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Effect of the environment in Antarctica on immune function and electroencephalogram*

Yu Yongzhong (于永中), Wang Zonghui (王宗惠), Zhang Wencheng (张文诚) and Wu Wen (巫雯)

Beijing Institute of Labor Hygiene and Occupational Diseases, Beijing 100020, China

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Abstract An observation on the changes of immune function (serum immunoglobulin, lymphocyte transformation) and electroencephalogram were carried out when the explorers were residing in Antarctica for a long time.

Serum IgM, IgG decreased by the end of twelve months residing in Antarctica. It were only 40%; 38% ($P < 0.01$) of the previous value before leaving for Antarctica. Serum IgA increased first and then returned to its previous value before leaving for Antarctica. When they returned back to Beijing for 2 months serum IgA was lower than that before leaving ($P < 0.05$). Lymphocyte transformation rate decreased to 45% ($P < 0.05$) of its previous level before leaving for Antarctica. The low lymphocyte transformation rate lasted for 2 months after return. But the variation of Ig level and lymphocyte transformation rate were small in the control group at different seasons. It is obviously that the significant change of Ig level and lymphocyte transformation rate of explorers residing in Antarctica is the result of special environment.

The desynchronization process on electroencephalogram (EEG) increased. The frequency and index of β-wave band increased during their stay in Antarctica. There is a close relationship between the decrease of lymphocyte transformation rate and the increase of the index and amplitude of β-band on EEG. It indicated that the decrease of immunity (especially cell mediated immunity) resulted from living under stress for a long time.

Key words Antarctica, immune function, electroencephalogram

1 · Introduction

Antarctica is the unique continent that is remote from human society with no any native permanent residents. More than 95% of its surface is covered with ice all the year round. The average thickness of the ice-cover is 2000 m, and at the thickest place the thickness is 4800 m. The climate is bitter cold. The average atmospheric temperature in a year is −25 ℃. The average speed of wind is 17～18 m/s, and the highest speed of wind is 100 m/s. Snow storms are frequent. In the areas along the sea coast, even in summer, the highest temperature is only −5～−10 ℃. There is almost no any animal or plant alive on the land originally. It is a long "all daytime" in summer and a long "all

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nighttime" in winter. The environment of Antarctica is quite clean without contamination, but Antarctica is not a suitable natural environment for human to live on. If people come here working for a long time, they will suffer from great physiological and psychological stress.

In order to investigate what are the physiological and psychological changes of people residing in Antarctica for a long time (more than one year), what effect of these changes may be caused on the health and working capacity, and how to take preventive measures on the problems of medicine and public health for the peaceful utilization of the Antarctica, an observation on changes of immune function and electroencephalogram was carried out in this study.

2 Subjects and methods

(1) Subjects were explorers of the 8th Chinese Antarctic Research Expedition working at Zhongshan Station, the base for Chinese scientists in Antarctica. The Zhongshan Station is located in 69°22′24″ S, 76°22′40″ E. The average atmospheric temperature of a year is −5℃ and the highest atmospheric temperature in summer is 0℃. The study was carried out from December 1991 to April 1993.

(2) Serum immunoglobulin (Ig), lymphocyte transformation were tested by routine methods before leaving for Antarctica, by the end of the sixth and twelfth month residing in Antarctica and two months after return. Electroencephalogram was measured before leaving for Antarctica, by the end of the third, sixth, ninth, twelfth month residing in antarctica and two months after return. Samples collected for examining microorganisms inside and outside Zhongshan Station were cultured in broth medium under 37℃.

3 Results

3.1 Serum immunoglobulin

It was found that serum IgM decreased continuously while the subjects residing in Antarctica. By the end of twelve months residing in Antarctica, it was only 40% ($P<0.01$) of the previous value before leavig for Antarctica. Serum IgG, which increased first and then decreased by the end of twelve months residing in Antarctica, decreased to only 38% of its previous value. Serum IgG returned to its normal value in 2 months after return. Serum IgA increased first and then returned to its previous value before leaving for Antarctica after six months residing in Antarctica. But when they returned back to Beijing for 2 months, serum IgA was lower than that before leaving ($P<0.05$).

In order to exclude the influence of seasonal variation, a group of control subjects staying in Beijing was also tested at the same time with the explorers. The tests were carried out before the explorers leaving for Antarctica, after their return and in between.

The results (Table 1) showed that the variation of Ig level and lymphocyte transformation rate was small in the control group at different seasons. It is obviously

that the significant change of Ig levels and lymphocyte transformation rate of explorers residing in Antarctica is the result of special environment.

Table 1. Comparison of serum immunoglobulin prior during and post residence in Antarctica between explorers and controls ($\bar{x}\pm SD$)

Immuno-globulin	Group	Before leaving for Antarctica	Reside in Antarctica		Two months after return
			6 months	12 months	
IgM	Explorers	178.0±86.3	156.0±63.4	106.0±72.9**	154.9±73.7
	Controls	125.3±64.4	114.7±44.1		
IgG	Explorers	112.7±18.3	142.9±24.1	70.2±27.4**	118.6±28.7
	Controls	114.2±32.1	99.3±27.3		
IgA	Explorers	104.5±29.7	134.9±42.9*	117.8±42.8	89.1±47.6*
	Controls	102.7±32.8	104.2±47.7		

* $P<0.05$, ** $P<0.01$; Explorers: n=21; Controls: n=20

3.2 *Lymphocyte transformation*

It is generally considered that immunoglobulins in human body are antibodies produced by plasmacyte responding to invading antigens (microorganisms, chemicals, etc.). The decrease of immunoglobulins is the result of decreased humoral immune response. The T lymphocytes with recognition receptors on the surface membrane for specific antigens while stimulated by these antigens will be differentiated into large amount of effective lymphocytes. The effective lymphocytes sensitized by meeting with the antigens again can produce multiple lymphocyte factors killing target organisms. The response of T lymphocytes stimulated by phytohemagglutinin (PHA) *in vitro* and transformed into lymphoblasts is similar to that stimulated by T cell-dependent antigens. The increased rate of T lymphocyte transformation while stimulated by PHA means that the activity of cellular immunity increased and vice versa.

The lymphocyte transformation rate of the explorers residing in Antarctica decreased significantly ($P<0.05$) to 45% of its previous level before leaving for Antarctica (Table 2). The low lymphocyte transformation rate lasted until 2 months after return.

Table 2. T lymphocyte transformation rate (%) ($\bar{x}\pm SD$)

Group	Before leaving for Antarctica	Reside in Antarctica		Two months after return
		6 months	12 months	
Explorers	66.95±11.0	47.88±23.4*	36.42±16.0*	34.76±14.7*
Controls	50.30±18.0	65.35±12.7		

* $P<0.05$; Explorers: n=20; Controls: n=20

3.3 *Electroencephalogram*

The amplitude and index of α-bands on EEG were lower compared with those prior to residing in Antarctica (Table 3), but the difference was not significant by two factors

analysis of variance.

Table 3. The change of frequency, amplitude and index of α-band in EEG prior, during and post residing in Antarctica ($\bar{x}\pm SE$)

Time	Frequency (Hz)	Amplitude (μV)	Index (%)
Before leaving for the Antarctica	10.12±0.8	32.18±11.2	69.60±24.8
Residence in Antarctica			
3 months	10.18±0.8	32.59±11.6	64.95±26.5
6 months	9.88±0.7	29.06±10.4	64.29±25.7
9 months	10.00±0.9	32.55±14.3	62.15±27.3
12 months	10.00±0.9	28.13±11.2	59.25±30.0
Two months after return	9.98±0.7	31.71±13.6	62.75±31.9

n=23

The frequency, amplitude and index of β-bands were in a tendency to increase slightly(Table 4). The increase of the index of β- bands was more significant. These indicated that the dissimilation of electric activity in higher nervous system, and stress on higher nervous system increased. These changes were recovered after return back to their original place but the degree of recovery on the index of β- bands was rather poor. The succeeded effect on explorers may be rather strong after a longer period of time staying in Antarctica.

Table 4. The change of frequency, amplitude and index of β-band in EEC prior, during and post residing in Antarctica ($\bar{x}\pm SE$)

Time	Frequency (Hz)	Amplitude (μV)	Index (%)
Before leaving for the antarctic	18.82±2.5	6.62±5.3	18.65±16.3
Residence in Antarctica			
3 months	20.50±2.3*	7.30±3.7	36.04±26.0**
6 months	20.35±2.3*	7.17±3.3	36.29±22.8**
9 months	20.35±2.2*	8.37±4.7	37.30±24.1**
12 months	20.62±1.5*	8.00±3.7	43.80±28.0**
Two months after return	19.80±1.8	7.12±2.9	30.30±23.4

Compared with the value before leaving for the Antarctica. * $P<0.05$; ** $P<0.01$; n=23

3.4 *Microorganisms in the environment in Antarctica*

It was found in the 6th Chinese Antarctic Research Expedition that immune functions of the explorers tended to decrease. In order to find out the relationship between the decreased immunity of the explorers and environmental microorganisms, a study on the microorganisms existing inside and outside the station was added to the investigation plan. The results in Table 5 showed that no microorganism could be found from the samples collected in winter (June) time outside the station when they were incubated under 37℃ in medium. Only a few microorganisms were found in summer (December) from where 100 m away from the station. Even incubated under lower tem-

Table 5. Microorganisms found at Zhongshan Station in Antarctica (CFU/m³)

Places	Month	Morning	Evening	$\overline{X}$
Bed room	June	648.69	707.67	
	Dec.	629.04	78.63	516.09
Sports room	June	117.95	235.89	
	Dec.	209.94	249.26	203.26
Power station	June	156.26	204.41	
	Dec.	141.53	94.36	149.39
Dining room	June	100.85	283.07	
	Dec.	13.37	249.26	161.63
Television room	June	65.26	293.15	
	Dec.	62.96	172.99	137.34
100 m away from	June	0	0	
the station	Dec.	26.72	40.02	16.68

perature, very few microorganisms could be found from outside of the station, but microorganisms could be found in rooms. If the density of microorganisms in the air collected from different places is arranged in a descending order, it is bed room, sports room, recreation room, dinning room, power station and television room. The microorganism density was related to the degree of people assembling in that room. The more people assembling in a room and the less air conditioning, the more microorganisms being found. According to the examination conducted by Chen *et al.* (1992) and Cheng & Song (1994), the number of atmospheric microorganisms was 0～185.2 CFU/m³, and the number of strains was 17.9 CFU/m³ on the continent of Antarctica. Microorganisms were found only in 60% of samples. Most microorganisms found in Antarctica adopted to live under 4～15℃. Most microorganisms were not present under the temperatures higher than 15℃, and no one could be found under the temperatures higher than 25℃. It is obviously that the microorganisms found in rooms were brought from the original living places where they used to live, and the microorganisms found around the residence were contaminated questionable pathogenic microorganisms (Table 6).

Table 6. Germs isolated from indoor and outdoor air of Zhongshan Station

Sampling number		Germs		
Indoor	4	Staphylococus	Xylstalphylococcus	nonpathogen
	5	.....	.....	
	7	.....	.....	
	10	Streptococcus	Streptococcus	Dubious pathogen
Outdoor	12	Bacilli		

4 Discussion

The immune function of most explorers decreased after residing in Antarctica and recovered when they returned back. The results in this study is identical to that in the 6th Chinese Antarctic Research Expedition (Yu *et al.* , 1991) . It obviously results from the special effect of environment in Antarctica on human health. It is considered that the decrease of immunity was originated from lacking stimulation from exterior antigens (microorganisms, chemicals, etc.). It is also possible (probably the major one) that the explorers were living in an environment isolated from normal human society and lacking necessary stimulating factors from normal human life. The extent of activity and the chance contacting with other people were limited for these explorers. Their life were monotonous, lonely with a feeling of isolation from the outside world. The inappropriate medical care in Antarctica made them worry about suffering from illness. In the winter time, the number of task force members was much less, the extent of activity was more limited (only in house). They suffered polar night. The mental and psychological stress was much heavier. These could be observed and identified from the results of EEG. There was a relationship between the increase of index of β-band and the decrease of lymphocyte transformation (Fig. 1).

The effect of stress lasting for a long period of time on the activity of higher nervous system may lead to increase β-endorphin (Ni, 1993), depress T lymphocyte proliferation and depress B lymphocyte function, therefore, the IgG and IgM also decreased correspondingly. The function of T lymphocyte did not recover in a short period of time after return, but the production of IgG and IgM from B lymphocyte returned to its previous value before leaving for Antarctica. Because the production of IgA absolutely depends on the association with the function of T lymphocyte which was depressed during the residence in Antarctica, the production of serum IgA decreased continuously until they returned back to the original places, the value was even lower than that in Antarctica .

A lot of studies (Ding, 1989) showed that many diseases are related to stress. Six hours electric stimulation may increase the sensitivity of mice to Herpes Simplex virus, Poliovirus and Aphthous Stomatitis virus. Isolated mice was susceptible to myocarditis. Keller and Stein (1984) reported that the stress induced by limiting activity and by binding may increase the morbidity of sarcoma, breast cancer and leukaemia of mice. Laudenslager and Ryan (1983) reported that the depression of lymphocyte proliferation induced by stress is related to the change of psychological status. Schleifer (1984) reported that human bereft of spouse may affect lymphocyte proliferation, and the immune function may decrease in two months after bereaving of spouse.

It is considered that living under stress for a long time may cause the immune function decreased, which is more obvious on the effect of cellular immunity, and cause the probability of suffering from varied diseases increased (Shavit and Terman, 1985).

5 Conclusion

(1) Living in Antarctica for a long time may lead to the decrease of immunity,

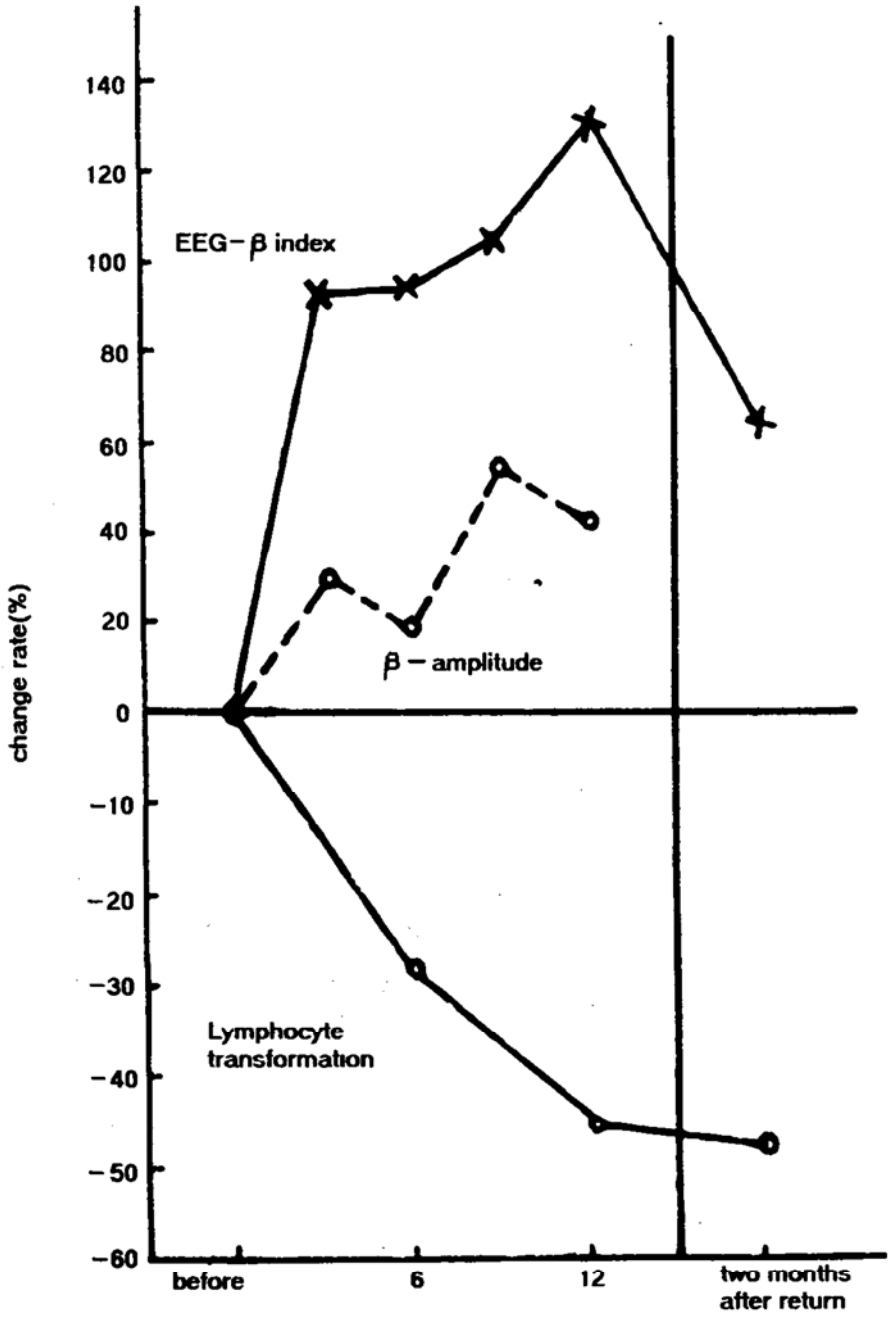

Fig. 1. Lymphocyte transformation and EEG index of β-bands.

which can be recovered gradually .

(2) Living in Antarctica for a long time, the index and amplitude of β-band on EEG increased significantly. This is the results of increasing dissimilation of electric activity in the higher nervous system. The increased mental tension is the response to stress.

(3) There is a close relationship between the decrease of lymphocyte transformation and the increase of the index and amplitude of β-band on EEG. It indicated that the decrease of immunity(especially cell mediated immunity)resulted from living under stress for a long time.

(4) No microorganisms living under 37℃ can exist in the atmosphere in

Antarctica. Most microorganisms found in the living room are not pathogenic, which may be brought by the explorers from the outside of Antarctica. The possibility of these microorganisms cau. ing contamination to Antarctica is very few.

Improving and creating an environment for living and working in Antarctica and making it closed to the original places where they used to live on, providing reliable medical and health care, decreasing or releasing the degree of mental and psychological stress are the major measures to prevent human from decreasing immunity and preventing them from varied diseases. The question whether the microorganisms existing in cold environment is harmful to human is to be answered.

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