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Evaluation of Physical Activity on Exposure to Antarctic Environment

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Abstract

. The Antarctic environment presents extremes of meteorological elements to the members of expedition, A study was conducted to analyze the mechanisms of decreased performance of subjects in Antarctica, for which the first author participated in the Tenth Indian Scientific Expedition. Harvard step test was performed on seventeen members and their heart rate (HR), blood pressure (BP), oral temperature (T_0) and skin temperature (T_sk were determined before and after exercise. Two recordings were taken viz. basal (in the ship) and the other after 8 weeks of the Antarctic stay. A cold chamber simulation study, back at India, was conducted on rats to study the effect of cold exposure alone as the primary factor affecting the physical performance. A significant reduction in Physical Fitness Index (PFI) was observed in men after Antarctic stay. Whereas, in rats there was an improvement after cold acclimatization. The "Hypodynamia" was more marked than anticipated in men and cold exposure alone cannot be the sole contributing factor.

Introduction

Life at a polar station involves a continued and high level of physical activity. All station personnel help with domestic chores which often involve quite heavy manual labour, digging snow, carrying loads around the station, apart from attending to their assigned jobs at the station. The energy cost of performing any task in polar region is quite high because of the difficulties in working in heavy clothing and travelling in the harshest known environmental conditions which limit the physical efficiency of the worker. Although extensive studies have been conducted to evaluate the changes in body functions induced by various forms of stresses in Antarctica, most of the researchers have devoted their effort to study the state of individual function system (Budd & Warhaft, 1966; Wyndhan *et al.,* 1964; Wyndham *et al.,* 1968; Duncan, 1988; Buguet *et al.,* 1987). North American, European and Australian literatures are only now beginning to explore changes in physical performance induced by exposure to Antarctic environment. (Soroko *et al.,* 1984; Palinkas, 1987; Bodey, 1978). It appears that moderate amount of cold stress has a positive effect upon most of the individuals (Kruk *et al,* 1991, Bittel *et al,* 1988); but a severe continued exposure has a depressant effect, upsetting the normal

balance of anabolic and catabolic hormones (Herr and White, 1991). There is little study available on the impact of combined stresses such as cold, excessive ultraviolet irradiation, high geomagnetic waves and altered day-night rhythm as existing in Antarctica on human physical performance.

Therefore a study was conducted to determine environmental risk factors that lead to various alterations in the physical performance of subjects visiting Antarctica. Similarly one parallel simulated study was also conducted on Wistar rats exposed to cold temperature (4-6°C) at AIIMS laboratory in New Delhi, to determine the effect of cold alone on the physical activity of them.

Materials and Methods

The study on human subjects took place between December 1990 and February 1991 i.e., during austral summer at the Indian Antarctic station "Maitri". The ambient temperature ranged between -19° to +3°C, with wind speeds upto 60-80 kms/hr. The animal study was conducted at AIIMS laboratory in a cold chamber. The ambient temperature of the chamber was kept constant between 4-6°C, with light: dark cycle of 12:12 hrs.

The subjects were members of the Tenth Indian Antarctic Expedition. Seventeen members, all Indians, in good health who had passed a medical examination before coming to Antarctica, participated in the study. Their mean average age was 35.5 years (range 25-53 yrs), mean height 168.3 cms and mean weight 64.82 kgs. All had a similar lifestyle which consisted of taking part in the everyday domestic activities of running a polar base station as well as performing their specialized task outdoors.

A detailed history and physical examination was conducted on the ship. The number of studies performed on each subject was variable depending on their obligations, whether they winter over and their willingness to volunteer.

Measurements were made at two periods over the interval of 12 weeks in which the study was conducted. The control study (basal) was performed in the ship *MV Thuleland* in the calm seas on the way to Antarctica. The Antarctic study took place after seven to eight weeks of stay at "Maitri" station.

"test Procedure of Physical Performance in Human Subjects

The members of 1990-91 summer party were asked to perform a standard Harvard step test. All experiments were performed in the morning after the subject had a night's sleep and a standard breakfast. The subjects were comfortably clothed in woollens and relaxed in a hut for 10 minutes. The initial heart rate (HR), blood pressure (BP), oral temperature (T_0) and finger skin temperature (Tsk) were recorded. Each subject stepped up and down from a 18" platform 25 times per minutes. Each subject performed the exercise for 5 minute, unless he was exhausted

before that. After the cessation of exercise the above said parameters were repeated. The duration of exercise was recorded using a stop watch. The recovery in heart rate was counted for 30 sec, after 30 sec (1/2 min) and 1 min 30 sec (90 sec) of the cessation of exercise with a stop watch. The oral temperature was read by means of a clinical thermometer which was calibrated against a standard before expedition left India. A digital electronic thermometer was used for measuring the finger skin temperature. The systolic and diastolic blood pressures were recorded by means of mercury sphygmomanometer. Finally, the physical fitness index (PFI) of each subject was calculated according to the formula:-

$$PFI = \frac{\text{Time of stepping in sec}}{5.5 \times \text{pulse count}} \times 100$$

All measurements were made in the hut which was maintained at 3- 4°C more than the ambient temperature. All the subjects continued to perform their routine work during the period of study.

Test Procedure of Recording Physical Activity in Animals

Seven Wistar rats were taken for the study with a mean body weight of 188.7±15.19 gms. Small and large activity was monitored for one hour per day at fixed time interval (between 0930 and 1330 hrs) with the help of Coulbourn Small Animal Movement Monitor (model E61-11). Food was given *ad libitum* and after 5 days of control recording at 26±2°C, animals were exposed to 4- 6°C temperature in a cold chamber. Two days of activity monitoring was done at that temperature and then animals were left for cold acclimatization (CA) for 10 days. After 10 days the activity was again monitored for 5 days. Body weight was measured every third day.

The data obtained was analyzed by pooling and determining the mean and SE. Animal activity was analyzed by taking the percentage of basal values. Statistical analysis took into account the variable number of subjects at each observation period. The Student's 't' test was used for comparison of population of unequal size. Only subjects with complete data at each observation period were included in this analysis. A *'p'* value of <0.05 was inferred as significant.

Results

Human study

]) Effect of Antarctic exposure on basal parameters

The basal HR increased from 71.88±1.94 to 76.23±2.14 after Antarctic exposure but the increase was not significant'(Table 1; Fig 1). Whereas the systolic and diastolic BP increased significantly after 8 weeks of stay in Antarctica (Fig. 2), the

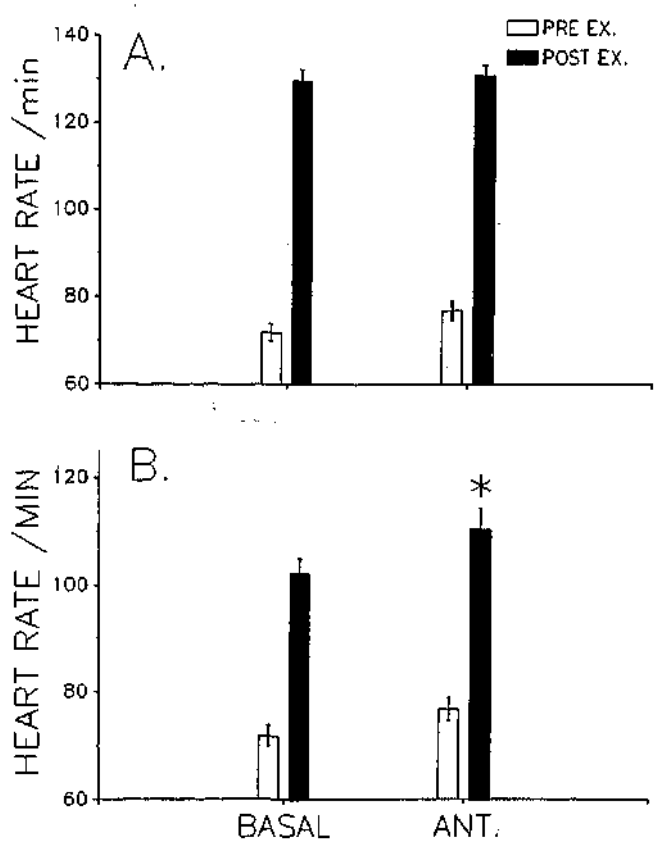

Fig. 1. Heart rate after 30 (A) and 90 secs (B) following exercise (Basal and after 8 weeks of Antarctic stay) shows a significant increase in Antarctic post exercise 90 sees value (= $p < 0.05$).*

significance of diastolic BP being more *($p<0.00l$)* than systolic BP ($p<0.005$). The oral temperature was significantly lowered in Antarctica , the mean values being 36.86±0.007°C in the pre antarctic condition and 36.27±0.16°C after Antarctic exposure (Table 1). Skin temperature also went down and the mean difference of them was highly significant (Table 1).

2) *Effect of exercise*

a) Pre Antarctic: With a standard Harvard step test, the subject's HR after 30 sec of exercise rose upto 129.65+2.68 mm of Hg and after 90 sec to 103.76±2.61 mm of Hg from the basal value of 71.88±1.94 mm of Hg whereas the systolic BP increased to 154.24±36.2 and diastolic BP decreased to 67.58+1.40 from the basal mean values of 115.88±2.0 and 76.97±1.19 mm of Hg respectively. All of these

Table 1: Cardiovascular and Temperature Responses to Exercise

Parameter (n=17)	Before exercise		After exercise	
	Pre Ant.	Ant. Exposure	Pre Ant.	Ant. Exposure
1) Fatigue time(min,)	—	—	3.19	1.94
			±0.34	±0.42
2) Physical Fitness	—	—	71.18	43.24
Index (PFi)			±6.58	±7.9
3) Heart rate/min.	71.88	76.23		
	±1.94	±2.14		
a) 30 secs recovery			129.65[2]	130.122
			±2.68	±2.33
b) 90 secs recovery			103.76	107.06
			±2.61	±3.83
4) Oral Temp.(°C)	36.86	36.27[1]	36.97	36.53[2]
	±0.007	±0.163	±0.08	±0.12
5) Skin Temp. (°C)	33.77	26.26[1]	31.04[2]	21.68[2]
	±0.18	±1.39	±0.47	±0.46
6) BP (mm Hg)				
a) Systolic	115.88	125.29[1]	154.24[2]	160.00[2]
	±2.0	±2.04	±36.2	±4.52
b) Diastolic	76.97	88.06[1]	67.58[2]	76.62[2]
	±1.19	±2.04	±1.40	±2.81

[1]Significant differences ($p<0.05$) Pre vs Post Ant. basal values.

[2]Significant differences ($p<0.05$) before vs after exercise.

changes were found highly significant (Table 1). The mean fatigue time was 3.19±0.34 and PFI was 71.18±6.58.

After exercise the oral temperature showed an insignificant rise (36.86±0.007 to 36.97±0.08°C). Whereas the skin temperature dropped significantly (31.04±0.47 from 33.77±0.18°C).

b) *Post Antarctic:* In Antarctica the subjects showed a typical "hypodynamia" with early fatigue (from 3.34±0.37 to 1.7510.46 min) and lower PFI than the Pre Antarctic value (43.24±7.9 vs 71.18±6.58) (Fig. 3). Fig. 1 shows that the post exercise increase in HR was more in Antarctica with a greater significant recovery HR of 90 secs (Fig. IB). The post exercise BP showed a typical increase of systolic BP and the decrease of diastolic BP (Fig. 2). The fall in diastolic BP was comparatively less than the pre Antarctic exercise values (76.62±2.81 vs 67.58±1.40 mm of Hg).

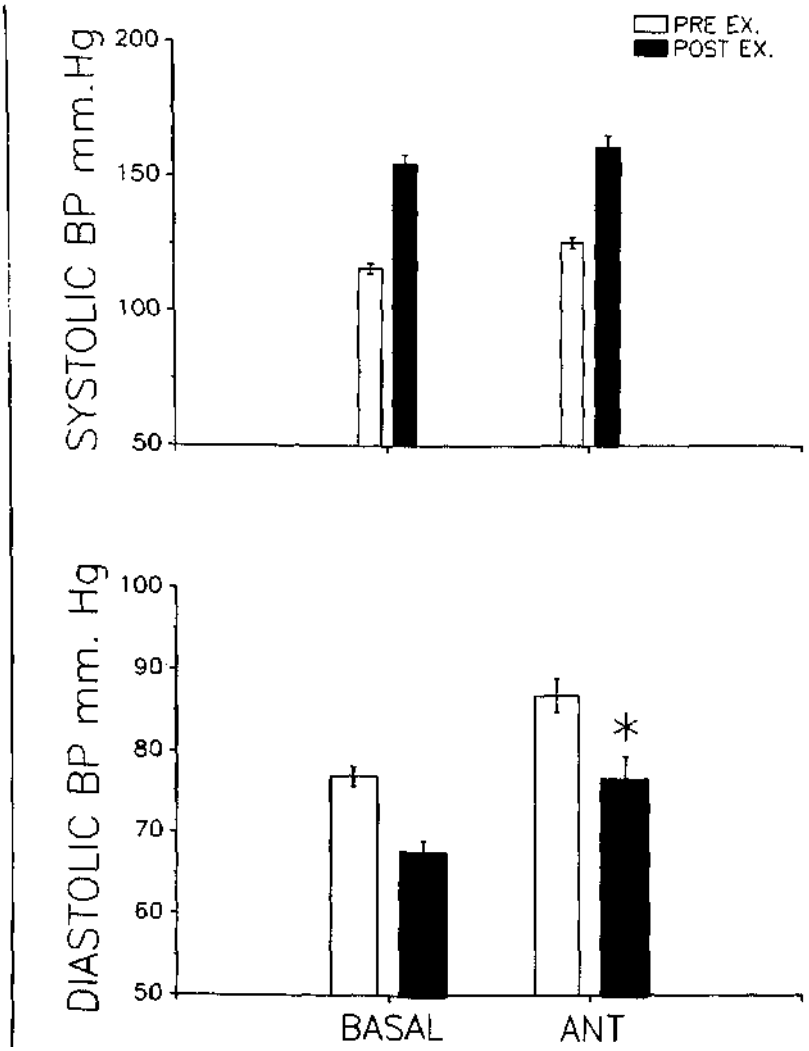

Fig.2. Systolic and diastolic BP before and after exercise under basal and Antarctic stay for 8 weeks. The figure shows a significant increase in diastolic BP in Antarctic post exercise state (= $p<0.05$).*

The oral temperature significantly increased after exercise. Also the difference of pre (36.97±0.08) and post Antarctic exercise (36.53±0.12) effect on the oral temperature was quite striking and highly significant. The skin temperature revealed a significant fall from 31.04±0.47 to 21.68+0.46 (Table 1) in the post exercise period.

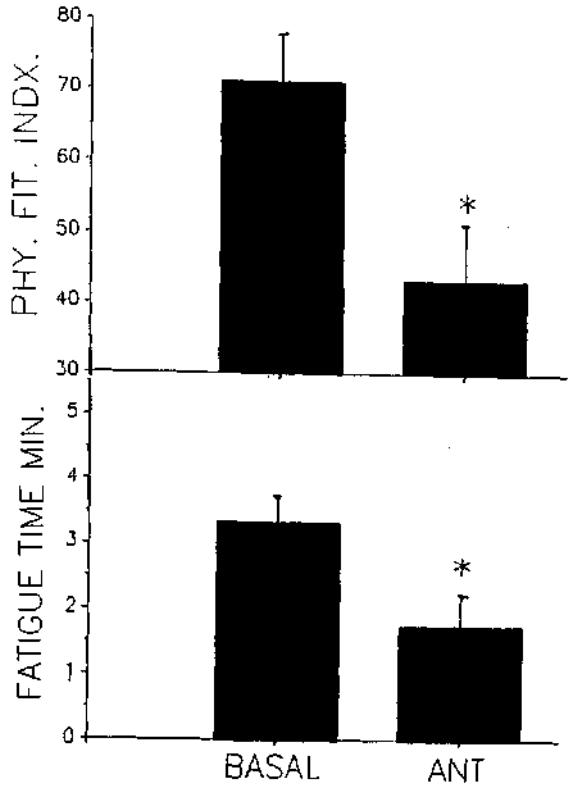

Fig.3. Physical fitness index and fatigue time, basal and after 8 weeks of Antarctic stay showing a significant reduction in Antarctica (* = p< *0.05).*

Animal Study

1) *Body weight:* After 10 days of CA there was a significant increase in the body wt ($p < 0.01$) of rats (Fig.4)

2) *Physical activity:* Basal large movements (LM) and small movements (SM) of 7 rats varied from 100 to 186.5% and 79.03 to 179% respectively at room temperature 26±2°C and showed no significant change during 5 days of recording. Acute cold exposure (CE) for two days showed decreased LM and SM. Following CA for 10 days (day 8 to 17) there was a significant progressive increase in the LM from 759.3 to 2008% ($p < 0.02$) and SM from 171.9 to 279.1% ($p > 0.001$). One day exposure to warm temperature (16°C) on the day 21 reduced both LM and SM to 1022 and 205.2% respectively. Repeat exposure to 4-6°C on the day 22 brought back both the activities to higher level of 2035% (LM) and 259.3% (SM) (Figs 5&6).

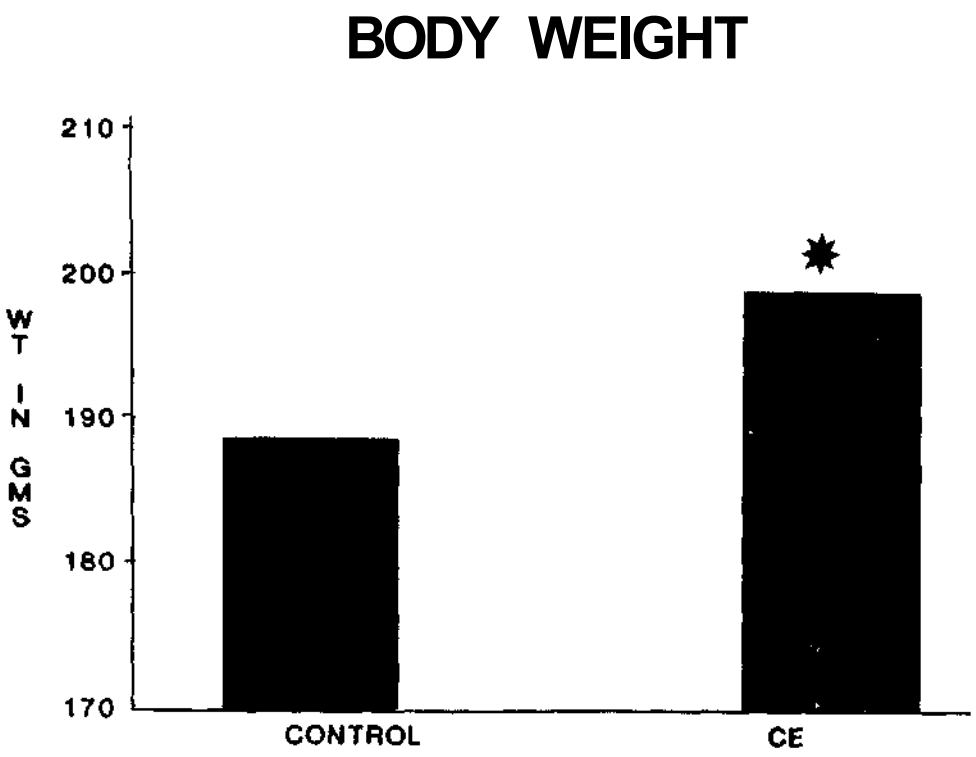

Fig.4. Body weight of the rats showing a significant increase during cold exposure (CE) after 10 days of cold acclimatization (= p <0.01).*

Discussion and Conclusion

The result of our study reveals man's ability to live and work in the intolerable conditions of Antarctica. The physiological changes demonstrated in this study indicate decreased physical performance or "hypodynamia". These findings were more marked than anticipated on the basis of effect of acute cold exposure (Soroko *et ai,* 1984; Bodey, 1978). Since the mean ambient temperature ranged from -19 to +3°C, this cold temperature is comparable to winter temperature of many places, and the decrease in physical performance due to such cold exposure has not been reported (Kruk *et* al., 1991), although lowered physical petformance has been reported in subjects having hypothermia (Herr and White, 1991; Major *et al.,* 1981 and Chin *et al,* 1991). Although the data shows that Antarctic exposed subjects displayed a lower oral and skin temperature but this cannot be designated as hypothermic state. The results of animal studies suggest that there is significant

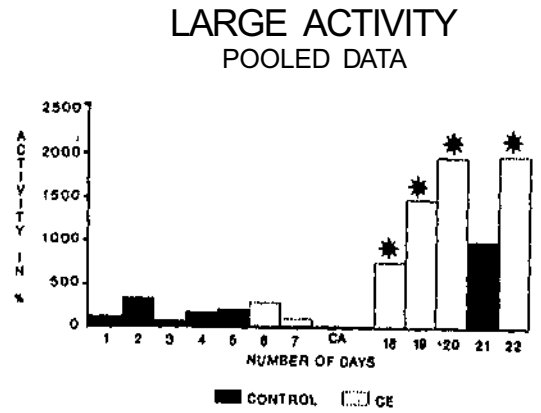

Fig.5. Large activity showing a significant increase after 10 days of cold acclimatization which was not observed during control and pre acclimatized conditions. Warm temperature exposure on day 21 sandwiched between cold exposure shows a fall in large activity (= p < 0.02).*

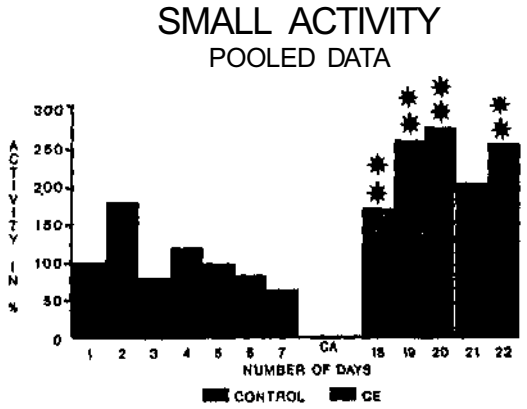

*Fig.6. Small activity showing a highly significant increase after 10 days of cold acclimatization which was not observed during control and pre acclimatized conditions. Warm temperature exposure on day 21 sandwitched between cold exposure shows a fall in small activity (**=p<0.001).*

decrease in physical activity on acute cold exposure, a logical expectation would have been higher srnall movement activity due to shivering thermogenesis after 2 days of CE. However this was not seen most probably due to hypothermia which results in generalized decrease in metabolic activity.

Another point of interest is that after cold acclimatization all the animals showed relatively significant improvement in physical activity, this is in agreement with laboratory data of Keating, 1961, Therefore we sugggest that decrease in physical

fitness of members after cold acclimatization to Antarctic cold may not be due to cold exposure.

This study thus documents unexplained "hypodynamia" in the persons who stayed for 8-10 weeks in Antarctic summer. No adverse consequences of exposure to severe cold were identified and with appropriate clothing, the activity was maintained. But the man's capacity to work less poses questions of great interest to future investigations.

Acknowledgement

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