Original Article

Effect of Chronic Low Level Low Frequency Vibration on Tracking and Visual Vigilance

MK Vyawahare, B Aravindakshan

Nine male volunteers were subjected to low level vibration for 2 1/2 hours in the frequency range 3-21 Hz, to see the effects of continuous vibration exposure on Tracking and Visual Vigilance Tasks. The level of vibration was kept above that obtained in AN-32 and HS-748 M aircraft at frequencies below 21 Hz. Computerised tasks of Object Tracking and Visual Vigilance were presented to subjects at 1/2 hour intervals on a 14" colour monitor, which was kept at a distance of 75 cm from the eye level. The duration of the task was 2-3 minutes. Performance of subjects with and without vibration stress was determined at each 1/2 hour interval starting from 0 min and evaluated in terms of time taken per trial and accuracy on the task.

Performance on these tasks was not affected adversely by continuous vibration of low intensity. On the otherhand, Visual Vigilance Task showed slight improvement under vibration. If the visual tasks are not continuous and rest period available in between, continuous low frequency vibration at levels advocated by ISO 2631's FDP boundary may not affect the visual performance.

Key words : Vibration Stress, Visual Performance.

Introduction

Vibration is one of the most fundamental stresses of an operator's environment[1]. To aviators it presents problems due to mechanical interference and physical disturbance. In transport planes, helicopters and surveillance planes, chronic low level vibrations are invariably present. Vibrations reaching the aircrew has a broad spectrum in respect of frequency and energy content[2]. However, primary whole body human response to vertical vibration is confined to frequencies below 80 Hz[3]. Effects of intense vibration on visual performance is well established[4]. However, the effect of vibration on performance as a function of time is not well understood yet. Similarly, effect of chronic low level vibration, when mechanical interference is not predominant, is expected to give fatigue induced effects on performance. This paper presents our findings on the changes on Tracking and Visual Vigilance Task performance on exposure to 2 1/2 hours of continuous vibration at levels higher than those available in IAF's transport aircraft as well as those advocated by ISO 2631[5].

Material & Methods

An electrohydraulic vibration simulator available at IAM was used in the study. The level of vibration was kept above those obtained in AN-32 and HS-748 M aircraft at frequencies below 21 Hz. Vibration frequency and intensity were sensed by an accelerometer fitted on to the platform of the vibrator.

An Object Tracking and a Visual Vigilance Tasks were presented to the subjects with the help of a Video Display Unit (VDU) of a PC/XT. The VDU was placed at a distance of 75 cm from the subject's eye level.

Nine male volunteers from the Institute staff (age : 30 ± 4.4 years, height 172.9 ± 4.8, weight : 65.6 ± 5.0 kg) were the subjects in this study. All the subjects had Snellen's acuity of 20/20 or more in both eyes. One subject used spectacle for visual correction. Most of them had previous exposure to vibration in the simulator and those who were not exposed to vibration earlier were given familiarisation runs. All the subjects were given sufficient practice on the tasks to get an almost error free performance.

Object Tracking Task : The VDU screen was divided into 4 quadrants and both X & Y axes were graduated in units of 5. An elliptical boundary was drawn within the rectangular screen and graduated in degrees, the total angle being 360 degrees. Different geometrical objects viz., Triangle, Square, Parallelogram or Circle

* Scientist D and Head, Department of Applied Physics and Biodynamics; ** Senior Scientific Assistant, Institute of Aerospace Medicine, Vimanapura, Bangalore - 560 017

were made to appear in a group of 3 or 4 in the region surrounded by the axes and periphery of the ellipse.

The task consisted of two parts. The first part was to specify the quadrant, number of objects and the object that had appeared in a colour different from the rest. To indicate the different coloured object, subject pressed T, S, P or C for triangle, square, parallelogram or circle respectively. The pattern of objects remained on the screen for 500 ms. The second part was to locate the co-ordinates of the centre of the different coloured object. For this, the same pattern appeared once again on the screen and remained there till the co-ordindates were specified. With the help of cursor movement keys of the computer key board, subject had to bring "+" marked cursor on to the centre of the different coloured object and enter X, Y & Theta values. Immediately after that another set of objects appeared and the test continued. The duration of the trial was 100 sec.

2, 3 & 5 points were given for specifying correctly the quadrant number, number of objects and different coloured object, respectively. 5 points each were assigned for correctly locating X, Y & Theta co-ordinates. 4 points were awarded for subject response lying within ± 4 units and ± 4^{o} of correct X, Y, and Theta co-ordinates.

Visual Vigilance Task : It consisted of generating five or six alphabets on the monitor screen in any one of the four quadrants. A particular letter was chosen, which appeared on the top of the screen. Depending on whether or not the chosen letter appeared on the set displayed, subject had to press Y or N for 'yes' or 'no' answer. If the chosen alphabet was surrounded by an alphabet, subject reacted by pressing Y, otherwise by N. Once the subject had reacted for both the requirements, another set appeared. Display time for each set was 500 ms and in one trial subject was required to complete 20 sets. For each set 10 points were assigned. 5 for correctly responding for the desired letter and 5 for identifying whether or not the desired letter was surrounded by the same alphabet.

Visual Performance without Vibration : Subjects reported for experiment at around 1000 hrs in the morning after having a good overnight sleep and morning breakfast. Two practice trials were given before the actual test was administered. After that, the subject performed on the Object Tracking task for a duration of 100 sec. This time was referred to as 0 min. Similarly, the subject performed the tasks at 30, 60, 90, 120 & 150 min. After each trial, the print out of the score was taken. During the intervals between two trials, subject was kept busy on computer games.

Visual performance with vibration : From ISO 2631, it is seen that the Fatigue Decreased Proficiency boundary for 2 1/2 hrs continuous vertical whole body vibration exposure in the frequency range 4-8 Hz is 0.071 g rms. Therefore, vertical vibration at 7 Hz and 0.075 g rms was administered and visual task presented (0 min performance with vibration). Vibration exposure was continued on cessation of the tasks and frequency of vibration varied between 3 & 21 Hz in a random fashion. Before the start of the next trial, vibration frequency and intensity were again set to 7 Hz and 0.075 g rms. Subject's performance on the task was again determined at 30, 60, 90, 120 & 150 min. On completion of 150 min vibration, vibration was shut off and subject allowed to recover for 15 min. At the end of 15 min recovery, subject once again performed on the visual tasks. This phase was referred to as performance after 'recovery'.

From the performance data, time taken per trial & correct score percentage with and without vibration were determined for each interval. Performanace without vibration (WOV) at 0 min was compared with performance at 30, 60, 90, 120 & 150 min Similary, performance with vibration (WV) at 0 min was compared with performance at each 1/2 hr interval and that after recovery was compared with performance without vibration at 0 min. Performance without vibration was also compared with performance with vibration at corresponding periods.

Result

Tables I gives the average time/task and correct score percentage of Object Tracking

TABLE I : Object Tracking Task

Trial Status		Experimental phase (in minutes)						
		0	30	60	90	120	150	Recovery
Time/Task in sec								
Without	Mean	30.45	29.95	28.84	28.77	29.33	29.68	—
Vibration	± SD	7.33	6.16	6.94	6.05	7.96	7.97	—
(WOV)	* MD	—	0.50	-1.61	-1.69	-1.12	-0.77	—
	t	—	0.54	2.83	1.85	1.52	0.85	—
	p	—	NS	<0.05	NS	NS	NS	—
With	Mean	30.29	28.19	28.71	28.44	27.18	27.40	27.50
Vibration	± SD	7.22	5.89	6.87	6.01	5.88	7.97	—
(WV)	@ MD	—	-2.10	-1.57	-1.84	-3.11	-2.89	—
	t	—	1.70	2.01	1.97	2.29	4.85	—
	p	—	NS	NS	NS	NS	<0.01	NS
	#MD	-0.16	-1.76	0.13	-0.32	-2.15	-2.28	-2.95 +
	t	-0.10	1.45	0.08	0.21	1.42	1.24	-2.08
	p	NS	NS	NS	NS	NS	NS	NS
Correct score percentage								
Without	Mean	96.96	96.18	96.19	96.82	97.58	94.82	—
Vibration	± SD	4.63	4.38	7.25	3.40	2.92	5.76	—
(WOV)	* MD	—	-0.78	0.77	-0.14	-0.62	-2.14	—
	t	—	0.31	-0.27	0.08	0.63	2.00	—
	p	—	NS	NS	NS	NS	NS	—
With	Mean	96.59	95.14	98.00	95.46	97.04	93.52	94.16
Vibration	± SD	4.86	5.84	4.00	4.16	2.99	8.82	2.93
(WV)	@ MD	—	-1.45	1.41	-1.14	0.44	-3.07	—
	t	—	0.49	0.57	0.55	0.21	0.97	—
	p	—	NS	NS	NS	NS	NS	NS
	#MD	0.00	-0.02	0.01	-0.02	-0.04	-0.03	0.00 +
	t	0.25	2.62	2.23	0.73	2.43	1.36	0.18
	p	NS	<0.05	NS	NS	<0.05	NS	NS

Task at 0 th min and at every half hour interval for a period of 2 1/2 hours with and without vibration.

Under static condition, time/task decreased from 30.45 sec at the beginning of the experiment to 29.68 sec at 150 min. At the 60 min, the rate was significantly better than that at the starting. However, thereafter decrease in time was not significant. With vibration, speed at 150 th min was significantly better than the onset speed. However, speed with vibration and without vibration at corresponding times did not differ statistically. Correct score percentages were unaffected by time and vibration stress.

Table II gives the average performance on Visual Vigilance Task in terms of time/task and correct score percentage. Speed at 120 min was significantly lower under static condition whereas, it was better with vibration at the 30 min as well as 120 min. Under vibration exposure too, time did not affect the correct score percentage.

Discussion

Performance of subject WOV on computerised Object Tracking as well as Visual Vigilance Tasks in terms of time/task showed a slight significance at the 60 th and 120 th min marks respectively. Object Tracking task showed a slight betterment whereas Vigilance task showed a slight increase.

With vibration exposure, object tracking showed betterment in terms of time taken. This may be due to the fact that vibration at the initial stage or at 1st exposure gives rise to maximum discomfort and with passage of time, one gets accustomed to it. However, on comparison, with

TABLE II : Visual Vigilance Task

Trial Status		Experimental phase (in minutes)						
		0	30	60	90	120	150	Recovery
Time/Task in sec								
Without	Mean	1.48	1.49	1.49	1.50	1.51	1.50	--
Vibration	± SD	0.10	0.10	0.10	0.12	0.11	0.10	--
(WOV)	* MD	—	0.01	0.01	0.02	0.03	0.03	--
	t	—	1.65	2.23	1.50	2.95	1.23	--
	p	—	NS	NS	NS	<0.02	NS	--
With	Mean	1.47	1.47	1.48	1.48	1.47	1.47	1.48
Vibration	± SD	0.08	0.09	0.11	0.08	0.09	0.09	0.09
(WV)	@ MD	—	0.01	0.00	0.00	0.00	0.00	--
	t	—	0.58	0.31	0.21	0.35	0.00	--
	p	—	NS	NS	NS	NS	NS	--
	#MD	0.00	-0.02	-0.01	-0.02	-0.04	-0.03	0.00 +
	t	0.25	2.62	2.23	0.73	2.43	1.36	0.18
	p	NS	<0.05	NS	NS	NS	NS	NS
Correct Score Percentage								
Without	Mean	98.06	97.50	98.06	98.61	97.78	98.06	--
Vibration	± SD	2.08	25.50	3.49	1.32	3.17	2.08	--
(WOV)	* MD	—	-0.56	0.00	0.56	-0.28	0.00	--
	t	—	0.45	0.00	0.80	0.29	0.00	--
	p	—	NS	NS	NS	NS	NS	--
With	Mean	97.50	99.17	98.06	97.22	99.17	98.89	98.06
Vibration	± SD	2.17	1.77	2.08	3.17	1.25	1.82	2.73
(W V)	@ MD	—	1.67	0.56	0.28	1.67	1.39	--
	t	—	2.31	0.55	0.29	1.79	1.12	--
	p	—	NS	NS	NS	NS	—	
	#MD	-0.16	1.76	0.18	0.32	-2.15	-2.28	-2.95 +
	t	0.10	1.45	0.08	0.21	1.42	1.24	-2.08
	p	NS	NS	NS	NS	NS	NS	NS

* Mean differences with WOV 0 min. values
@ Mean differences with WV 0 min. values
# Mean differences between corresponding periods of WOV and WV
+ Mean difference between 'recovery' and WOV 0 min.value

the corresponding periods with and without vibration, no significant change in object tracking speed is observed. In terms of accuracy no difference is seen with and without vibration. Some decrement in the mean value is observed with time, without and with vibration. Some decrement in the mean value on correct score is observed with time, with and without vibration i.e., 96.96% at the 0 min to 94.82% at 150 min and 96.59% at 0 th min to 93.52% at the 150 min. However, the changes are statistically insignificant.

In the vigilance task, time/task with vibration was better at the 30 and 120 min mark. Though, a quicker response was indicated at these two stages accuracy of response remained unchanged. Thus, it was observed that performance of subjects, who were well trained in visual tasks, had not been affected even in the worst vibration situation avilable in our transport aircraft. On the contrary, some improvement in performance was noticed.

A number of different sensory and motor performance of an operator may be affected by vibration[6]. Wilkinson & Gray[7] exposed subjects to 5 Hz, 1.2 m/sec/sec rms amplitude for 3 hrs and found that tracking performance for zero order tracking tasks improved as compared to static condition, although changes were statistically insignificant. This is in exact conformity with our

findings. Guignard[8] studied subjects on tracking and search for periods between 16 min to 8 hrs at vibration of 2, 4 and 8 Hz at appropriate ISO FDP boundary for each period of exposure and found no significant effects of vibration on performance on any one of the tasks within the exposure period.

Studies that are carried out to investigate vibration response on reaction time, have demonstrated that reaction time is relatively unaffected by vibration[9,10]. Allen[11] indicated that for casual exposures, any performance decrement due to vibration does not get worse with time. Vibration effects are restricted primarily to onset and resonance, atleast for a period of upto 3 Hrs[12]. In our study too, only onset effect of vibration was visible but overall reaction time improved somewhat at some stages whereas accuracy remained unaffected.

From our study and other studies mentioned above, there does not seem to be any evidence to support the notion that visual performance deteriorates during exposure to low level vibration.

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