

Cervicalgia under high sustained G

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Cervicalgia due to high sustained accelerations among pilots of advanced fighter jets in IAF was studied through a detailed questionnaire survey. A total of 154 incidences of cervicalgia were reported by 55 out of 82 pilots. Most pilots reported strain in their neck above 6 G. Pilots experiencing cervicalgia in MiG 29, Mirage 2000 and other fighter aircraft were found to be 63.6%, 80.76% and 54.2%, respectively. Occurrence of cervicalgia in terms of the number of hours flown was also studied. On comparing the degree of cervicalgia in three groups, the mild-type was found to predominate over moderate. However, severe cervicalgia in MiG 29 group and other aircraft group was found to be more than in Mirage 2000 group. Incidence of cervicalgia was found to be increasing with increasing flying experience, age, height and weight. In trainer flying cervicalgia occurred more in pilots in the rear seat. Cases of cervicalgia were reported during combat missions, and only 1% reported it during dual checks and low-level sorties. Cervicalgia was found to be directly related to the weight of the helmet used. Neck movements during high G were found to be the most significant cause of cervicalgia, 82% pilots gave history of upward or lateral movement of the neck while pulling G.

Keywords: Cervicalgia; High sustained G

The evolution of fighter flying has led to pulling of higher G loads. Operating in the high-G environment gives rise to G-related problems like greyout, blackout, arrhythmia's and loss of consciousness (G-LOC). Cervicalgia, though recognized as early as the 1950s [1], was unheard of till recently. Cervicalgia denotes pain in the region of neck. Today, it is the most discussed problem, other than G-LOC, among the aviators. In the recent years, several cases of severe neck problems such as slip disc, hernia-

tion of disc, fracture of cervical vertebra and spondylitis have been reported by various Air Forces of the world [2-8]. In the Indian Air Force, three pilots have lost their flying category permanently on this account. Hence, cervicalgia has assumed a lot of significance and is a matter of great concern in today's fighter flying.

The neck is the only part of the pilot's body which remains unsupported while he is sitting fully harnessed on an ejection seat. Hence, it is highly susceptible to injuries during abrupt G conditions. The cervical spine and the neck muscles have to support the weight of the head (approx. 4 kg), the helmet (1.7-2.2 kg) and oxygen mask assembly (approx. 450 g). This total weight of about 6 kg at 1 G increases manifold under high G conditions. Thus, at 8 G the neck has to bear about 48 kg of weight.

The cervical spine as such is capable of sustaining axial weights of up to 91 kg without difficulty. However, when the force is acting in directions other than the axial, its weight-bearing capabilities are reduced to less than 50%. Thus, even 42 kg of weight at 7 G may be sufficient to cause neck injury in an aviator flying in a dynamic situation. Abrupt G loading can also result in flexion, extension or compression injuries in the neck.

The incidence of cervicalgia has been reported to be between 50 and 75% in US Navy and US AF pilots of HPF aircraft. Research in India has also indicated higher incidence of cervicalgia in MiG 29 and Mirage 2000 pilots.

A detailed questionnaire survey was carried out to find out the exact incidence of cervicalgia in our pilots of HPF aircraft. Pilot's Med Form-1 was scrutinized and pilots were examined for any restrictions in their neck movements. The

highest order of confidentiality was maintained so as to obtain open and correct answers. Eighty-two pilots flying MiG 29, Mirage 2000, MiG 21, MiG 23 and Jaguar aircraft formed a part of this study. To facilitate a comparative study, the pilots were divided into three groups. Group A comprised 32 MiG 29 pilots, Group B 26 Mirage 2000 pilots and Group C 24 pilots from other fighter aircraft (MiG 21, MiG 23 and Jaguar).

The questionnaire was aimed at finding the following:

(a) The level of G at which the pilots felt strain in their necks.

(b) The percentage of pilots affected and the incidence of cervicalgia per 100 h of flying in the 3 groups.

(c) The severity of cervicalgia - mild, moderate or severe.

(d) The incidence of cervicalgia in relation to the pilot's flying experience, age, height,

Table 1. Strain at the neck and G loads

| G level | Percentage of pilots |
|--------------------------|----------------------|
| No strain at any G level | 3.6% |
| Strain at 5 G and above | 7.4% |
| Strain at 6 G and above | 28% |
| Strain at 7 G and above | 22% |
| Strain at 8 G and above | 18.3% |
| Strain at 9 G and above | 20.7% |

Table 2. Incidence of cervicalgia in various groups

| Type of aircraft | Number of pilots who have not suffered cervicalgia | Number of pilots who have reported cervicalgia | Number of incidences of cervicalgia |
|-------------------------------------|--|--|-------------------------------------|
| Group A MiG 29 n = 32 | 11 (34.4%) | 21 (63.6%) | 58 |
| Group B Mirage 2000 n = 26 | 5 (19.23%) | 21 (80.76%) | 74 |
| Group C other aircraft n = 24 | 11 (45.8%) | 13 (54.2%) | 22 |

Table 3. Cervicalgia in relation to the number of hours flown

| Type of aircraft | Incidence of cervicalgia per total number of hours flown |
|------------------------|--|
| MiG 29 | 1/118 |
| Mirage 2000 | 1/127 |
| Other fighter aircraft | 1/454 |

weight, max G and its duration, type of sortie, type of neck movement while pulling G and the type of helmet used.

The results of the above survey are discussed below.

Table 1 shows the level of G at which the pilots felt strain in their neck. It is seen that usually strain in neck was felt above 5 G. Table 2 shows the percentage of pilots affected by cervicalgia in the 3 groups. Out of the total of 82 pilots, only 55 reported having suffered cervicalgia. The table shows that the maximum number of pilots reporting cervicalgia belong to the Mirage 2000 group.

The incidence of cervicalgia in relation to the number of hours flown is shown in Table 3. The incidence of cervicalgia in other fighter groups was found to be significantly lower as compared to MiG 29 or Mirage 2000 groups.

Severity of cervicalgia in the three groups. The severity of cervicalgia was graded as mild, moderate or severe. Mild cervicalgia represents slight discomfort or stiffness of the neck not affecting his flying task, moderate being muscle catch spasm or pain in the neck not sufficient to discontinue flying, and severe cervicalgia being an acute or persistent pain in the neck resulting in discontinuation of flying. Table 4 shows that a maximum number of pilots from the Mirage 2000 group reported mild cervicalgia, whereas moderate and severe cervicalgia occurred more in MiG 29 and other aircraft groups.

Table 5 shows that the percentage of pilots reporting cervicalgia increases with the flying experience, 93% pilots with a flying experience

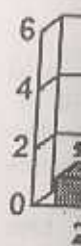


Figure 1
aircraft

of moderate or severe cervicalgia was less than 10%.

Pilot's age

The incidence of cervicalgia was studied in pilots aged 35 yr and above. The incidence of cervicalgia per pilot was higher in the 35 yr and above group.

Cervicalgia and pilot's height

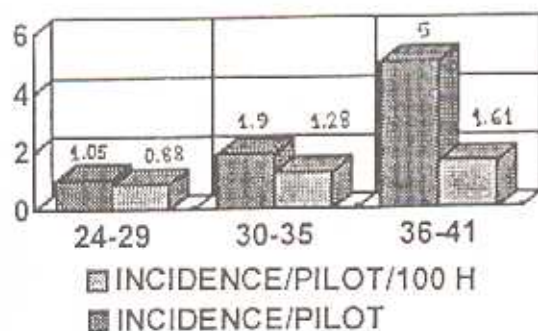
The percentage of pilots reporting cervicalgia was higher in the 181-190 cm height group, as compared to the 171-180 cm height group, as

Table 4. Severity of cervicalgia in the three groups of aircraft

| | MiG 29 | Mirage 2000 | Other aircraft |
|----------|--------|-------------|----------------|
| Mild | 43% | 67% | 41% |
| Moderate | 43% | 30% | 36% |
| Severe | 14% | 3% | 23% |

Table 5. Cervicalgia with relation to flying experience (all aircraft)

| Flying experience | Pilots reporting cervicalgia |
|-------------------|------------------------------|
| <500 h | 41.6% |
| 500-1500 h | 65% |
| >1500 h | 93.25% |

**Figure 1.** Pilot's age and incidents of cervicalgia MiG-29 aircraft

of more than 1500 h reported to have experienced cervicalgia compared to 41% who had less than 500 h of flying experience.

Pilot's age and incidence of cervicalgia. The incidence of cervicalgia per pilot per 100 h was studied in three age groups, 24-29 yr, 30-35 yr and 36-41 yr (Figure 1). In MiG 29 the incidence of cervicalgia per pilot and incidence per pilot per 100 h of flying was higher in higher age groups.

Cervicalgia with respect to pilot's height. The percentage of pilots reporting cervicalgia in height groups 160-170 cm, 171-180 cm and 181-190 cm is the maximum in the 181-190 cm group, as shown in Table 6.

Table 6. Cervicalgia with respect to pilot's height (all aircraft)

| Height in cm | Short (161-171) | Medium (171-180) | Tall (181-190) |
|--|-----------------|------------------|----------------|
| No. of pilots | 27 | 43 | 12 |
| Pilots reporting cervicalgia | 15 | 31 | 9 |
| Percentage of pilots reporting cervicalgia | 55.5% | 72% | 75% |

Table 7. Cervicalgia in relation to pilot's weight (MiG 29)

| | Weight (kg) | | |
|--|-------------|-------|-------|
| | 54-65 | 66-77 | 78-89 |
| No. of pilots | 10 | 18 | 4 |
| Pilots reporting cervicalgia | 4 | 14 | 3 |
| Percentage of pilots reporting cervicalgia | 40% | 77.7% | 75% |

Cervicalgia in relation to pilot's weight (MiG-29). The percentage of pilots reporting cervicalgia, as well as the incidence of cervicalgia per pilot, is higher in pilots in the higher-weight groups, as shown in Table 7.

Type of sortie. In all, 99% pilots reported cervicalgia during combat missions, maximum in 2vs2 and then 2vs1, 1vs1, 3vs2 & CAP in decreasing order. Only 1% pilots reported cervicalgia during dual check and low-level flying.

Trainer flying. Out of the total 154 incidences of cervicalgia reported in this study, 31 incidences took place in trainer aircraft. Out of these, 27 incidences occurred in aircrew who were not in command of the aircraft and were in the rear seat. Considering that the total hours of trainer flying are just about 20% of the total flying-hours, the above figures are very significant.

Max G and its duration. The incidence of cervicalgia was found to be directly proportional to the level of G pulled. The level of the max G pull and the percentage of pilots report-

Table 8. Incidence of cervicalgia in relation to the max G pulled

| Level of max G | Pilots reporting cervicalgia |
|----------------|------------------------------|
| 5 G | 1.3% |
| 6 G | 7.2% |
| 7 G | 23.4% |
| 8 G | 29.2% |
| 9 G | 30.5% |
| 10 G | 8.4% (by Mirage 2000 pilots) |

ing cervicalgia are shown in Table 8. In all combat sorties in which cervicalgia was reported, the duration of max G varied from 5 to 10 s.

Cervicalgia in relation to the type of head gear. Pilots of MiG 29 use ZSH 5 and ZSH 7 helmets. The weight of these helmets with HMSD (helmet-mounted sighting device) is about 2 kg. Mirage pilots use Geneoun-Genu, a helmet which weighs 1.7 kg. Jaguar pilots use RAF MK-3C, which also weighs 1.7 kg. MiG 21 and MiG 23 pilots use ZSH-3, or indigenous which weighs 1.5 kg. Out of the total incidences of cervicalgia reported by MiG 29 pilots, 70% occurred when HMSD was used. This shows that the incidence of cervicalgia is directly proportional to the weight of the helmet. Pilots preferred to fly with ZSH-7, which they found lighter and better-fitting.

Cervicalgia in relation to the type of neck movements. Forty-five out of 55 (82%) pilots who suffered cervicalgia confirmed neck movements while pulling G. The position of the head and neck adopted and the percentage of pilots reporting cervicalgia are shown in Table 9.

Conclusions

1. Cervicalgia is a significant medical problem related to fighter flying.
2. The incidence of cervicalgia is found to be directly proportional to pilot's height, weight and age. Even flying experience is no bar to cervicalgia.
3. Cervicalgia is also directly related to the weight of the helmet worn and the level of max G pulled.

Table 9. Occurrence of cervicalgia with respect to the position of head

| Position of the head | Pilots reporting cervicalgia (%) |
|--|----------------------------------|
| While looking up | 71% |
| Sideways | 20% |
| Check G | 4.5% |
| Sudden neck flexion or head falling in the lap | 4.5% |

4. In trainer flying, aircrew not in command of the aircraft are more liable to suffer cervicalgia.

5. Mainly, neck movements, particularly upwards and sideways while pulling G, result in cervicalgia.

Prevention

1. Regular physical exercises are a must to keep the muscles in good tone, which will enable them to combat G forces effectively. Exercise schedule must include specific exercises of the neck muscles.
2. Keep the neck movements to a bare minimum while pulling G. Upward and lateral movements of the head and neck must be checked completely.
3. During trainer flying, the pilot who is not in command of the aircraft should be more vigilant in practising AGSM (anti-G straining manoeuvre). AGSM will improve G tolerance and reduce the incidence of cervicalgia and G-I.O.C.
4. Lighter and better-fitting helmets are a necessity of today's modern flying.
5. A good high-flow ready pressure suit, indigenous or Russian PPK-3, should be made available to MiG 29 pilots to enhance blood supply to upper torso and neck.
6. The indoctrination course for high sustained G should be a must for all aircrew of fighter stream and should not be restricted to the pilots of MiG 29 and Mirage 2000 alone.

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