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Auditory evoked responses in tropical men during sojourn over the arctic region

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Abstract The influence of an arctic environment on auditory evoked responses, both brainstem and cognitive, were evaluated in 10 Indian soldiers. They were first tested in Delhi and then flown to an arctic region where they were tested in the first week and again in the eighth week of their stay. Two migrants from Moscow, their usual place of residence, and six natives, born and brought up in the arctic, were also tested for comparison. The Indians, on their return to India, were tested again. The auditory evoked responses were recorded using the Nicolet (USA) Compact 4 Instrument. The Indians showed a delay in all the waves of the auditory brainstem response (ABR) during their induction in the arctic and these persisted even on their return to India whereas the migrants and the natives had relatively higher ABR latency values.

Key words Arctic environment
Auditory evoked responses · Brainstem · Cognitive

Introduction

Stress is well known to influence the spontaneous EEG (Saunders and Zubek 1967) and evoked activity of the cerebral cortex. When a tropically acclimatized man is first exposed to the alien environment of the arctic, several exogenous and endogenous environmental factors are expected to influence the neurophysiological and visceral functions. The extreme cold climate, altered solar periodicity in the form of day and night duration, anxiety, and sensory deprivation are some of the environmental factors prevailing in the arctic, which could result in stress.

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It has been well documented that cold alters peripheral nerve conduction (De Jesus et al. 1973; Lal and Anantharaman 1974) and also affects neural processing in the central nervous system (CNS). Therefore, conduction of sound from the organ of corti to the auditory cortex may also be influenced by the extreme cold of the arctic. The present study was undertaken to evaluate the influence of the arctic environment on the auditory evoked responses, both brainstem and cognitive, in tropically acclimatized men during acute induction and acclimatization in the arctic. Their responses were compared with those of natives and migrants to the arctic region.

Materials and methods

Evoked potential recordings were made on 10 Indian volunteers chosen from different regions of India; two migrants were tested after arrival at Kirovsk from Moscow, the usual place of their residence. Six natives, born and brought up at Kirovsk in the Russian arctic within the north polar circle were also tested. All the subjects were between 20 and 30 years of age. The Indian subjects were first tested at Delhi in India (29° N, 77° E), then flown to Kirovsk in the Russian arctic (70° N, 38° E), and were tested during the 1st week of arrival and again during the 8th week of their stay. They were subsequently flown back to Delhi and retested within 1 month. The migrants and natives were tested only once during their stay at Kirovsk for the purposes of comparison.

The auditory brainstem response (ABR) of both the right and left ears and the P3 component of cognitive potential (P300) were recorded using the Nicolet Compact-4 Instrument (Nicolet, USA). All the recordings were carried out in the morning hours after a light breakfast, in a dimly lit laboratory under controlled environmental conditions.

Recording of ABR

Electrodes were attached at the vertex (Cz) and the ear lobes, with the ipsilateral ear lobe serving as the earth. Monaural auditory stimuli consisting of clicks of 100 μ s square pulses were delivered through an electrically shielded earphone at the rate of 11.1/s. The intensity was 70 dB above the click hearing threshold.

The evoked electrical activity was amplified 10000 times and a band pass of 150–3000 Hz was used to filter out the low and

Table 1 Auditory brainstem response of tropical men at the arctic compared to migrants and natives. Values are mean ± SEM

	Right ear			Left ear		
	I	III	V	I	III	V
Delhi (A)	1.69 ± 0.03	3.79 ± 0.04	5.63 ± 0.05	1.69 ± 0.03	3.87 ± 0.03	5.68 ± 0.09
At arctic (1st week) (B)	1.71 ± 0.03	3.93 ± 0.08	5.64 ± 0.08	1.71 ± 0.03	3.88 ± 0.03	5.65 ± 0.08
At arctic (8th week) (C)	1.72 ± 0.04	3.88 ± 0.06*(a)	5.77 ± 0.04*(b)	1.74 ± 0.05	3.88 ± 0.03	5.75 ± 0.03
Return to Delhi (D)	1.81 ± 0.08	3.92 ± 0.09	5.78 ± 0.09	1.69 ± 0.02	3.78 ± 0.11	5.78 ± 0.05
Migrants (E)	1.85 ± 0.05*(c)	4.21 ± 0.09	5.86 ± 0.12	2.00 ± 0.06**(d)	4.11 ± 0.31	5.93 ± 0.19
Natives (F)	1.88 ± 0.11	4.19 ± 0.13	5.91 ± 0.11	1.68 ± 0.04**(e)	3.97 ± 0.05	5.99 ± 0.09*(f)

*[a] Significance C vs A $P<0.05$
[b] Significance C vs A $P<0.05$
[c] Significance E vs B $P<0.05$
**[d] Significance E vs B $P<0.01$
[e] Significance E vs F $P<0.01$
[f] Significance F vs B $P<0.05$

Table 2 Interpeak latencies of auditory brainstem response in tropical men, during stay at the arctic compared to natives and migrants. Values are mean ± SEM

	Right ear			Left ear		
	I–III	III–V	I–V	I–III	III–V	I–V
Delhi (A)	2.01 ± 0.05	1.84 ± 0.04	3.87 ± 0.06	2.19 ± 0.03	1.77 ± 0.08	3.96 ± 0.09
At arctic (1st week) (B)	2.22 ± 0.09	1.71 ± 0.05	3.93 ± 0.09	2.17 ± 0.03	1.77 ± 0.07	3.94 ± 0.09
At arctic (8th week) (C)	2.16 ± 0.05	1.90 ± 0.05	3.98 ± 0.07	2.14 ± 0.05	1.86 ± 0.05	3.99 ± 0.05
Return to Delhi (D)	2.10 ± 0.05	1.87 ± 0.05	3.97 ± 0.04	2.19 ± 0.05	1.90 ± 0.06	4.09 ± 0.06*(a)
Migrants (E)	2.36 ± 0.13	1.65 ± 0.21	4.01 ± 0.06	2.11 ± 0.37	1.82 ± 0.50	3.93 ± 0.13
Natives (F)	2.32 ± 0.16	1.72 ± 0.11	4.04 ± 0.11	2.28 ± 0.05	2.03 ± 0.08*(b)	4.31 ± 0.09*(c)

*[a] Significance D vs B $P<0.05$
[b] Significance F vs B $P<0.05$
[c] Significance F vs B $P<0.05$

high frequency electrical noise. It was averaged over 2000 click presentations for 10 ms sweep time. The averaged evoked response was displayed and printed on paper. At least two trials were obtained from each side of stimulation to ensure reproducibility of the responses. The peak latency of wave I, III and V and interpeak latency of I–III, III–V and I–V and the ratio of amplitude of V and I were analysed.

Recording of P300

The P3 component of the cognitive response of the subject was recorded using the prefixed program of the Nicolet Compact-4 system. The subject was asked to count the number of a rarely occurring stimulus ignoring frequently occurring stimuli with the eyes open and fixed at some point. The responses to the frequent stimulus and the responses to the rare stimulus were averaged. The wave form pairs were replicated and printed on paper. The different waveform latencies and amplitude were noted.

Statistical analysis of the data was performed using Student's *t*-test.

Results

ABR

The latencies of waves I, III and V and the interpeak latencies (IPL) between I–III, III–V and I–V of all the subjects recorded under different conditions are given in Tables 1 and 2. The Indian subjects showed a significant delay ($P<0.05$) in peak latency of waves III and V of the right ear on the 8th week of their induction at the arctic compared to the corresponding Delhi values. Similarly the peak latency of wave I of the right ear ABR was prolonged ($P<0.05$) in migrants compared to that of Indians during the 1st week of induction. The left ABR also showed a significant delay ($P<0.01$) in wave I latency of the migrants when compared both with the Indians on the 1st week of induction and also with the natives. Natives showed a significant delay ($P<0.05$) in wave V latency in comparison to that of Indians in the 1st week of induction.

Table 3 Ratio of amplitude of wave V and I in auditory brainstem response

	Right ear Ratio of V/I	Left ear Ratio of V/I
Delhi (A)	1.61 ± 0.31	1.28 ± 0.17
At arctic (1st week) (B)	0.87 ± 0.13	0.78 ± 0.09
At arctic (8th week) (C)	0.90 ± 0.15*(b)	0.90 ± 0.12
Return to Delhi (D)	2.00 ± 0.29*(a)	1.28 ± 0.16*(c)
Migrants (E)	1.00 ± 0.09	1.39 ± 0.53*(d)
Natives (F)	1.51 ± 0.17	2.08 ± 0.19***(e)

*[a] Significance D vs B $P<0.05$
[b] Significance D vs C $P<0.05$
[c] Significance D vs B $P<0.05$
[d] Significance E vs B $P<0.05$
***[e] Significance F vs B $P<0.001$ and F vs C $P<0.001$

Table 4 Latency and amplitude of P300 in tropical men at the arctic in comparison with migrants and natives. Values are mean ± SEM

	Latency (ms)		Amplitude (uv)	
	P2	P3	Amp-P2	Amp-P3
Delhi	169.60 ± 8.653	329.92 ± 7.639	5.64 ± 0.740	11.09 ± 1.038
At arctic (1st week)	178.24 ± 5.227	317.40 ± 9.164	7.59 ± 0.653	13.37 ± 2.053
At arctic (8th week)	164.48 ± 5.359	315.52 ± 8.940	6.26 ± 0.470	11.07 ± 1.198
Return to Delhi	160.96 ± 7.028	310.40 ± 11.120	6.72 ± 0.960	11.16 ± 1.106
Migrants	169.60 ± 12.800	363.20 ± 11.200	3.17 ± 0.440	5.81 ± 1.225
Natives	172.27 ± 3.244	316.80 ± 12.67	8.04 ± 1.303	14.29 ± 3.601

The interpeak latencies (IPL) showed a non-significant increase in the right ear ABR. However, in the left ear ABR, the IPL I–V of the Indians showed a significant prolongation when tested on their return to Delhi. In natives, IPL of I–V and III–V were longer ($P < 0.05$) than the corresponding IPL values of Indians in the first week of induction.

The ratio of amplitude of wave V/I showed a decreasing trend in the tropical men in an arctic environment as a result of a decrease in wave V amplitude and a concurrent increase in wave I amplitude (Table 3).

P300

There was no significant difference in the values of P300 of Indians and natives (Table 4).

Discussion

The tropical subjects showed a delay of all the waves I, III and V during their induction in the arctic. This became more pronounced during 8th week of their stay and persisted even on their return to India. This suggested there was a decline in sensory reception and afferent conduction, probably due to an altered sensory threshold and synaptic delay (Lowitzsch et al. 1977). The migrants as well as the natives had relatively higher ABR latency values suggesting that the arctic environment itself may be a causal factor in the decline in auditory function. The severe cold stress in the arctic probably was playing a part in this delay in two ways: firstly by influencing nerve conduction and secondly by the vasoconstrictor effect on the cerebral region, which became more prominent during the prolonged stay.

It is known that exposure to a cold environment causes a reduction in peripheral nerve conduction (De Jesus et al. 1973; Dioszeghy and Stalberg 1992). However, the effect of cold on central nerve conduction has not previously been well explored. In view of the altered solar periodicity in the arctic, disturbed biorhythms (Ray et al. 1992) as well as cold may be responsible for the observed effects. The central nerve conduction time is delayed even after reinduction to a tropical climate since the IPL I–V was delayed in the Indians when its retest value was compared with the previous Delhi value. Probably the return to its normal value took a longer time and this aspect needs to be studied further. The natives also showed a delay in the IPL of I–V. Therefore, it may be concluded that cold stress caused an appreciable permanent delay in the central nerve conduction time since IPL I–V has been considered (at least in part) as an estimate of central transmission time in the brainstem auditory pathway (Musiek and Gollegly 1985).

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References

De Jesus PV, Hausmanowa-Petrusewicz I, Barchi RL (1973) The effect of cold on nerve conduction of human slow and fast nerve fibres. Neurology 23:1182–1189
Dioszeghy P, Stalberg E (1992) Changes in motor and sensory nerve conduction parameters with temperature in normal and diseased nerve. EEG and Clin Neurophysiol 85:229–235
Geerlings AHC, Mechelse K (1985) Temperature and nerve conduction velocity. Some practical problems. Electromyogr Clin Neurophysiol 25:253–260
Lal SK, Ananthraman (1974) Conduction velocity in the fastest motor fibres of ulnar nerve. Ind J Physiol Pharmacol 18:35–37
Lowitzsch K, Hopf HC, Galland J (1977) Changes in sensory conduction velocity and refractory periods with decreasing tissue temperature in man. J Neurol 216:181–188
Musiek FM, Gollegly KM (1985) ABR in eighth nerve and low brainstem lesions. In Jacobson JT (ed) The auditory brainstem response. College Hill, San Diego, pp 181–202
Ray US, Selvamurthy W, Mukhopadhyay S, Purkayastha SS, Ilavahagan G (1993) Sleep pattern and circadian variations of some physiological functions of tropical men during sojourn in the arctic winter. In: Mohan Kumar V, Mallick HN, Nayar U (eds) Sleep-wakefulness. Wiley Eastern Limited, New Delhi, pp 113–118
Saunders MG, Zubek JP (1967) EEG changes in perceptual and sensory deprivation. EEG and Clin Neurophysiol Suppl. 25, 246–257