9
Ankylosing Spondylytis	One case	–	One case

* Total > 100% as 11 cases had multiple diagnosis.

Table 5: Use of investigative tools: Total and Helicopter aircrew

Investigative Tools	% Cases Investigated		Contributory in % Cases	
	Total (n = 41)	Helicopters (n = 15)	Total (n = 41)	Helicopters (n = 14)
Vibration	80.5	93.3	21.2	21.4
Centrifuge	21.3	NA	33.3	NA
Spinal static range of motion	97.6	100	12.5	20
CT Scan	31.7	33.3	46.1	60
MRI	9.7	13.3	100	100
Psychometry	39.0	40	12.5	33.3

Table 6: Aeromedical disposal: Helicopter and Fighter Aircrwew

	Fit for type flying (%)	Converted to transports (%)	Grounded (%)
Helicopter aircrew	26.7	66.7	6.7
Fighter aircrew	33.3	50	16.7

Table 4 shows the various diagnoses of the cases under study. Table 5 shows the use of investigative protocols in all the aircrew and in helicopter pilots along with the percentage positivity (frequency of being significantly contributory in the evaluation). Table 6 shows the final disposal recommended to the fighter and the helicopter aircrew.

Discussion

The study sample of spinal pain disorders has been found to have a relatively low mean age. The commonest age group in the helicopter aircrew was 30-40 yr. It is possible that the data is biased towards younger age group because the younger aged pilots carry out most of the flying task and at higher ages, administrative appointments may be the reason for lesser-reported incidence of LBA. This sample represents only those cases, which sought the highest medical care and may only be the proverbial 'tip of the iceberg', of sub-clinical and mild clinical cases amongst the aircrew.

There was only one case in our series who was undergoing training and was detected to have congenital unilateral sacralisation of LV5. Stringent spinal fitness criteria followed at the time entry in to flying stream, as laid down in the relevant guidelines [26], is considered the reason for absence of any congenital disorders in our series. It is hence emphasised that these criteria must be strictly adhered to at the entry medical evaluation itself and that the present guideline on spinal fitness at entry appears to be adequate. It is however brought out that 2 cases of non-specific LBA were detected to have multiple Shmorl's nodes on CT Scan. In our considered opinion however, this finding by itself may not be a sufficient reason to recommend CT Scan of the spine at the time of entry into flying stream and the present routine X ray examination is adequate.

The incidence was the highest in fighters and helicopter aircrew and comparable to each other. Amongst the fighter aircrew, the commonest aetiological causes were ejection and high G exposure. There was one case of acute lumbago and two unusual cases of cervical fracture on exposure to high G forces. One of these cases sustained fracture of bifid spine of CV5 during neck movements in a combat sortie. Due to non-availability of fracture dating investigations, it could not be determined if the spinous process of CV5 fractured due to G forces and became bifid or under the influence of G forces, a congenitally bifid spine was fractured. It is brought out that bifid spinous process at any level except SV5 is a bar to entry for flying [26]. This pilot's old X rays taken at entry, were also not available for resolving this issue. The other case was detected to have anterior compression fracture of DV5 after an episode of G LOC. Such fracture has not been reported in the available literature on the issue. Again, non-availability of fracture dating investigation failed to determine if the pilot had an undetected fracture of DV6 prior to G LOC episode or the compression fracture occurred due to whip lashing of the neck on occurrence of G LOC. The presence of dorsal vertebral fracture could not be satisfactorily explained by empirical biophysical calculations. Both the cases were recommended transport flying.

The areomedical protocol in fighter aircrew concentrated on

a) Ejection fitness determination in accordance with the laid down guidelines [26].

b) General spinal tolerance to stretching\jumping and to simulated vibratory environment.

b) Assessing spinal tolerance to sustained loading; under simulated exposure to high G forces in the Human Centrifuge.

Amongst the helicopter aircrew, Idiopathic aetiology was elicited in about 73% cases and detailed interviews with patients revealed that in all cases helicopter flying had an aetiologic role. About 46% of these pilots reported with non-specific LBA and about 27% more were diagnosed clinically as prolapsed intervertebral discs (PIVD). Thus, majority of these helicopter pilots had symptoms of nonspecific disc/soft tissue damage. The evaluation of the helicopter pilots hence hinged on the integrity of the intervertebral discs and ability to sustain vibratory forces at abnormal ergonomic postures of helicopter flying. The re-flighting of the helicopter pilots with significant disc damage, as seen on CT Scan\MRI, was done into the transport stream, as a preventive measure against further disc damage and is in accordance with the recommendations of Shahnan et al [3].

In our series of cases, the contribution of CT scan in correct disposal of the case was >45%. MRI was done in 4 cases and in each case it was contributory. X-ray findings in all these cases were non-specific and inconclusive. Commonest finding was that PIVD was missed completely on routine X-rays. Confirmation of Spondylolysis was also done with CT scan in one case. In two cases the CT scan revealed multiple Schmorl's nodes. Thus in doubtful cases, these investigations were of immense use. However, most of the CT scans were done by the patients under local arrangements by the SMOs and there was a variability in the reporting of these CT Scans. The inter-observer and intra-observer errors in these investigations being reportedly high, [20] this arrangement is considered inadequate. A standardized CT scan acquisition and reporting system at IAM must be instituted.

Tolerance of the aircrew to simulated vibrations was useful in aeromedical disposal of 21.2% of total cases and 21.4% of helicopter pilots. This nonspecific test was reported to have a positivity of > 10% of all the spinal disorders over a period of 8 years of evaluation at IAM [25] The high positivity in our series is because of pre-selection of the sample. The positivity in the post ejection fractures was lessor than in disorders involving soft tissue damage. The higher incidence of positivity in our series was because our sample excluded pure vertebral fractures and selectively included other type of soft tissue spinal disorders. The ability to tolerate vibratory forces on ground; is considered an important ingredient of the evaluation protocol.

Psychometric evaluation is being done in cases in which the symptoms were found to be in excess of those expected from the clinical and radiological findings.. Laboratory based Psychological tests are required to be read in conjuction with the executive report on flying, as sought by IAM in all such cases. In our study, a very low positivity was found on psychometry. The present system of psychological evaluation has the following problems:

a) The executive report is often sketchy and non-specific about the performance of the pilot with respect to the disability in question. It does not yield much information on the psychological factors also.

b) Available psychological test battery is inadequate and nonspecific. There is a scope for developing LBA specific testing protocol.

c) There is no reliable method to assess latent fear of flying / motivational problems.

d) Attempts can be made by a determined malingerer to feign questionnaire based psychometric tests.

e) Presence of symptoms can itself cause anxiety and other psychosomatic symptoms, making diagnosis of the cause or the effect difficult.

Specific low backache oriented psychological evaluation for the aircrew needs to be locally devised and utilized to improve specificity and sensitivity of this method of testing.

In our study, the data regarding weight correlation with LBA and correlation with smoking was not done as the aircrew was not forthcoming in the history of obesity/excessive smoking at the onset of pain. The referral case sheets also did not yield meaningful data on the issue.

For the purpose of a more objective assessment at periodic reviews at IAM, it is felt that the AMA of the aircrew should provide the following information at the time of referring the patient:

a) Aeromedical history of the pain with specific reference to flying.

b) Specific postural compromises and controls design factors involved in flying the aircraft on which aircrew is current.

c) Daily activities such as sports, two-wheeler driving, spinal exercises etc., carried out by the aircrew, as these indicate day to day spinal tolerance on ground.

d) History of smoking and obesity of the pilot.

e) Opinion on improvement\deterioration of symptoms.

f) Psychological attitudes of the pilot and motivational issues.

The notion of achieving primary symptom control through ergonomic design intervention, based on biomechanics principles, has so far not been helpful. The traditional secondary prevention strategies of rest and return to restricted work duties are seemingly suboptional. Biomechanics/ergonomic considerations may be related to the first onset of low back pain, but there is little evidence that secondary control based solely on these principles will influence the risk of recurrence or progression to chronic disability. Psychosocial influences surrounding the disability and the work organisational issues are important. Burton [27] suggests that a proactive approach to rehabilitation of LBA cases should be done by recommending, whenever possible, early return to normal rather than restricted duties as well as complementary psychosocial advice if the issue of chronic disability is to be successfully tackled. The current international consensus in assessment of nonspecific spinal pain in industrial workers is to give adequate weightage to the presence of symptoms in the given occupational setting [27]. In aeromedical evaluation protocol, these issues must form the corner stone of any flying fitness. The pilot, if found to have incompatibility to cope with anticipated spinal stresses in his day to day flying environment, should be offered a suitable change of aircraft [1]. However, in the absence of reasonable clinical and investigative evidence to that effect, early return to flying must be advised to avoid psychosocial embarrassment to the pilot in his squadron environment.

Conclusions

1. A standardised CT scan acquisition and reporting system must be instituted at IAM.

2. The ability to tolerate vibratory forces on ground is considered an important ingredient of the aeromedical spinal evaluation protocol.

3. Specific low backache oriented psychological evaluation for the aircrew needs to be locally devised and utilised to improve specificity and sensitivity of this method of testing.

4. The referral case sheets should yield meaningful information and data on the disability

5. A proactive approach to rehabilitation of LBA cases should be done by recommending, whenever possible, early return to normal rather than restricted duties as well as complementary psychoso-

cial advice if the issue of chronic disability is to be successfully tackled.

6. The current international consensus in assessment of nonspecific spinal pain in industrial workers is to give adequate weightage to the presence of symptoms in the given occupational setting and the same principle must be made use of in the aeromedical evaluation of spinal disorders.

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