Effects of Zinc Deficiency On Body Composition of Rats in Different Growth Stages

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SUMMARY

Rats of three different ages, i.e., 4 weeks old (stage 1), 5 weeks old (stage 2), and 7 weeks old (stage 3) were assigned to four groups, as follows : initiation, zinc-deficiency, ad libitum control and pair-fed control with 8 rats in each group. Before and 4 weeks after the initiation of feeding trials in each growth stage, animals were sacrificed and plasma zinc concentration and body composition were measured. In the earlier 2 stages, contents of protein, fat and ash were less in the zinc-deficient animals than the pair-fed control. And the ratio of fat/protein was lower in the zinc-deficient animals than the pair-fed ones. It is suggested that zinc deficiency more severely impaired the deposition of fat than that of protein of in the younger rats. On the other hand, these impairments desappeared in the last stage when fat deposition most rapidly occured in ad libitum groups. It appeared that the suppressive effects of feeding the zinc-deficient diet were attenuated in the latter growth stage.

It is well known that the reduction of growth rate and anorexia occur in zinc deficient animals. Although the anorexia induced the retardation of growth, Miller et al.[1] indicated that growth was impaired by moderate zinc deficiency in piglets prior to the reduction of appetite. It was also shown that, in zinc deficient animals, weights of most organs were less than those of pair-fed or ad libitum controls[2,3]. On the other hand, Park et al.[4] showed that gain of muscle was less than that of overall weight and suggested that zinc deficiency affected muscle synthesis more obviously than other components of weight gain. Because the components of gain are changed during growth stages, the suppressive effect of zinc deficiency might be different with growth stages.

MATERIALS AND METHOD

Male Wistar rats of three different ages i.e., 4 weeks old (stage 1), 5 weeks old (stage 2) and 7

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weeks old (stage 3) were assigned to one of four groups, as follows : initiation, zinc-deficiency, ad libitum control and pair-fed control with 8 rats in each group. The zinc deficient groups were freely fed the diet containing 1 mg/kg of zinc. The ad libitum controls fed freely were the control diet of the same composition as the zinc-deficient diet with supplemented $ZnCO_3$ which contained 40 mg/kg of zinc. The pair-fed groups were fed the same amount of the control diet consumed by the deficient groups. Before or 4 weeks after the initiation of feeding trials of each growth stages, animals were sacrificed. Blood samples were collected for the analysis of plasma zinc concentration by an atomic absorption spectrophotometry. After the removal of digesta, carcasses were minced and analyzed for body composition. The data were tested by analysis of variance. If the F-test showed statistical significance ($p<0.05$), means were compared by Tukey's Q-test and p values of less than 5% were considered significant.

RESULTS AND DISCUSSION

In every growth stage, the plasma zinc content was significantly less in the deficient group compared to others and the total feed intake was approximately 63% less in the zinc deficient rats than the ad libitum groups during the trials.

Body weight and dry matter content in the deficient group were almost similar to the respective initial group in every growth stage. It was shown that growth was severely suppressed in the deficient group during the experiment. Furthermore, body weight and dry matter contents were significantly less in the zinc-deficient groups of the stage 1 and 2 compared to the pair-fed groups of the respective stages. These results supported the direct effect of zinc deficiency on the reduction of body weight gain in animals. However, it is true that the retardation of body weight gain is mainly due to reduction of food intake in this experiment.

The protein gain was significantly longer in the ad libitum reats of the stages 1 and 2 than those of the stage 3. The protein content was much less in the zinc-deficient and the pair-fed animals than in the respective ad libitum ones in each growth stage. On the other hand, the protein content was significantly less in the zinc-deficient than the pair-fed group in the stage 2 and the same tendency was found in the stage 1. It has been reported that zinc deficiency suppresses protein synthesis, which is in agreement with the results of the eariler 2 growth stages of the present experiment.

The fat gain was significantly less in ad libitum rats of the stage 1 and 2 than those of the stage 3. In zinc-deficient groups of the stage 1 and 2, crude fat contents were significantly decreased. The fat content was decreased in the pair-fed animals of the stage 2 and was not changed in the stage 1. It is clear that the limitation of energy intake induced by zinc deficiency suppresses fat accumulation.

On the other hand, the fat content was significantly lower in the zinc-deficient than in the pair-fed animals in the stage 1 and the same tendency was also shown in the stage 2. It was reported that zinc deficiency impaired fat absorption throught the formation of chylomicron in the intestinal mucosa[5]. It is

Table 1. Effect of zinc deficiency on body composition (g) and plasma zinc concentration (mg l) in rats

	Initial	Zinc-def	Pair-fed	Ad libitum
	4 weeks to 8 old (stage 1)			
Plasma Zinc	1.04±0.02[a]	0.47±0.61[b]	1.41±0.29[c]	1.25±0.24[ac]
Body weight	82.5±8.6[a]	80.9±9.5[a]	98.7±11.6[b]	245.5±16.5[c]
Dry weight	21.6±2.2[a]	23.5±2.7[a]	28.8±3.7[b]	78.1±5.4[c]
Protein content	14.8±1.6[a]	18.1±2.3[b]	20.6±2.6[b]	49.7±4.4[c]
Fat content	3.8±1.2[a]	1.3±0.6[b]	4.1±1.4[a]	20.9±3.8[c]
Ash content	2.8±0.3[a]	3.8±0.4[b]	4.1±0.4[b]	7.2±0.5[c]
	5 weeks to 9 weeks old (stage 2)			
Plasma Zinc	1.01±0.17[a]	0.41±0.73[b]	1.44±0.19[c]	1.19±0.31[a]c
Body weight	112.1±8.9[a]	108.1±6.9[a]	136.4±12.5[b]	272.4±11.5[c]
Dry weight	31.0±1.8[a]	31.8±2.7[a]	38.7±3.3[b]	89.9±5.2[c]
Protein content	19.7±2.0[a]	23.6±1.4[b]	27.2±1.9[c]	55.51±2.7[d]
Fat content	6.8±1.1[a]	2.6±1.4[b]	4.0±1.3[b]	24.9±3.3[c]
Ash content	3.5±0.2[a]	4.9±0.3[b]	5.7±0.4[c]	8.4±0.9[d]
	7 weeks to 11 weeks old (stage 3)			
Plasma Zinc	1.02±0.21[a]	0.46±0.08[b]	1.41±0.21[c]	1.22±0.17[a]c
Body weight	203.7±15.4[a]	208.1±13.9[a]	217.7±9.5[a]	357.3±21.9[b]
Dry weight	58.5±4.8[a]	66.8±4.3[b]	68.4±2.8[b]	132.0±14.3[c]
Protein content	41.4±3.5[a]	46.0±3.3[b]	47.3±2.4[b]	71.3±4.9[c]
Fat content	10.6±3.0[a]	12.4±2.6[a]	13.2±2.7[a]	48.7±13.5[b]
Ash content	6.5±0.6[a]	8.6±0.8[b]	8.0±0.5[b]	10.7±1.0[c]

means+SD for 8 rats

Values with different superscripts within lines are significantly different ($p<0.05$)

possible that the reduction of fat absorption lowered fat content in zinc deficient rats. It was reported, however, that fat/muscle deposition was increased by a moderate zinc deficiency in mice, which was thought to be the result of the suppressed protein synthesis[6]. In the present experiment, the fat/muscle rations were smaller in the zinc deficient animals than the pair-fed groups of the stages 1 and 2. It suggested that the severe zinc deficiency impaired fat accmulation more remarkably than protein deposition.

Ash content was less in the zinc deficient rats compared to the pair-fed ones in the stages 1 and 2. Calcium and phosphorus are predominant minerals existing animal bodies and those minerals are mostly located in hard tissues. In the present experiment, zinc deficiency impaired mineral deposition, which suggested that zinc deficiency suppressed bone formation and / or bone mineralization as many studies indicated.

In the stage 3, the differences of body weight, and protein, fat and ash contents between zinc deficient and pair-fed groups disappeared. It appeared that the suppressive effect of feeding the zinc deficient diet was attenuated in the latter growth stage. Because, in ad libitum controls, gain of protein was much more in the earlier growth stages, ash gain was constant and fat accumulation was prominent in the last stage of this experiment, the difference of major accumulating components among growth stages can

not account for the fact that the effect of zinc deficiency was attenuated by aging. It is known that zinc concentration in bone increases with growth and that zinc in bone is exchangeable pool. It is assumed that the older rats have more stock of zinc in bone and more resistible against low intake of zinc. It is possible that rats of the stage 3 have more zinc stocks than the youger rats at the initiation of the trials. Thus, the younger rats may easily show the changes in body compositions compared to the oldest rats. Though the plasma zinc concentration in the zinc deficient rats was not affected by age of animals at the end of trials, the reduction of plasma zinc by feeding the zinc-deficient diet might be faster in the younger rats.

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