A STUDY OF HUMAN ADAPTABILITY IN ANTARCTICA

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Abstract: The metabolic and nutritional conditions in Antarctica were studied in 29 members of the 10th Japanese wintering party (1968-1970), 25-47 years of age.

1. Change in basal metabolism: It has long been known that there is an apparent seasonal variation in basal metabolism of Japanese people; higher rate in the winter and lower late in the summer. There has hitherto been much argument, and many possible factors such as natural environment, composition of food, mode of living, racial disposition, have come up for discussion. However, little is known about the real mechanism causing this peculiar phenomenon. This report is the experiments carried out by author in hope that a comparative study in a special environmental condition might throw light on this problem.

Generally, in Antarctica, the basal metabolism showed the highest value, 40-43 kcal/m^2/h in January-February, then it gradually decreased to 35-38 kcal in the Antarctic fall. Then it tended to rise again to 39.42 kcal in August and September. In the Antarctic winter, June and July, there is little daylight and little chance to go out, and basal metabolism drops to the lowest level of the year.

As described above, the characteristic feature of basal metabolism in Japanese, the apparent seasonal variation, was not affected by the Antarctic environmental and living conditions. However, the values for basal metabolism in Antarctica are higher in every age than the standard values in Japan, as recorded by the Ministry of Health and Welfare.

2. As to the behavioral pattern and activity level of wintering members in Antarctica, several studies have been reported. The author tried to show physical activity level of the subjects by counting daily step using a stepmeter (pedometer). On the average, in the Antarctic summer, December and January, the step count is 15,000, the largest count of the year. It drops to the lowest level, 6,000 steps, in the antarctic midwinter, June and July. These changes seem to have a close relation to the changes in length of daylight. The correlation coefficient between step count and ambient temperature was 0.53, and that between step count and daylight length was 0.64.

3. Food intake: In general, the metabolic balance was always positive throughout the year in Antarctica, resulting in the weight-increase of most wintering members during their stay in Antarctica. Skinfold thickness in the upper arm and around the navel increased in parallel with body weight.

4. Comparing the sleeping pattern of the summer with that of the winter, there was no conspicuous feature in the former, but a symptom of intermittent sleep and a tendency of nocturnal habits were observed.

5. Considering monthly the change of physical rhythm per day, there was only narrow margin of variation and the night-and-day rhythm was absent in midwinter period.

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1. Introduction

As the subjects of medical studies in the polar resions, the coldness, the changes in night-and-day patterns and the influence of isolation come into consideration.

In the 10th wintering party, the amount of basal metabolism, the circadian rhythm of body temperature, the behavioral pattern of life and the food intake of 8 members were continuously recorded every day for a period from November 1968 to February 1970. Other members were requested to cooperate with the examination in order to find out the influence of polar meteorological conditions and environment upon man. The results are reported here. The results that overlap those of Dr. HIROSE of the 8th party and Dr. OHKUBO of the 9th party are omitted because of the limited space.

2. The Method

Examinees are members from 25 to 47 years of age who are in charge of medicine, civil engineering and construction, communication, glaciology, meteorology and cooking including the leader (Table 1). We also paid much attention to the differences in their daily behavior depending on thier ages and occupations. They were all healthy and no one got sick all through the year.

Table 1. A list of examinees (10th party).

Items / Subjects	Discipline	Age	Height	Weight
			cm	kg
K	Leader	47	172.0	61.0
H	Medicine	39	168.3	58.1
O	Ionosphere	29	164.2	59.0
Se	Construction	28	181.5	83.5
A	Communication	26	162.8	60.0
N	Glaciology	25	164.3	51.2
Sa	Meteorology	25	171.0	68.4
M	Cook	25	175.4	70.2
Average	—	30.5	169.9	63.9

* Those who already experienced wintering are not included.

Each examinee's breath was taken in a Douglas bag to measure the basal metabolism for 3 to 5 days every month when he woke up early in the morning at intervals of 8 to 12 hours after the meal, and analized by the ordinary method.

The circadian rhythm of body temperature was measured repeatedly by taking temperature and urine of each examinee every 3 or 4 hours every day (the results are under way), and the figures were recorded every time. Especially, the oral temperature was measured under the tongue for 5 minutes and once again for one minute to make sure that there was no rise in the temperature, and then the figures were recorded. A polyethylene bottle of 500 to 1,000 ml was prepared to avoid careless discharge of urine.

The changes of circadian rhythm were analized by a large computer after the examinees returned to Japan. Every behavior of the wintering members was recorded on the given form to make data for the pursuit of the seasonal behavioral pattern and the energy consumption (computed by the list of *RMR* and the results of time study). The behavior of each member had been expected to be monotonous, so we asked each of them to carry always a pedometer, and record the exact number of daily steps, to make an index of the change of behavior. The use of the pedometer, among other examinations, interested the examinees very much, and they carried it almost all the time except when they took bath and went to bed. The meters were inspected every 2 or 3 months so that inaccurate meters were replaced without fail.

As to the food intake the nutritive value of food was calculated by weighing the food materials, before and after cooking. The measurement was made on every meal for two weeks every month to study the relations between the seasonal change of basal metabolism and the food quality. There is a report on psychological effects by KITAMURA (1963) and MATSUDA (1964), which is one of the most difficult subjects for examination in a closed society with a limited number of persons. We could not spend much time in that field because our main purpose was a physiological examination, but a few interesting things appeared in our daily life, as will be described later.

3. Results

The results will be divided roughly into the following items and inquired into one after another.

3.1. The outline of examinees

The 10th wintering party had been called "Young 10th party" before their departure from Japan. As is shown in Table 1, the average age is a little under 31 and only 2 out of 29 members had experience of wintering. This shows that Antarctic expeditions have come to a turning point in each field. Fig. 1 illustrates the age groups and the number of experienced members of wintering parties since 1956. The total number of the 10th wintering party is 3 times as many as that of the first party and they are younger by 6

years on the average. The number of members is shifting from a small group to a medium-sized group and they are becoming younger. Therefore, it becomes much more difficult to control the group than before and requires a lot of considerations because it is a sort of a household of promiscuous people with different specialities and experiences. Fig. 2 shows the life patterns

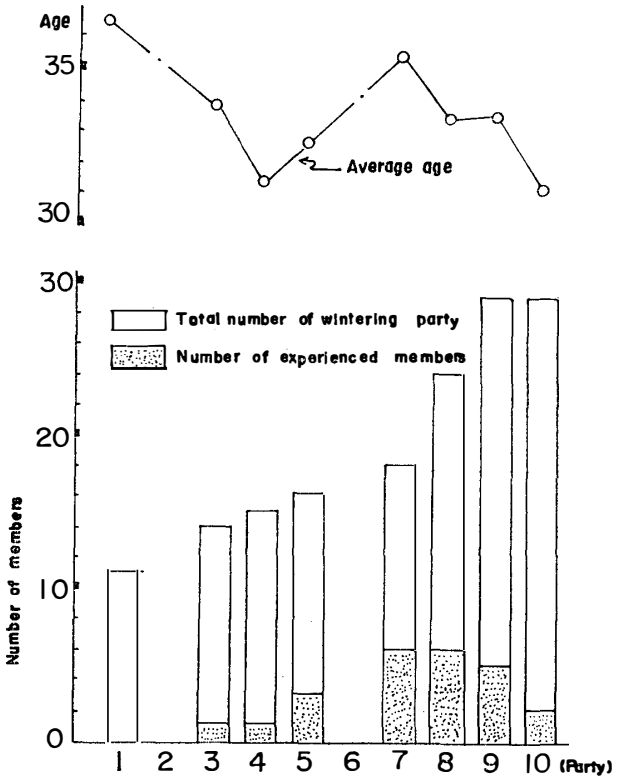

Fig. 1. The consitution of each wintering party.

	Hour of rising	Breakfast	Tea time	Lunch	Dinner
Week days	0700	0730-0800	1000, 1500	1200-1300	1800-1900
Holidays	——	Blunch 0800-1200			1800-1900

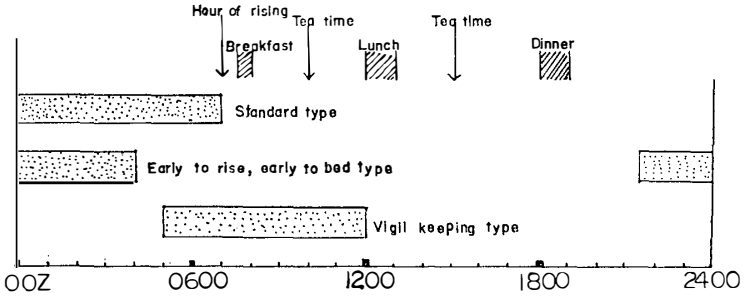

Fig. 2. Life pattern.

of members in the respective fields.

Those who live in accordance with the regulations of the party will be regarded as the 'standard-type'. Those who are in charge of communication and have to adjust themselves to the hours of communication with Japan and foreign countries will be classified as the 'early to bed, early to rise-type'. Those who keep vigil to observe the aurora during midwinter (from May to July) will be classified as the 'vigil keeping type'. (The bars dotted with black points in Fig. 2 show the sleeping hours). Besides these unavoidable variations of duties, the meteorological conditions of Antarctica have a considerable influence upon the members mentally and physically, since the sun shines day and night in summer, known as the season of nights with the midnight sun, and there are long, dark and cold nights in winter.

3.2. Seasonal change of basal metabolim

It is almost the concerted view of the researchers (SASAKI, 1970; YOSHIMURA, 1969) that the Japanese basal metabolism changes in conformity with the seasonal change. The view, however, is diverse on whether the phenomenon is due to the Japanese physical constitution or the effects of the natural environment, food quality and physical exercise. Generally speaking, basal metabolism of the Japanese has a tendency of a 'low in summer and high in winter' type. It will be very interesting to know whether or not there is any seasonal change in the natural environment of Antarctica where the daily atmospheric temperature remains below zero and the night-and-day pattern changes outstandingly throughout the year. To pursue this problem we measured basal metabolism (*BM*) of the above-mentioned 8 examinees for 3 to 5 days every month, the result of which is shown in Fig. 3.

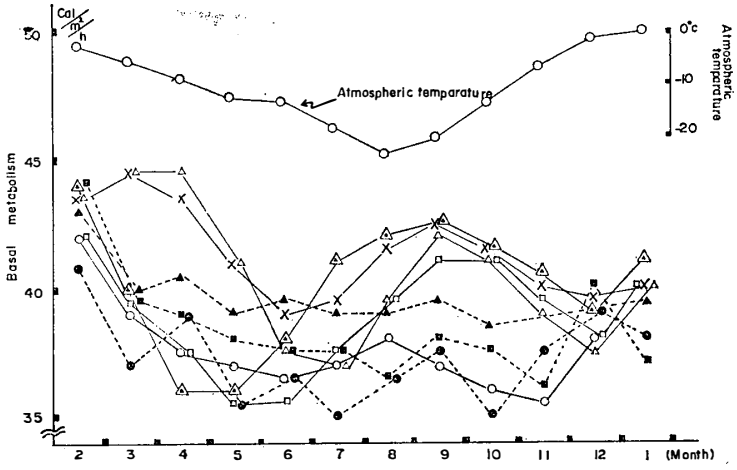

Fig. 3. Seasonal change of basal metabolism (1969-1970).

The upper part of Fig. 3 shows monthly average temperature of Syowa Station all the year round, and the lower part shows monthly average values of basal metabolism measured (3–5 days/month) on the respective examinees. The general trend of the 8 examinees was as follows : basal metabolism reaches the highest point of 40–43 kcal/m²/h from early January when they landed on the station to February, and then lowers (about 35–38 kcal/m²/h) in April, May and June when their life was stabilized. The temperature of this period is around 10°C below zero, which corresponds to fall in Antarctica. Following the period, in August and September when it gets coldest, a clear increase (37–42 kcal/m²/h) can be seen in the basal metabolism.

June and July correspond to the period of midwinter in Antarctica during which the opportunities to go out and to feel biting cold are very few except working for removing ice or passing through the ice tunnels. Even so, the figure shows a seasonal change, low in summer and high in winter. Although there are 3 *BM* curves (dotted lines) running irrelevant to the change of atmospheric temperature, these are of the examinees who worked harder or were fatter than other members. While, the causes that the basal metabolism of all the members was high when they reached the base are due to the fact that such a hard labor unimaginable in Japan as construction works acted as a stress as well as the one when they entered into the polar regions after passing through the South Pacific Ocean.

In this way the basal metabolism shows a tendency of being low in summer and high in winter even in the polar regions. It will be regarded as the result of our continuous long time reactions brought about by the change of atmospheric temperature in Japan. It will be very interesting to see the

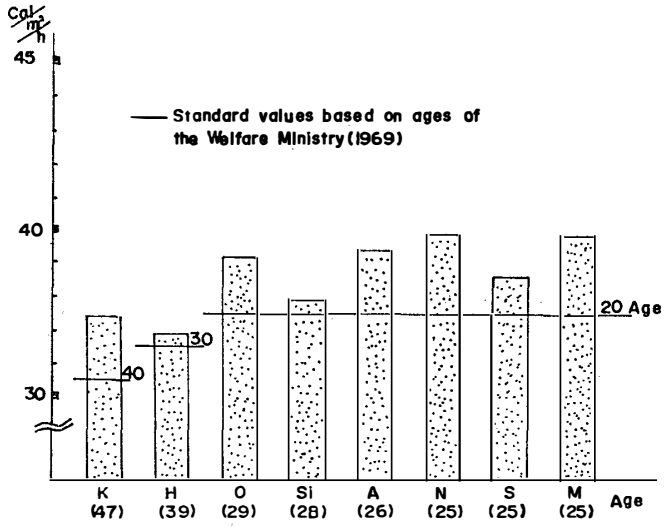

Fig. 4. Annual values of basal metabolism in Antarctica (average).

result with the one of SASAKI (1970) and YOSHIMURA (1969) who have lived in foreign countries for a few years. Especially, compared with the standard values of basal metabolism described in the white paper 'Necessary Amount of Nourishment of the Japanese' issued by the Ministry of Health and Welfare in 1969 averaging the annual results of examinees measured this time, we can see apparently that members of the wintering party highly acclimatized themselves to the severe cold in Antarctica (Fig. 4).

Concerning the basal metabolism, there have been the results of BUSTON (1940) and OHKUBO and KOBAYASHI (1971), but there is no such evidence that metabolism has been apparently be acclimatized by the climate. In this point a further biochemical examination should be done. The author would like to add that in order to compare with the standard values of the Ministry of Health and Welfare, FUJIMOTO and WATANABE's equation (1968); $A(\mathrm{cm}^2)=W^{0.444}(\mathrm{kg})\times H^{0.663}(\mathrm{cm})\times 88.83$, was used in the measurement of the surface area of the body and the calculation of basal metabolism instead of the conventional one of TAKAHIRA.

3.3. Number of steps in the period of wintering

The details of the behavioral pattern of the wintering party are omitted, since Messrs. HIROSE (1969) and OHKUBO and KOBAYASHI (1971) already reported on this subject. However, with the number of steps measured by the pedometers the author could prove that there is a considerable difference between the movements during the summer and during the winter (Fig. 5). The lowest line in the figure shows the monthly average number of daily steps of 8 examinees. As is shown in the figure, the number of steps becomes highest during the summer (December and January) when the sun shines day and

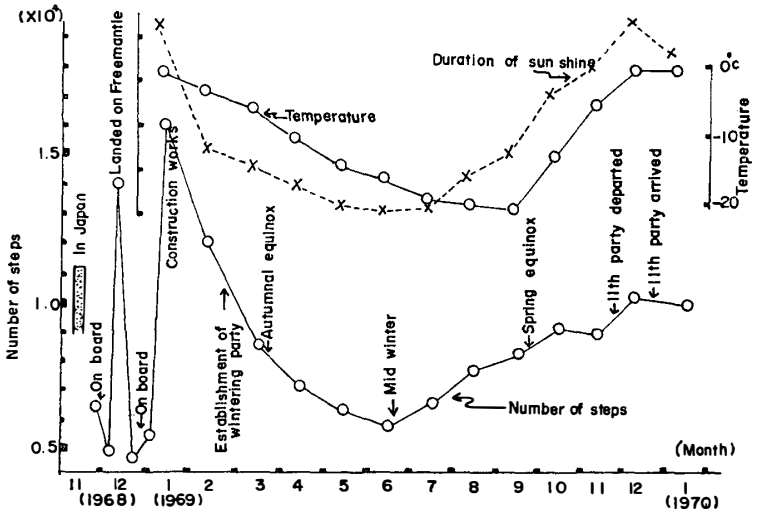

Fig. 5. Number of steps in wintering (by the pedometer).

night, and then it declines with the fall of temperature and the shortening of the duration of sunshine. The number of steps (about 13,000 steps) shown at the left end of the figure with the dotted rectangle is the examinees' value measured while they were in Japan. The value seems a little higher than that of general office workers (about 7,000 steps on the average), because they were about to get on board the ship, but after the departure it extremely decreased to about 4,000–5,000 steps on board the ship (December 1968). The number increased to 14,000 steps during the week when we stopped at a port of Australia, which proves how active landing makes us. And then, again on board the ship, it showed the lowest number of 3,000 steps during passing through the storm zone, when a considerable number of persons moved and ate only a little.

After entering into Syowa Station, they became much more active than those who are in Japan, though each movement differs with the respective occupations. Here it amounted to 15,000 steps on the average with the highest number of 30,000 steps. As mentioned above, it decreased afterward as time went on. Observing in detail these developments for the year, the author found that our movements change in remarkable contrast with the duration of sunshine and the value becomes lowest in the period of endless nights (from May 30 to July 14), and that although the temperature tended to fall even after the period of endless nights was over the movements increased with the enlarging duration of sunshine irrespective of the fall of temperature. In examining the correlations chefficient between each examinee's monthly average number of daily steps recorded on the pedometer, and the temperature and the duration of sunshine, the author found a fairly high coefficient of 0.53 in the former and 0.64 in the latter. The individual number of steps showed little change in the movement of the aged, but a little change between the leader and the members in change of cooking and communication.

3.4. Seasonal change of food intake

Food intake is closely related to the member's behavior. From the viewpoint of energy balance, it would be desirable to store up surplus energy in the polar regions in case of emergency. To investigate the actual condition, food intake of examinees was measured at every meal and also at the time eating or drinking between meals. The results of the investigation are shown in Table 2, dividing the year into 5 terms, January (summer) (it was summer when we arrived at the station), March (autumn), June (winter), September (spring) and December (summer).

The amounts of intake during the respective terms were 3145, 2804, 2973, 2860 and 2923 kcal/day, which were more than those consumed, *i.e.* 3116, 2740, 2557, 2700 and 2854 kcal/day. This will be more clearly indicated by

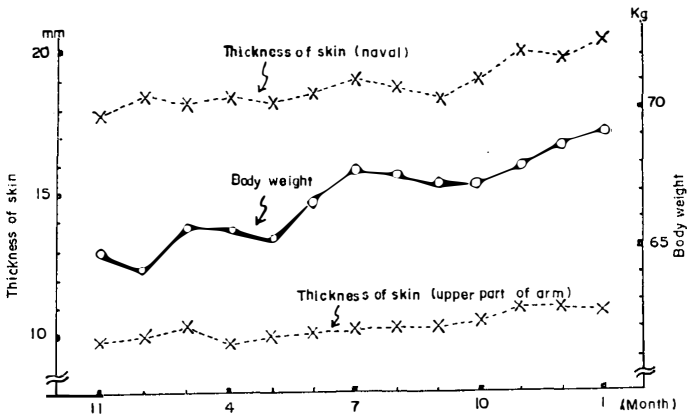

Fig. 6. Monthly mean values of body weight and skin thickness of the 8 members of the wintering party.

the change in weight and the thickness of skin (Fig. 6). Although they worked in the vast polar region, the task assigned to each of them was regular research. Explosive energy consumption such as in sports was observed except when we did it intentionally. Thoughtfully prepared dishes by members in charge of cooking to lessen the monotony of our life and stimulated our appetite, so it cannot be denied that all of us tended to get fat.

The lower part of Table 2 shows the total calorie intake during each term by the percentages of carbohydrates, fat and protein. The caloric percentage of the general Japanese reported by the Ministry of Health and Welfare is shown at the top of Fig. 7. From this, we can see that 70% of total food intake for most Japanese is made up of carbohydrates and the rest 30% by fat and protein, whereas the wintering party took 45% of the total

Table 2. Seasonal change of food intake (per day).

Items \ Seasons (Month)		Units	Summer (1)	Autumn (3)	Winter (6)	Spring (9)	Summer (12)
Weight		kg	64.0	65.2	66.1	67.0	68.5
Calorie consumption		kcal	3116	2740	2557	2700	2854
Food intake	Calorie	kcal (kcal/kg)	3145(49.1)	2804(43.0)	2973(48.0)	2860(42.7)	2923(42.9)
	Protein	g(g/kg)	112.2(1.75)	108.0(1.66)	110.5(1.65)	107.8(1.61)	117.1(1.71)
	Fat	g(g/kg)	92.0(1.44)	85.3(1.31)	98.1(1.48)	87.2(1.30)	85.6(1.25)
	Carbohydrates	g(g/kg)	467(7.30)	401(6.15)	412(6.23)	411(6.13)	421(6.15)
Calorie percentage	Protein	%	14.3	15.4	14.9	15.1	16.1
	Fat	%	26.3	27.4	29.7	27.4	26.3
	Carbohydrates	%	59.4	57.2	55.4	57.5	57.6

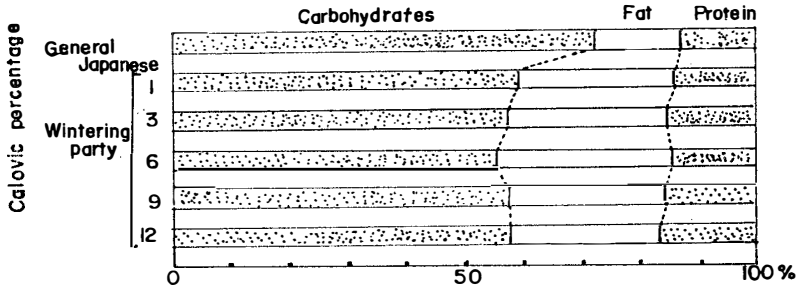

Fig. 7. Seasonal change of food intake (per day).

from fat and protein. Their eating habits tend to relatively high fat and high protein intake, compared with those when they were in Japan. This has an important meaning for the protection of the body in the cold regions. Physiologically considering the seasonal change of basal metabolism and referring to the result that the western people's basal metabolism of high fat and high protein is not subject to the seasonal change, it was expected that members of the Antarctic expedition might not undergo the seasonal change, as mentioned in 3.2. In this connection, YUKIYOSHI's examination (1968) shows that the percentage of fat and protein to the Canadian's total calorie intake is 55%, which is much higher than that (40–45%) of the wintering party.

3.5. Quantity and quality of sleep

The four seasons come regularly in Japan, but not so at Syowa Station. From December through January it does not get dark even at night. This is the period of nights with the midnight sun. On the other hand, from June through July is the period of midwinter when it remains dark day and night. For the summer and the winter, 15 members who did not go out for the inland trip went through a one-week time study of the state of their sleeping under these circumstances (this included the 8 members who were asked to cooperate with the monthly examination).

The results are illustrated in Fig. 8, which shows the weekly sleeping conditions of four examinees (indicated by alphabets). Looking at the sleeping hours in the period of the midnight sun (white pattern) and the midwinter (black pattern), the average of the former is 6.53 hours and the latter 7.01 hours, so there was no significant difference.

Generally speaking, babies have the longest sleeping hour and it is said that they sleep 2/3 of the day regardless of day and night. As they grow up, they get used to be awake during the stimulative daytime and to sleep during the less-stimulative nighttime, their sleeping hours being 1/3 of the day or 7-8 hours. The situation might be fairly different in the Antarctic where the places they work and live are close together and yet they have endless day and nights. The actual measurement, however, resulted in about 7 hours

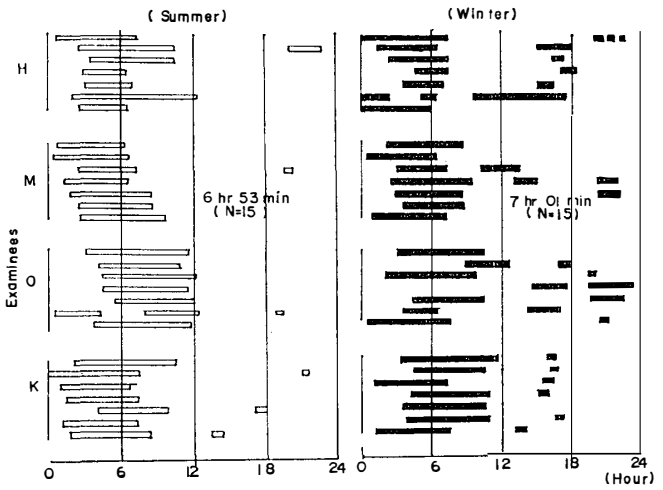

Fig. 8. Sleeping condition.

of sleep. Paradoxically, the sleeping hours of the grownups would be approximately 7 hours. For even a few sleepless nights continue, it has become about 7 hours on the average with something worked in compensation for that. In the period of midwinter after half a year had passed since landing at the station, our behavior was restricted as mentioned in part 3.3. and accordingly psychological stress smoldered in us. Besides, in view of the fact that they can only have intermittent naps and there are not so many topics, much attention should be paid to midwinter period in terms of hygiene. EDHOLM also pointed out this and said that the sleeping pattern of these periods of nights with the midnight sun and midnights is intermittent. According to my investigation, they had relatively continuous sleep in the period of nights with the midnight sun and conspicuously intermittent sleep in the midwinter period.

The subject indicated by "O" in Fig. 8 was an observer of cosmic-rays, so his sleeping hours did not come under the sleeping pattern of the midwinter. It deserves, however, much attention that sleeping patterns of others were disorderly in the midwinter regardless of the type of their work. Looking at this figure, attention must also be paid to the fact that each subject seldom went to bed early in the evening and appeared to be nocturnal, except for the subject "O".

3.6. Circadian rhythm of body temperature

The number of our pulse and body temperature were low at night when we are not active, and reached the highest points at midday. Gradually descending afterward, they become normal at midnight. What would be the values when we suddenly enter into a region of entirely different longitude and latitude where the night-and-day pattern undergoes big changes due to

the midnight sun period and the midwinter period?

To clarify these points, the body temperature and the quantity of urine of 8 subjects engaged in the Antarctic expedition were measured for 3–4 hours every month (study of the quantity of urine is under way). When the oral temperature was extremely low as the subject was out in the severest cold,

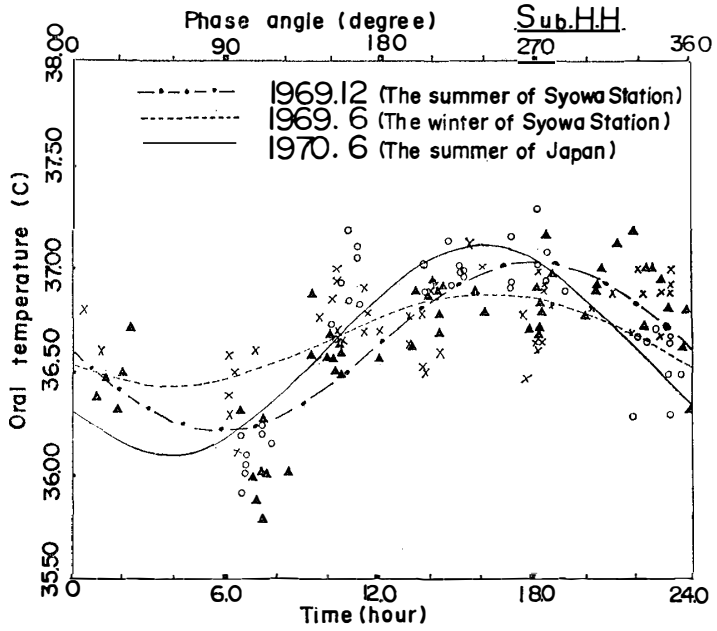

Fig. 9. The actual value of the subject H. H.

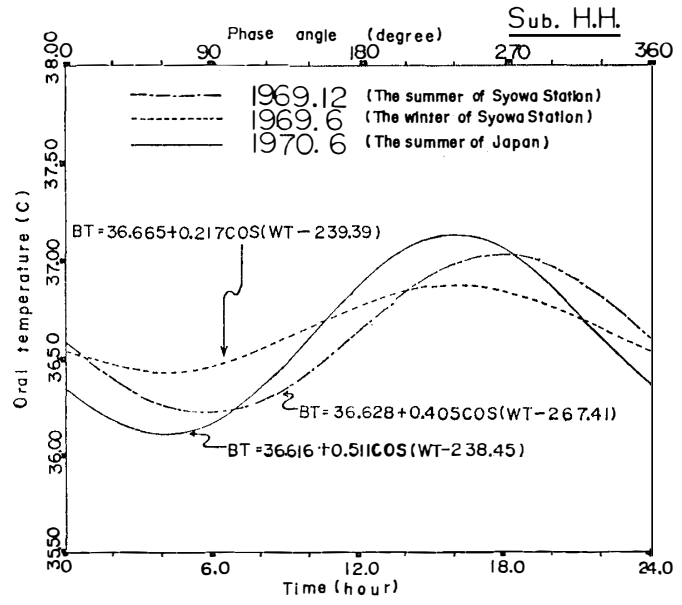

Fig. 10. The comparison of daily variation of circadian rhythm between Syowa Station and Japan.

measurement was made after the temperature returned to normal. The actual value of the subject H.H. measured every four hours every day is shown in Fig. 9. The results of the period of midnight sun (summer at the station; marked ▲) midwinter (winter at the station; marked ×) were plotted together with those in Japan (results of June in Japan; marked ○) for comparison. Furthermore, for an accurate analysis of the measured values, a big computer was used to work out, by the consignor method, the experimental equation (Fig. 10). The solid line indicates the change of body temperature in the summer of Japan, the chain line in the summer at the station and the dotted line in the winter at the station, respectively. The result (BT=36,628 +0.405 cos [WT-267.41]) of the summer at the station (chain line) is quite similar in its range and phase to the one in the summer of Japan (BT=36.616 +0.511 cos [WT-238.45]). That is, when they are living where the sun shines day and night, the results almost correspond to those measured in Japan where nights and days come regularly. The results in the winter at the station are more or less similar to them, with the margin of alteration quite small or even (BT=36.665+0.217 cos [WT-239.39]).

As Westerners call this phenomenon 'big eye', many people become nocturnal and sleep from dawn till noon. Such a nocturnal habit is ascribed to the fact that in Antarctica it does not get light until about noon even during the midwinter period (cf. Fig. 8). Therefore, so long as they do not wake up and begin to move consciously in the morning on a clock, the physical rhythm will be extremely changeless.

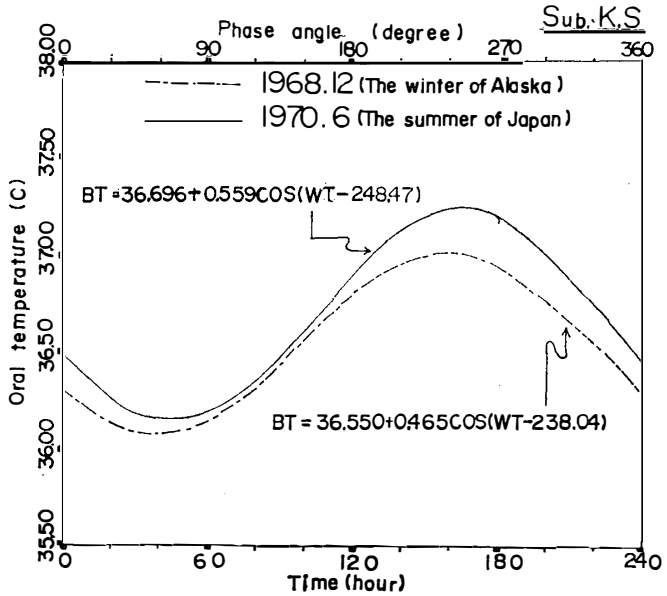

Fig. 11. The comparison of daily variation of circadian rhythm between Alaska and Japan.

This will be more clear when we refer to the results of MORIMOTO and his colleagues (Fig. 11). The result of measurement on the subject K. S. which in Alaska, situated in almost the same latitude north as Syowa Station, shows that the values obtained in December, the period of midwinter in Alaska, are closely similar in the phase and range to those of June in Japan. It is interesting to see the result with the story that K.S. worked at a research institution in America and lived with the same sensibility to time as he was in Japan.

The previous result of Syowa Station is free running result in placing the subjects at the mercy of nature. To be considered here is the fact revealed in the sleeping pattern (Fig. 7), that subject H.H. became nocturnal in winter and his body temperature tended to be high because his active energy increased at a time when body temperature descends at night which can be seen in the case of diurnal habits, and that as he slept in the daytime when body temperature rises, his active energy decreased and felt the generation of his temperature, which caused the decrease in the range of the variation of his temperature.

3.7. Psychological condition in wintering

Observations during the wintering are mainly inactive and intellectual activities, so serious consideration must be given to keep the men healthy, mentally and physically. In this connection the number of pulse of the party, members in their daily life was measured consecutively, using the telemeter of Mitsubishi Electrics (PT120B-type) that weights about 1 kg (including a battery) and measures $80 \times 55 \times 35$ mm. They wore it at their sides. It induced the electric waves from their chests, which were received at the study room of the station. The effective distance of transmission was approximately 3 km, by which we could almost grasp their usual living conditions. According to the data, the number of pulse in a day comparable to that of 120–200 pulse/min in sports was only 140–170 pulse/min in the ice-removing work (cracking an iceberg for getting drinking water), 126–138 pulse/min in walking on the ice and 144–156 pulse/min in walking on the snow, and in almost all cases of a quasi-quiet condition it was around 100 pulse/min. In view of this point, the author assumes that the physical functions of the expedition party members at the station will drop, unless they bear it in mind to take some exercise to a considerable extent in their leisure hours.

On the other hand, in view of the fact that the ice-removing work, even if it was necessary for their life, proved to be a good training for their body as a different type of sports, it seems necessary to install a gym or a health control center where training is performed, since a water-storing tank for

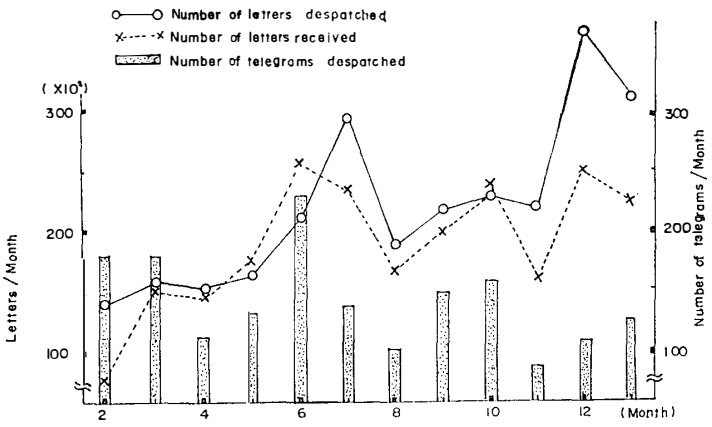

Fig. 12. Monthly number of private telegrams dispatched and received.

drinking water is to be set up in the future. Although it is very difficult to read man's mind in wintering, the following phenomenal facts are worthy of mention. Fig. 12 shows the number of letters privately dispatched and received, and the number of private telegrams dispatched. The solid line shows the number of letters dispatched from Syowa Station to Japan and the dotted line received from Japan. The vertical lines with arrow heads show the number of telegrams dispatched from Syowa Station to Japan. Looking at these vertical lines, we notice that the number of telegrams is outstandingly high in the beginning when we arrived at the station and during the mid-winter period, but except these it is almost constant, being about 140–150 telegrams a month, that is, 4 per day on the average. On the contraty, the number of letters dispatched apparently rises with the passage of time. The contents of telegram became gradually more detailed, probably because they wanted to hear some topics from outside which became scarce day by day. That the number of telegrams from Japan is fewer than that from the station is due to the fact that the number of persons who were qualified to send telegrams was limited and they were less anxious to get news than those at the station.

It is true, however, that the life at Syowa Station was more comfortable than expected and that we enjoyed to live as human beings. The members of the 10th party played various activities in leisure hours, the author found many traces in them of having been considered well without being swayed by the benefits of todays's extremely developed civilization. Although we had birthday parties and literary exercises at primary schools and junior high schools, we were not so much excited by them when we were in Japan. We have recognized for the first time since we came to Antarctica, however, that they played a vital role in providing places for conversations. Among games,

mahjong was more popular than go and shogi (Japanese chess). It depends on each individual's taste, but the strong almost always won in go and shogi. In mahjong, however, even the weak had the chance to win if he was lucky and it also had an advantage that many persons could join in it. Among sports, they liked skiing better than skating, probably because there was no fixed link and it was discouraging to skate on a vast pond without spectators. In skiing, however, they could criticize others sliding down as they passed by the course riding on the private lift going up, and that had been the stressor on their behavior.

As a countermeasure for leisure hours in wintering, a place to give out energy is absolutely necessary to keep each one's health and to get good results in observations. We hope there will be a place where we can be active in the period of midwinter.

4. Conclusion

By measuring the basal metabolism, time study, the number of steps, the nutrition intake and the circadian rhythm of body temperature of 29 members who took part in the Antarctic expeditions and 8 examinees who cooperate with the medical examinations, we got the following results :

1. The basal metabolism showed a seasonal change of "low in summer and high in winter" even when the atmospheric temperature was below zero.
2. The annual average values of basal metabolism of the wintering party were the same as, or above, the standard value in Japan, which apparently shows the wintering members acclimatized themselves to the Antarctic environment.
3. The percentage of carbohydrates in the total calorie intake was 55% at the station, which was less than that of Japanese (70%). While, fat and protein intake was more than that of Japanese but less than that of Westerners.
4. The annual number of steps measured by the pedometer was highest in summer (the period of midnight sun) and lowest in winter (the period of midwinter). The change was in propotion to the duration of sunshine rather than to the change of atmospheric temperature.
5. Observations made at Syowa Station were, as a whole, the routine work, so all the members tended to become fat due to accumulated energy. As a countermeasure, installation of a gymnasium is advisable.
6. The quantity of sleep was about 7 hours throughout the year, indicating the general sleeping hours of grownups.
7. Comparing the sleeping pattern in the summer with that in the winter, there was no conspicuous feature in the former, but a symptom of intermittent sleep and a tendency of nocturnal habits were observed.

8. Considering monthly the change of physical rhythm per day (the change of the temperature under the tongue), there was only a narrow margin of variation and the night-and-day rhythm was absent in winter. The decrease in the change of body temperature in winter can be regarded as a result of the fact that the active rhythm and the inherent rhythm of body temperature compensated each other.

Especially, taking it into consideration that the rhythm of body temperature changes more remarkably in winter than in summer together with the result of the item (7), we have to pay much attention to the control of wintering life in the period of midwinter.

Concluding the above-mentioned results, it is found that the Japanese sensible to the seasonal change are well acclimatized even to the severest cold region. Men living under specific circumstances such as midnight sun period and midwinter period have more problems in the latter than in the former. Since the recent observations are steadily developing, the author thinks now is the time to give more consideration to a place where we can be active and make programs for leisure hours in order to keep good health.

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