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Original Paper

Changes due to Aging in the Serum Biochemical Profile and Weights of Internal Organs Using the Rat as a Model

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Summary

Rats were used as the experimental aging model. The rats were divided into four groups, aged 10, 37, 75 and 92 weeks. Serum biochemical data and organ weights were studied to determine the effects of aging. Serum protein in the older rats was unchanged when compared with the 10 week old rats, while serum albumin decreased. The A/G ratio decreased with aging. There was a sharp decrease in alkaline phosphatase at 37 weeks and activity remained low thereafter. Total serum cholesterol and phospholipids increased with aging. There was no variation in sodium and chlorine in this experiment. Liver and kidney weights in relation to body weight decreased with aging.

Data variations in the biochemical profile may be caused not by increased synthesis but by a decrease in the catabolic rate.

Introduction

If one assumes that the number of aged people in Japan will increase as the life span becomes longer and longer, it follows that problems of aging will become increasingly important.

Although it is inevitable that functions decrease with aging, it will be important to keep organs functioning properly for as long as possible in order to maintain good health. To delay the loss of organ functions, good nutrition is vital. This is especially true for the aged who have lost function in their internal organs.

Furthermore, the total physical state of the person must be considered as he ages.

Factors such as variations in the social environment[1)-3)], the person's eating habits[4),5)] and stress[6),7)] should be taken into account. Morever, the treatments he has received for various illnesses[8),9)] should be noted.

At the present time it is not clear what effects aging has on the morphology and the functions of the internal organs. This experiment was designed to shed light on this problem. Before autopsy, the rats were fed a commercial pellet diet ad-lib and stress was avoided as much as possible. Data was obtained by measuring the internal organ weights and serum biochemistry of the rats. The rat model yielded data which clearly shows the effects of aging.

Experimental procedures and materials

1. Animals and diet

44 male SD rats bought at 7 weeks old from Japan Clare Co. Ltd. were used in this study. Throughout the experiment, they were fed solid feed MF (Oriental Yeast Industry Co. Products) and food and water were provided ad libitum. They were housed in a chamber lit for 12 hours daily (Light on 8:00-20:00).

2. Timing of blood and organ collections

Blood and organ samples were collected at 10 weeks old (n=11), 37 weeks old (n=5), 74 weeks old (n=10) and 92 weeks old (n=9). 9 rats died before samples could be collected and are not included in the data.

3. Sample collection and analytical methods

Samples were collected using the following procedure. The rats were fasted for 16 hours (from 6:00 pm to 10:00 am) before blood was collected. Blood was collected from the inferior vena cava under ether anesthesia and the serum was immediately frozen. Serum protein was measured by the Biuret method[10)], A/G ratio by the BCG/Biuret method[10),11)], alkaline phosphatase (ALP) by the PNP method[13)], phosphorus by the enzyme method[14)], total cholesterol and free cholesterol by the enzyme method[15)] and sodium and chlorine by the electrode method[16)]. After blood samples were collected, the rats were decapitated, exsanguinated, and the liver, kidney, the small intestine and visceral fat were removed and washed with saline. Relative ratios of wet organ weights were calcu-

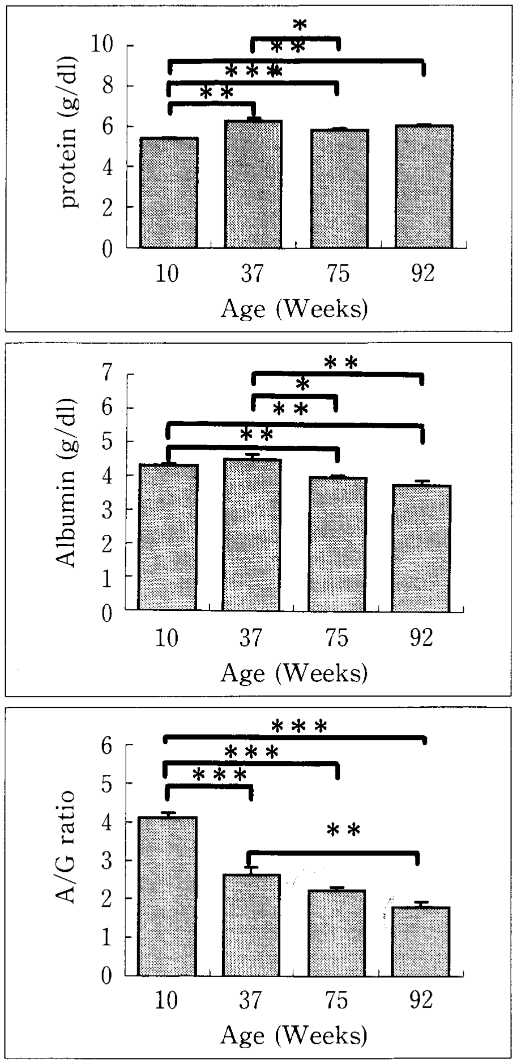

Fig. 1 Serum protein, albumin and the ratio of albumin/globulin (A/G) level in rats aged 10, 37, 75, and 92 weeks (means ± SE). 10 weeks, n=11; 37 weeks, n=5; 75 weeks, n=10; 92 weeks, n=9. *$p<0.05$; **$p<0.01$; ***$p<0.001$.

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4. Statistical analysis

The means and standard errors were calculated for the biochemical profile data and internal organ weights. Student's t-test was used to calculate standard errors.

Experimental result

1. Serum biochemical inspection value

Serum protein was higher at 37 weeks compared to 10 weeks (p±0.01) and then decreased significantly at 75 weeks ($p<0.05$). Albumin was also higher at 37 weeks compared to 10 weeks and then gradually decreased at 75 and 92 weeks. High values for the A/G ratio were obtained in rats aged 10 weeks. However, the values at 75 and 92 weeks were significantly decreased (Fig. 1).

Serum alkaline phosphatase levels were elevated in rats aged 10 weeks, decreased at 37 weeks and remained lower at 75 and 92

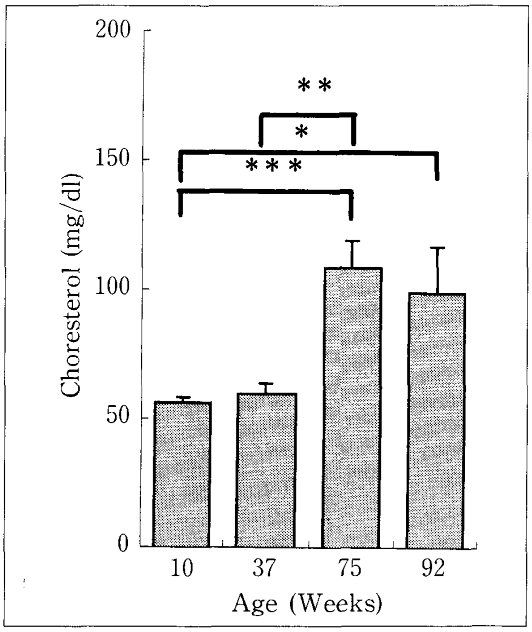

Fig. 3 Serum cholesterol level in rats aged 10, 37, 75, and 92 weeks (means ± SE). 10 weeks, n=11; 37 weeks, n=5; 75 weeks, n=10; 92 weeks, n=9. *p<0.05; **p<0.01; ***p<0.001.

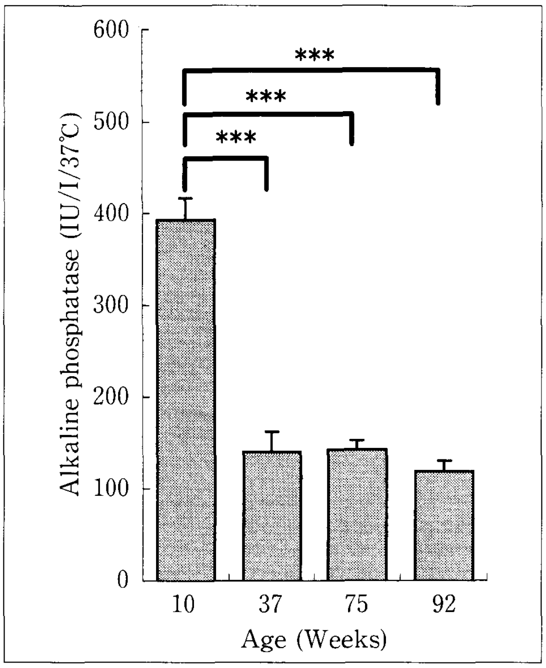

Fig. 2 Serum ALP level in rats aged 10, 37, 75, and 92 weeks (means ± SE). 10 weeks, n=11; 37 weeks, n=5; 75 weeks, n=10; 92 weeks, n=9. *p<0.05; **p<0.01; ***p<0.001.

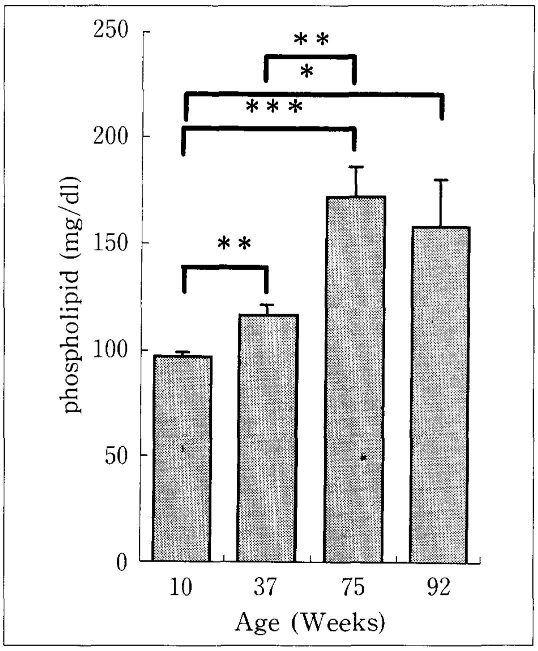

Fig. 4 Serum phospholipid level in rats aged 10, 37, 75, and 92 weeks (means ± SE). 10 weeks, n=11; 37 weeks, n=5; 75 weeks, n=10; 92 weeks, n=9. *p<0.05; **p<0.01; ***p<0.001.

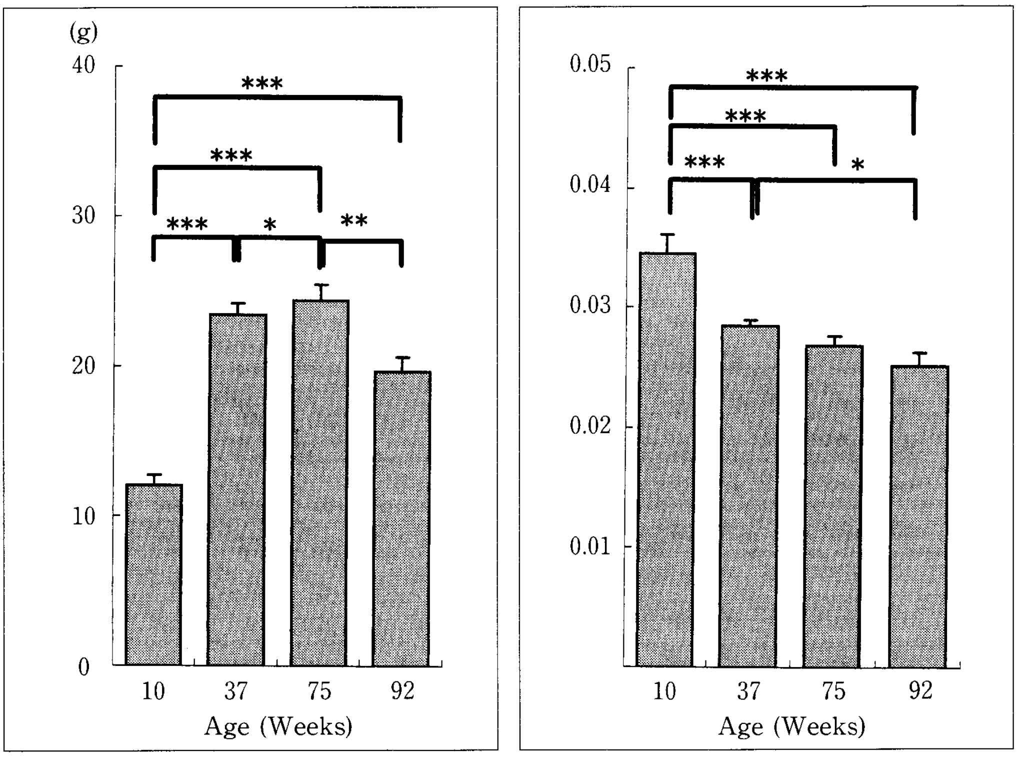

Fig. 5 Liver weight (left) and liver weight/body weight ratio (right) in rats aged 10, 37, 75, and 92 weeks (means ± SE). 10 weeks, n=11; 37 weeks, n=5; 75 weeks, n=10; 92 weeks, n=9. *p<0.05; **p<0.01; ***p<0.001.

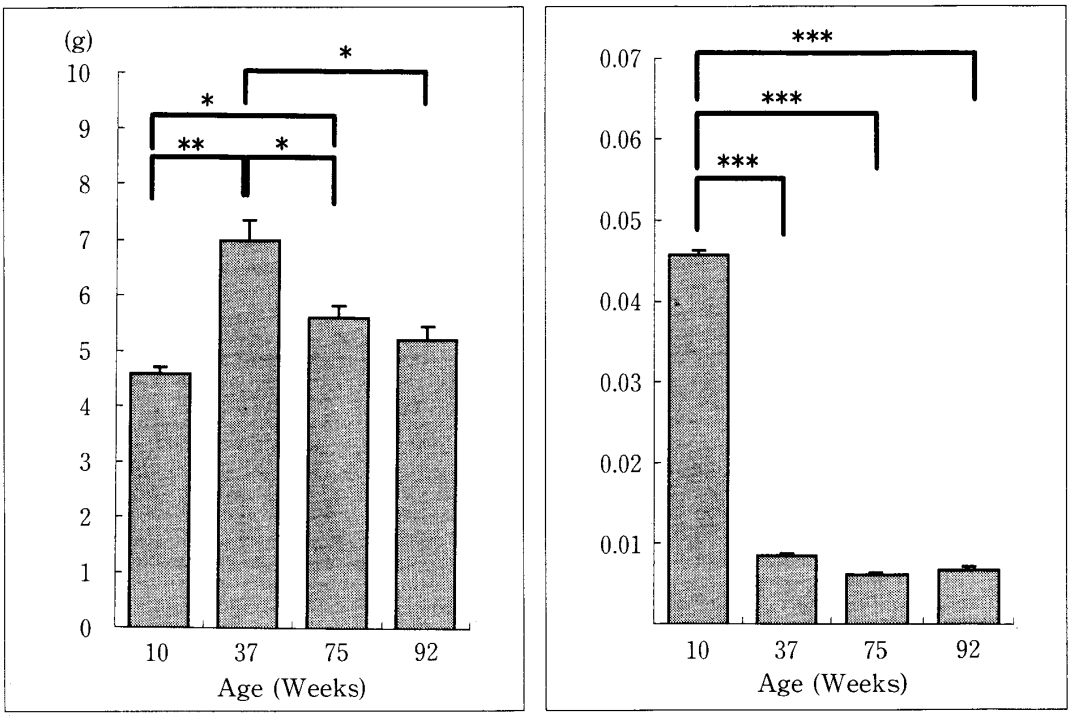

Fig. 6 Intestine weight (left) and intestine weight/body weight ratio (right) in rats aged 10, 37, 75, and 92 weeks (means ± SE). 10 weeks, n=11; 37 weeks, n=5; 75 weeks, n=10; 92 weeks, n=9. *p<0.05; **p<0.01; ***p<0.001.

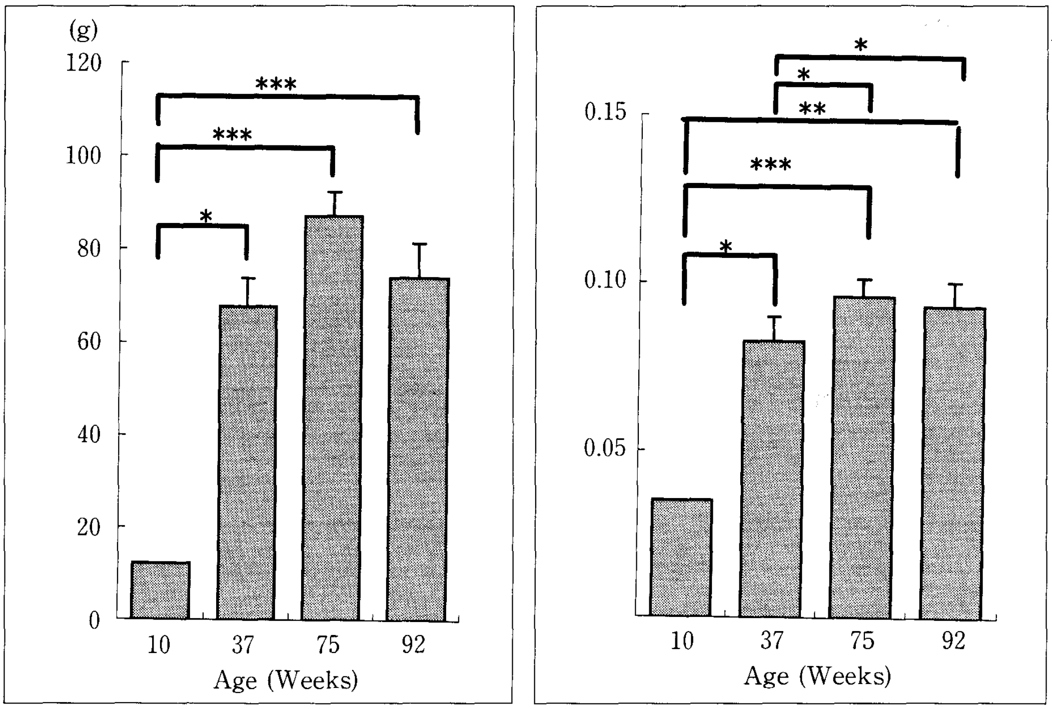

Fig. 7 Visceral fat weight (left) and visceral fat weight/body weight ratio (right) in rats aged 10, 37, 75, and 92 weeks (means ± SE). 10 weeks, n=11; 37 weeks, n=5; 75 weeks, n=10; 92 weeks, n=9. *p<0.05; **p<0.01; ***p<0.001.

weeks (Fig. 2). The value of serum total cholesterol was much higher in the 75 week old rats than the 10 week old rats (Fig. 3). Serum phospholipid levels also increased in rats aged 75 weeks (Fig. 4).

2. Internal organs: wet weight and relative weight ratio per body weight

Wet liver weight increased proportionally, in rats aged 10, 37 and 75 weeks (in rats aged 37 weeks: $p<0.001$, 75 weeks: $p<0.05$). Liver weight/body weight ratio decreased significantly at 37 weeks compared with rats aged 10 weeks ($p<0.001$), and continued to decrease at 75 and 92 weeks as well (Fig. 5). Small intestine weights were highest in the 37 week old rats ($p<0.01$). However the small intestine weight/body weight ratio in rats aged 37 weeks decreased significantly. The ratio decreased in the 75 week and 92 week old rats as well (Fig. 6). Visceral fat increased greatly in rats aged 37 weeks when compared with 10 weeks ($p<0.01$) and fat levels were also high in the rats aged 75 weeks. Visceral fat weight/body weight ratio increased progressively in rats aged 37, 75 and 92 weeks (rats aged 37 weeks: $p<0.001$, 75 weeks: $p<0.01$, 92 weeks: $p<0.001$)(Fig. 7).

Discussion

Serum protein increased slightly with aging and albumin showed a decrease. Therefore, the A/G ratio decreased. It is known that body weight and liver weight decrease with aging[17)-20)]. Our data also showed that the liver weight/body weight ratio was lower in rats aged 37, 75 and 92 weeks when compared with rats aged 10 weeks.

According to Tauchi, the number of liver cells decreases with aging[21),22)]. As the liver becomes lighter in relation to body weight, it becomes less efficient. Therefore, the albumin decrease in this experiment may be a result of reduced protein synthesis in the liver[23)].

Alkaline phosphatase didn't vary except that it was very high in the 10 week old rats. In humans it is known that alkaline phosphatase is highest during the period of maximum growth. Very old people sometimes show high values[24]. According to Sharl, alkaline phosphatase increase in older people is caused by a decrease in liver and gallbladder function[25]. Touitou says that bone loss (osteoporosis) in conjunction with a decrease in liver and gallbladder function causes an increase in alkaline phosphatase activity[26]. Our data showed no increase in alkaline phosphatase with aging while cholesterol did increase. Kritchevsky reported that cholesterol production decreases with age[27]. If this is true, the increase in blood cholesterol with aging may mean that catabolism of cholesterol is slower than the rate of biosynthesis of cholesterol.

The data is not shown but phospholipids also increased along with cholesterol. Accordingly, we inferred that high lipidemia in aging rats was the result of slower lipid catabolism rather than greater synthesis. Although the data is not shown, sodium and chlorine levels also showed little variation in the serum. That may mean that electrolyte homeostasis in the serum is maintained during aging. However, the kidney, which is basic to electrolyte metabolism, also decreased in weight along with the liver as rats got older (data not shown). McLachlan and Wasserman also reported that the diameter of the kidney and its volume decreased with age[28]. The kidney gets smaller with age but there is no loss of function as long as homeostasis of electrolytes is maintained.

A proper diet is important in combating the problems of aging, along with other factors such as one's sex, the environment in which he lives and what kind of job he does. In this experiment, eliminating diet as a factor enabled us to examine the changes in internal organ weights and serum variations caused by aging. We should also examine the effects of various diets as well.

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