because of cerebal hypoxia and consequent changes in neuronal function and neurotransmitters. The decrement depends upon the severity and duration of hypoxia [1, 2, 3].

Noise affects communication, damages the sense of hearing and induces fatigue. Sound pressure levels in different aircraft ranges from 90db (A) to 122db (A). The effects of noise on performance depend upon the level of noise and level of of exposure. The reports of noise on performance are conflicting, varying from decrement, no effects or impairment in performance [4, 5].

Vibration is inherent in all forms of aviation. Vibration generated during helicopter flying, low level high speed flying and flight operations during turbulent weather may impose problems ranging from mechanical interference to physical disturbance which may eventually manifest as psychophyiological effects. Vertical vibration in the frequency range of 8-10 Hz maximally affects the human body interfering with the comfort, physical well being and performance of an aircrew. It has been demonstrated that different stress may produce specific patterns of reaction through quite different reactions. The interactive effects of these stresses when combined could be quite diverse ranging from 'no effects' to additive, synergistic and antagonistic type of interaction [1-6].

The General non-specific pattern of neuroendocrine reactions during exposure to combination of stresses appears to be dominated by increased sympathetic adrenal medullary and pituitary adrenal cortical activity. In most stressful situations both can occur, although with different latencies and duration of effect [7-12].

The present study has been designed to evaluate the combined effect of simulated environmental stresses of varying level of hypoxia with fixed levels of noise and vibr[...] neuroendocrine reaction and psycholog[...] performance. The laboratory data so gen[...] be used to extrapolate the neuroendocrine [...] and performance impairment as they [...] actual flight condition.

Material and methods

Simulation of hypoxia, Noise & Vibration:

Hypoxia was simulated by using gas [...] Gas mixtures with O_2 concentrations of [...] 14.4% and 11.2% provided equivalent [...] condition simulating altitudes of 8000, [...] 19000 ft respectively.

White noise at 85 db(A) was [...] using specially manufactured white [...] generators.

An electrohydraulic vibration simula[...] used to generate vibration in the frequency [...] of 8-10 Hz with amplitude of $1 m/s^2$ (0.1g[...]

Psychomotor performance was assessed by using three computerized validated tasks:

Perceptual speed test : This test [...] a persons ability to perceive complex detail [...] as possible. In this test subject is presented [...] 150 pairs of figures, set in two columns co[...] of certain numericals, punctuation's like co[...] semicolon, question mark, signs like $ or % [...] The subject has to check the visual input c[...] and quickly so as to arrive at a decision [...] the time limit of four minutes. The subjects [...] exhibit a higher score on percentage correct [...] total attempted and percentage of total att[...] will have good perceptual speed and obser[...] capacities.

Visual vigilance test : This test measures parameters like attention, psychomotor coordination, and vigilance and short term memory. In this test subject is presented with number of rings without much space in between. Each ring has an opening at a certain position. The rings are scattered in random order all over the screen. Hundred rings in ten rows are presented in each frame at a time. One target ring is presented on the side of the frame. The subject has to move the cursor onto the rings similar to the target rings and enter it by pressing space bar. The subject covers as many rings as possible within the prescribed test period of 300 seconds. Performance was assessed on the basis of the following parameters.

$$\text{Productivity 1} = \frac{\text{Total rings done}}{\text{Total time in seconds}}$$

Productivity 2 = Average reaction time (reciprocal of Productivity 1)

$$\text{Positive quality index} = \frac{\text{Total number of correct}}{\text{Max possible correct}}$$

$$\text{Negative quality index} = \frac{\text{Total number of wrong}}{\text{Max possible wrong}}$$

c) **Discrimination reaction time :**

This test checks reaction time to a complex visual in the form of two coloured boxes which appears on the screen at random interval and sequence. The response on positive probe is to one particular colour only. The subject has to identify the right probe and press any key as quickly as possible as and when it appears. The discrimination reaction time of the subject for that particular trial which is the time elapsed between the presentation of the stimulus probe and completion of the test is recorded.

3. Experimental protocol:

The study was conducted in a laboratory located at an altitude of 963m AMSL with temperature ranging from 24-27°C. The subjects were exposed to all the three stages of hypoxia, noise of 85 db(A) and vibration 1m/sec^2 in 8-10 Hz, all in combination. All subjects practiced, on all three PC based performance tasks, till they reached pateau of the learning curve, before the actual experimental protocol. Each of the performance task was administered to subjects at 35 mts after the administration of combination of noise and vibration which were kept fixed but the simulated altitude was set at 8000 (n=8), 12000 (n=7) & 19000 feet (n=5) respectively.

Data generated was stored in the second computer memory. The second computer was linked to the first computer, which was placed on a platform in front of vibrating subject but isolated from vibrating platform. The second computer was required to administer the tasks, monitor the completion of one task and sequentially start the next taxk at appointed times.

The double voiding technique was used for collecting the urine sample before and after completion of experimental procedures. The exact length of time for each collection time was noted and volume was measured. For determining urinary biochemical stress variables about 100ml urine was adjusted to pH_2 with Hcl and refrigerated. The urine samples acid were analysed for catecholamine (CA), Epinephrine (E), norepinephrine (NE) vinyl mandelic. The physiological, psychological, biochemical variables at three attitude exposures were analysed by students paired and unpaired t-tests (VMA), 3-methoxy-4-hydroxy-phenyl-glycol (MHPG), and 17 Oxogenic-steriods (17OGS) by standard technique. The concentration of each analyte was multiplied by volume, divided by time and expressed as excretion rate [8, 9, 10].

Table 1 : Changes in Heart rate (HR), Systolic & diastolic blood pressure (SBP &DBP) at 8000, 12000 and 19000 ft

Parameters	Pre run (n=20)	8000 (n=8)	12000 (n=7)	19000 (n=5)
HR Beats/min	75.7 ± 4.1	79.3 ± 4.0*	82.8 ± 7.8**	95.6 ± 4.0***
SBP mm Hg	113.3 ± 3.91	113.8 ± 3.9	115.4 ± 3.69	112.8 ± 3.82
DBP mm Hg	75.7 ± 3.17	75.6 ± 2.5	76.8 ± 2.08	75.8 ± 3.82

*, **, *** P<0.01

Table II : Performance changes at 8000, 12000 & 19000 ft

Parameters	Prerun (n=20)	8000 (n=8)	12000 (n=7)	.9000 (n=5)
Split ring orientation				
Productivity I	1.04 ± 0.15	1.10 ± 0.15	0.94 ± 0.2	0.78 ± 0.06
Productivity II	0.98 ± 0.14	0.85 ± 0.23	1.10 ± 0.23	1.28 ± 0.12
+ quality index	0.98 ± 0.01	0.95 ± 0.03	0.98 ± 0.02	0.85 ± 0.07**
- quality index	0.012 ± 2.46	0.008 ± 0.06	0.02 ± 0.20	0.11 ± 0.05**
Perceptual speed test				
% attempted	94.96 ± 6.24	94.51 ± 3.3	90.75 ± 2.4	85.88 ± 11.2
% total attempted	45.93 ± 1.44	53.08 ± 8.93	48.16 ± 4.3	44.76 ± 7.6**
Discrimination reaction time				
Total correct	7.73 ± 1.44	8.86 ± 1.31	9.00 ± 1.48	8.80 ± 1.66
Reaction time	0.39 ± 0.06	0.4 ± 0.06	0.46 ± 0.01	0.51 ± 0.01

* P <0.05, ** P<0.01

Table II : Changes in Catecholomine (CA), Epinephrine (E), Norepinephrine (NE), Vinyl mandelic acid (VMA), 3-Methoxy-4-Hydroxy phenyl glycol-(MHPG) & 17 oxogenic steroids (17OGS) at 8000, 12000 and 19000 ft

Parameters	Prerun (n=20)	8000 (n=8)	12000 (n=7)	19000 (n=5)
CA (ng/min)	71.7 ± 37.2	67.6 ± 54.2	67.6 ± 38.4	224.6 ± 158.9**
E (ng/min)	32.1 ± 18.7	30.4 ± 20.4	28.4 ± 15.6	75.3 ± 35.5**
NE (ng/min)	39.6 ± 21.5	37.2 ± 24.2	39.2 ± 26.6	149.2 ± 131.2**
VMA (mg/min)	3.17 ± 1.7	5.3 ± 3.4*	4.9 ± 3.9	5.1 ± 2.1*
MHPG (mg/min)	0.6 ± 0.30	1.58 ± 1.0**	0.93 ± 0.60**	1.0 ± 1.1
17-OGS (mg/min)	11.7 ± 7.3	19.9 ± 9.7**	15.2 ± 9.2	29.7 ± 13.9**

*p<0.05 ** p<0.001

Results

Table 1 depicts the changes in HR, DBP and SBP at each level of altitude. Only changes in HR were significatnt at all the three levels of altitude. Table 2 shows performance changes. There was no significant deterioration in the various performance parameters at 8000 and 12000 ft but at 19000 ft a significant decrement in the productivity I and II tests, positive quality index and negative quality index were noted.. At this altitude perceptual speed test in terms of total number of scores attempted and correct were less, so also the % of total attempted. The discrimination reaction time showed an insignificant increase. Table 3 represents biochemical changes. The changes in CA, E, NE was insignificant at 8000 and 12000 ft but was significant at 19000 ft. Changes in 17 OGS and VMA were significant at 8000 and 19000 ft but not at 12000 ft. Changes in MHPG were significant at 8000 and 12000 ft but not at 19000 ft.

Discussion

The discrimination reaction time test showed no performance decrement at 8000, 12000 & 19000 ft demonstrating that exposure to these altitude does not adversely affect colour perception and appropriate reaction time test. At 8000 ft and 12000 ft also no deterioration in any of the parameters of the split ring test was noted but at 19000 ft all parameters showed significant performance decrement indicating worsening of performance in terms of visual vigilance, attention, orientation pattern and short term memory. There was no significant deterioration in the perceptual speed test both at 8000 & 12000 ft but at 19000 ft a significant deterioration was observed. An earlier study from this laboratory has reported a singnificant performance decrement at an altitude of 12500 ft. Therefore, it appears that when an aviator is subjected to combined stresses of hypoxia (>12000 ft), noise and vibration, effects of hypoxia on performance decrement predominates, with some effect of noise and vibration which can compromise flight safety. This would mean that in helicopter "hopping sorties" at altitudes above 12000 ft there would be a progressive deterioration in observational skills and speed of decision making which could seriously jeopardize mission effectiveness [1-6].

Many different types of physical stimuli have been shown to increase the activity of sympathetic adrenal medullary and pitutary adrenal cortical activity. E in urine reflects adrenomedullary activity while NE gives a measure of the release from sympathetic nerves. VMA in the urine is an index of the rate of CA synthesis. 17-OGS excreted in the urine is a measure of change in adrenocortical activity. MHPG excreted in the urine is the functional measure of change in central nervous system activity [7-12].

In the present study, urinary levels of CA, E, NE, VMA, MHPG & 17-OGS during exposure to combined stress of noise and vibration with varying level of altitude exhibited a differential response. At 8000 ft VMA MHPG and 17-OGS increased significantly without any significant change in CA, E & NE. At 12000 ft there was a significant increase in MHPG level while others did not show any significant change. At 19000 ft CA, E, NE, VMA & 17-OGS increased significantly while changes in MHPG were insignificant. The rise noted at 19,000 ft in CA, E, NE were three times higher while 17-OGS were 2 times higher than their respective baseline value. The changes in various urinary parameters during exposure to three levels of altitude represented immediate re... onset of stress, adaptation and exhaus... respectively. These responses are compara... the "general non-specific pattern" of ne... crine reaction as propounded by "Selye"...

The role of CA's in the perform... different types of tasks has been ela... researched. "Frankenhaeuser" research ... that those subjects whose CA levels rea... to baseline (rapid decreasers) are psycho... better adjusted and perform more effic... achievement situations than those whos... return slowly to baseline (slow decreasers... study at 8000 and 12000-ft levels of CA... rapidly returned to baseline without any si... performance decrement. At 19000 ft howe... exposure levels of CA, E, NE were thr... higher than their respective baseline va... were associated with significant perfo... decrement. It has been shown that hi... excretion may be detrimental to perform... complex task requiring selective attentio... may be explained in terms of association b... CA levels and drive. The high drive interfer... the choice between competing respons... could possibly account for performance dec... at higher altitude of 19000 ft. The resul... present study are thus consistent wi... observation of 'Frankenhaeuser" & her co-w... [8-12].

It has been reported that MHPG me... excreted in the urine of humans arose from c... CA metabolism and was not a prod... concurrent biochemical changes taking i... MHPG levels increased significantly in s... performing difficult and complicated task in... number of complex perceptual-motor skil... precise spatial orientation. MHPG also in... significantly during examination in confide... successful subjects than the group with disc... and lack of confidence. In this study M... changes were found to commensurate ...

performance changes. At 8000 and 12000 ft MHPG levels increased significantly without any significant decrement in performance whereas at 19000 ft MHPG did not show any significant change while there was a significant deterioration in performance. MHPG is a measure of change in central nervous system activity and related with intensity of concentration, attention and alertness to perform the task. Insignificant change in MHPG at 19000 ft indicated that cerebal central nervous system activity gets adversely affected during exposure to higher level of hypoxia with a consequent change in neuronal function leading to functional impairment of mental performance [8].

It can thus be concluded that CA and its metabolite can form a valuable method to asses the performance changes in relation to changes in central nervous system activity during exposure to combined environmental stress of hypoxia, noise and vibration.

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