Body Burdens of Cesium-137 and Potassium-40 in Twenty-one Members of the Wintering Party of the 16th Japanese Antarctic Research Expedition 1975

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第16次越冬隊員の体内放射性物質 (^{137}Cs, ^{40}K) の測定報告

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要旨: 本研究では，第 16 次越冬隊員 21 名に対し，ヒューマンカウンターを用いて，出発前および帰国直後，人体内に存在する放射性物質 ^{40}K および ^{137}Cs を測定した．その目的は，(1) 自然放射性物質に属する ^{40}K から全身カリウム量を求め，南極での生活が身体組成に及ぼす影響を推定すること，および (2) 核爆発による放射性降下物である ^{137}Cs から，日本と南極における放射性物質の汚染の状態を人体を介して推察することである．

結果は次の通りである．

1) ^{137}Cs の測定値は，やまと山脈調査隊員 6 名では，出発前の 1.20 nCi から 1.69 nCi ($p<0.05$) へ有意に増加したが，基地隊員 15 名では，有意な変化はみられなかった．

2) 第 16 次越冬により，体重は有意に増加し ($p<0.01$)，それに伴い全身カリウム量も有意に増加したが，皮下脂肪に変化はみられなかった．

Abstract: In this study, body burdens of cesium-137 and potassium-40 were measured using a human counter with 21 members of the 16th wintering party. The purposes of these measurements were (1) to observe the radioactive pollution in Japan and Antarctica through the human body, and (2) to estimate the effect of the Antarctic living on the body composition. The results obtained in the present study were as follows;

1) The mean value of body burdens of ^{137}Cs increased from 1.20 to 1.69 nCi ($p<0.05$) in the case of six traverse members of the Yamato Mountains, while there was no significant difference in the case of fifteen base members.

2) The mean value of body weights increased significantly ($p<0.01$) after the Antarctic living and accordingly the total body potassium increased significantly ($p<0.05$), while the body fat remained unchanged.

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1. Introduction

The radioactive nuclides in the human body are roughly classified into two categories. One is the naturally existed radioactive nuclides, and the other is radioactive nuclides of fallout from the nuclear fission on a large scale, such as, tests of nuclear weapon.

In the present study, body burdens of cesium-137 (^{137}Cs) and potassium-40 (^{40}K) were measured using a human counter with twenty-one members of the wintering party of the Japanese Antarctic Research Expedition 1975. The purposes of these measurements were (1) to observe the radioactive pollution in Japan and in Antarctica through the human body, and (2) to estimate the effects of the Antarctic living on the work capacity through the change in body composition, since natural potassium which exists mostly in the active tissues in the human body contains ^{40}K in a constant ratio (0.012%).

2. Subjects and Methods

The subjects were twenty-one male adults, aged 24 to 43 years, who left Japan for Antarctica in the beginning of November 1974, and spent almost one year in Antarctica, and came back to Japan in the end of March 1976. The first measurement was carried out on the 24–30 of October 1974 (MIYASHITA *et al.*, 1975), and the second one was on the 22–23 of March 1976.

The ^{137}Cs and ^{40}K contents were determined by the whole body counter which was equipped in the Nuclear Science and Technology Research Center, University of Tokyo (KATSUNUMA and YOSHIZAWA, 1970). The counting system consisted of four unit plastic scintillator set up below a flat acrylic acid resin bed on which the subject lay, dimensions of each unit being 50 cm × 50 cm × 15 cm. Three human-shaped phantoms had been used in the present study. One was the water phantom for the background counting that was usually carried out before or after the measurement, and the other were the cesium phantom with about 100 nCi of ^{137}Cs aqueous solution and the potassium phantom which contained 602.5 g of K as aqueous solution. Counting time was 30 minutes for each subject.

Skinfold thickness was measured by a skinfold caliper of Key's type. Fat content was calculated from skinfold thickness with Keys and Brozek's formula (KEYS and BROZEK, 1953). Grip strength was measured by a spring type dynamometer.

3. Results and Discussion

3. 1. Radioactive pollution

After the partial test ban treaty in 1963 and subsequent stopping of nuclear weapons testing in the atmosphere by the United States and the Soviet Union, the level of

radioactive contamination in the biosphere has been reduced considerably (SHUKLA *et al.*, 1973). China and France who did not sign this treaty continue weapon testing in the atmosphere. However, at the present time there is no significant increase in the levels of radioactive contamination from these latter tests. Nevertheless, these tests do pose possible future hazards and should testing continue, periodic monitoring of the atmosphere and human subjects is necessary (SHUKLA *et al.*, 1973).

In Japan, the body burden of ^{137}Cs in normal adults has been determined monthly through 1967 to 1975 by whole body counting (ANZAI *et al.*, 1976). The mean value of ^{137}Cs for present 21 subjects before departure was very similar to Anzai's value for normal Japanese, though the body weight (mean: 62.6 kg) of present subjects was slightly more than that of Anzai's subjects (range: 50 to 60 kg).

No significant difference was found in ^{137}Cs content of 21 subjects between, before departure (1.40 nCi) and after Antarctic living (1.44 nCi). However, there were several subjects who showed remarkable increase in ^{137}Cs after the Antarctic living. Most of them were the traverse members who traveled to the Yamato Mountains for approximately two months from November 12, 1975 to January 12, 1976, during the Antarctic living.

21 subjects were divided into two group: six traverse members and fifteen base members. The former group showed a significant increase in ^{137}Cs from 1.20 to 1.69 nCi during the Antarctic living, while the latter group did not.

The major sources of body burden of ^{137}Cs are foods of many kinds and water. Since there was no difference in the kinds of foods taken between traverse members and base members, it could be assumed that the definite increase in ^{137}Cs of traverse members was caused by the water drank during the period of traveling. The base members made water from the snow or the icebergs near Syowa Station, while traverse members made water from the surface ice in the Yamato Mountains. Therefore ^{137}Cs content in ice in the Yamato Mountains should be directly measured in order to prove the above mentioned assumption.

3. 2. Body composition

OHKUBO (1972) reported that mean energy balance of 29 wintering members of the 9th Japanese Antarctic Research Expedition at the Station was positive, about 170 kcal, resulting in increase of body weight and skinfold thickness. HACHISUKA (1976) reported the same results of 29 members of the 10th Japanese wintering party. One of the main factors for increase in body weight with fat observed in the 9th and 10th wintering members is hypokinetic living in Antarctica because of long polar night, cold weather, and small space to move in Syowa Station.

During the last five years, Syowa Station has been enlarged and also in general the

wintering members have devoted more attention to their own health and physical fitness.

Therefore, measurement was performed to verify the change in body composition of the 16th wintering party during the Antarctic living. For this purpose, total body potassium was estimated from the ^{40}K content on 21 subjects before and after the Antarctic living on the base (most of body potassium is in the muscle and lean portions of the body) (FORBES and LEWIS, 1956).

The results showed that there was a significant increase (1.4 kg, $p<0.01$) in body weight accompanying a significant increase (3.0 g, $p<0.05$) in total body potassium yet without change in skinfold thickness before and after the Antarctic living. Therefore, it might be concluded that the increase in body weight was due to the increase in active tissues. This result was also supported by the significant increase (3 kg, $p<0.01$) in grip strength.

HACHISUKA (1976) said in his report of the 10th wintering party that as a countermeasure for leisure hour in wintering, a place to give out energy was absolutely necessary to keep each one's health and to get good results in observations. Thereafter Syowa Station has been changed with more comfortable conditions and the wintering members had become more concious of their own health, resulting in habitual physical activity. These facts might support the present results which were the very reverse to the results obtained in the members of several years ago.

Table 1. Comparison of cesium-137 before and after the Antarctic living.

	All members n=21		Traverse members n=6		Base members n=15	
	Before	After	Before	After	Before	After
Mean	1.40 nCi	1.44 nCi	1.20 nCi	1.69 nCi	1.48 nCi	1.34 nCi
SD	0.43	0.40	0.27	0.29	0.46	0.41
	ns		*		ns	

* $p<0.05$, before: 1974, after: 1976

Table 2. Comparison of body weight, total body potassium, body fat and grip strength before and after the Antarctic living (mean values of 21 members).

	Before	After
Body weight (kg)	62.6 (6.0)	64.0 (5.3)**
Total body potassium (g)	143.4 (4.4)	146.4 (9.8)*
Body fat (%)	11.5 (2.4)	11.7 (2.0)
Grip strength (kg)	46.0 (6.0)	49.0 (4.2)**

** $p<0.01$, *$p<0.05$, ( ) SD, before: 1974, after: 1976

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