Symposium Paper

AEROMEDICAL PROBLEMS OF HIGH SPEED LOW ALTITUDE FLYING

Physiological Aspects of High Speed Low Level Flying

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HIGH speed low level flying is likely to encounter turbulent conditions lasting for long periods of time. These turbulent conditions occupy a layer of a few hundred feet above the ground. Any low altitude flight over uneven ground on a windy day is bound to meet the turbulence. This turbulence produces vibrations in flight. It would be a different matter if the body of pilot was to vibrate at the same frequency as the aircraft which he flies and the instrument panel which he operates but the actual effect on pilot depends on the damping and cushioning between him and the aircraft structure causing him to be jolted at a frequency and amplitude different from those of the aircraft and its instrument panel. Jolts applied to the outstretched arms as the pilot is adjusting control knobs may tend to cause errors in adjustment through inadvertant movements. Buffetting produces unintentioned movements leading to operation of wrong switches or knobs. Continuous gusts and vibrations impair performance of tasks requiring full concentration by aircrew. The entire episode of vibrations can be simulated by a violent bout of shivering.

Flight through turbulent air subjects an aircraft to acceleration causing deviation from equilibrium in pitch, yaw and roll and to resonance between the rigid and elastic components of airframe. In actual flight conditions, it is difficult to dissociate the effects of turbulence from those of associated factors like heat, noise and visual fatigue as a consequence of concentrated look out for obstacles and other aircraft in the vicinity. All these factors join together to decrease aircrew efficiency and an increase in fatigue producing difficulty in reading maps and instrument panel. Fatigue may be mental which primarily fo- lows intense concentration and anxiety for the contro- lability and safety of aircraft. Muscular fatigue is th result of constant struggle by the pilot during flight t maintain the desired flight path and his complete ir ability to relax. He has to hold on to the contro column while the bumps cause him to be jolted in re lation to it. Physiological effects of mechanica vibrations fall in 2 categories.

(a) Changes due to the differential vibrator movement causing deformation of body struc tures. These changes depend on the frequenc and are related to mechanical resonance of bod structures.

(b) Generalised response to vibrations as a non specific stress. These changes are related mor to the intensity of vibrations and duration c exposure than to the frequency.

Mechanical vibrations are not always harmfu or unpleasant. At low sonic frequencies, they ar used in physical medicine and have been tried as means of inducing labour. They have also bee used in massage and rejuvenation in the 'Kaya Kalp techniques. The basis of all these therapies is thei tonic effect on circulation.

Let us first consider the changes brought abou by differential vibratory movements. The commones observed effect is on vision which shows a marke deterioration. At certain frequencies, eyes an some of their musculature start resonating on thei own producing a blurred image of the target. Aura

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acuity is not affected nor are the higher mental functions barring those produced by the acute discomfort. Reaction time increases specially at low frequencies and large amplitudes, again as a consequence of fatigue. Tracking performance gets impaired and there is an increase of muscle tremor as a result of an increase in electromyographic activity. This increased activity is particularly marked in postural muscles and is observed during the few minutes after the vibration has ceased. Speech which is a special form of coordinated postural activity can be seriously disturbed by heavy vibrations and jolting of the body producing difficulty in communication by aircrew in flight. Modulation of flow of air through respiratory passages and vibratory deformation of organs of speech further disturb this function. This disturbance is worst during the whole body vibration at frequencies between 3 and 15 Hz.

Human body, as a mechanical system, represents a complex spring mass system whose mechanical response to an identical mechanical stimulus and the resultant energy transmission is fairly consistent in all individuals. This mechanical response consists of a relative displacement of different tissue complexes with respect to each other. This displacement affects different receptors and the degree of this displacement determines the discomfort or pain experienced by the individuals. Whole body vibrations at frequencies below 1 Hz are preceived primarily by the vestibular system. Above this frequency, the vestibular sensation is augmented by stimulation of mechanoreceptors throughout the body including those in muscles, tendons and joints as well as those in viscera and skin. At about 15 Hz, skin is the chief organ of vibration sensibility. It is principally the Pacinian Corpuscles distributed widely in the body which are sensors of mechanical vibrations. Pain may appear in the abdominal region presumably as a result of stretching of ileum, caecum and hepatic flexure of large intestine and their supporting mesentery. Heart may vibrate at some frequencies on the diaphragmatic pericardium thus mechanically stimulating it. Major vessels and their supporting structures may vibrate or get stretched. Diaphragm may itself be displaced at its anterior attachments. These displacements and stretching may produce pain. Stretching of spermatic cord may produce testicular pain. Cyclic motion of thoraco-abdominal viscera may on the other hand produce dyspnoea. The most commonly experienced feeling is of general discomfort—a feeling of falling apart of muscles and joints. All these factors produce anxiety which may be the likely cause of hyperventilation—a prominent feature of vibration. Whole body vibration per se produces an increase in pulmonary ventilation. At a given frequency, the pulmonary ventilation is directly proportional to the amplitude of vibrations. Higher the amplitude greater the tidal volume and hence greater the hyperventilation. There is also an increase in metabolic oxygen uptake which is probably the result of an increase in muscular work required to maintain a normal posture in the face of violent shaking produced by vibrations. Individuals have to exert an extreme effort in flexing their skeletal and abdominal muscles to control themselves. This degree of exercise over a short period of time may explain, at least partly, the hyperventilation of vibrations. Other factors responsible for hyperventilation may be the fluctuation of respiratory flow at the end of each phase of respiratory cycle or the oscillations in gastric and oesophageal pressures and of abdominal contents in and out of the thoracic cage thus rapidly driving the gas in and out of the lungs. Whatever the factors responsible, there is a definite hyperventilation followed by hypocapnia.

In the cardiovascular system vibrations produce changes in pulse rate and blood pressure. These changes may be brought about by the vibration of heart and the major vessels or they may be non-specific, generally resembling the responses associated with alarm or moderate exercise. Pulse rate rises and so do the arterial pressure and cardiac output. Systolic pressure rises while the diastolic pressure remains unchanged thus increasing the pulse pressure. Whole body vibrations at moderate intensities also induce regional peripheral vaso-constriction.

Fluctuations have also been observed in the cellular and molecular composition of blood in response to an intense low frequency vibration. Eosinophil count falls and Neutrophil count rises. Increase in plasma glutamic oxalacetic transaminase levels also has been observed in monkeys during vibrations. These changes, however, are believed to be a non-specific response to stress. Certain metabolic and endocrinological effects also have been observed. Respiratory changes indicating increased metabolism have already been referred to earlier. Prolonged and intense low frequency vibrations have been reported to lead to a loss of weight in rats and mice. Continuous whole body vibrations may also produce cessation of oestrous cycle and life shortening in rats. All these changes again could fall under the general heading "Non Specific Response to Stress".

Whole body vibrations can alter the level of arousal in different ways depending upon the physical nature of stimulus. Low frequency steady state oscillations of 1 to 2 Hz can be soporofic in man. Baby rocking and the relaxation experienced in the rocking chair are the examples. Rand vibrations as experienced in low level high sp flying, however, tend to increase the arou Sinusoidal vibrations at frequencies between 0.1 t Hz can induce motion sickness. There may slight giddiness which persists for about a min after the cessation of vibrations. These effects possibly the result of stimulation of vestibular org which are the primary organs that perceive vibrati below 1 Hz frequency.