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Original Article

The Relation of Bone Mass to Dietary Intake in Female Students Enrolled in The Department of Human Nutrition of Chugokugakuen University

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Measurement of bone mass of 157 female students enrolled in The Department of Human Nutrition of Chugokugakuen University was performed by the quantitative ultrasound (QUS) method (the measured values are expressed as osteosono-assessment indexes or OSIs) in association with the measurement of bone mass influencing factors such as intake of foods classified by food groups, intake of nutrition and the energy intake ratios (energy intake proportions of carbohydrates, fats or proteins to the total energy intake). The data were analyzed and following results were obtained. The OSI is clearly negatively correlated with carbohydrate energy ratio ($r = -0.234$, $p < 0.01$) and nonalcoholic beverages (soft drinks; $r = -0.256$, $p < 0.01$).
When the OSI was compared between the high CE group (in which the carbohydrate energy ratio was 65% or higher than 65%) and the low CE group (in which the carbohydrate energy ratio was lower than 55.0%), the OSI of the former group (2.640) was significantly lower than that of the latter group (2.841). There were no significant differences in weight, BMI and experience of exercise between the low and high CE groups. But the high CE group took significantly smaller amounts of animal foods (meats, fish and eggs) and almost nutrients than the low CE group. Intake of almost nutrients of the high CE group was not satisfied recommended dietary allowance of these nutrients. The high CE group tended to be undernourished, therefore, the high carbohydrate energy ratio was thought to be a risk factor for low bone mass.

Key Words: QUS, dietary intake, carbohydrate energy ratio

Introduction

Osteoporosis is defined as a condition in which the amount of bone per unit volume is decreased but the composition remains unchanged [1]. The complications from osteoporosis such as compression micro fractures of the vertebrate and/or fracture in the femoral neck are a major cause of the lessening of activities of daily living (ADL) in the older population. Further more, after a fracture, condition of the older members of the population frequently worsens as day become bedridden and their quality of life is (QOL) seriously impairs. Thus the prevention of the osteoporosis is very important. It is very important for female students around age 20 to have a life style which can help to increase bone mass and to maintain the maximum bone mass attained in the latter

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half of their teens. We have previously analyzed the correlation between bone mass and dietary habits and some bone mass-influencing factors for female college students, and reported that the subjects with high bone mass (high osteosono-assessment index) have good nutritional habits [2]. The OSI was positively correlated to BMI, weight and the amount of exercise by the subjects [3].

In the present paper, the authors report more precise analysis of the correlation between bone mass and intake of foods and nutrients. The date was obtained from a questionnaire on dietary intake, administerd to about 157 female students, including 60 subjects already reported on in a previous paper [2].

Subjects and methods

Subjects

The subjects who participated in this study were 178 female students who were registered in the second year of Department of Human Nutrition at Chugoku Junior College and the third year of Department of Human Nutrition at Chugokugakuen University. In this report we used the data from 157 female students from whom we were able to get answers for most the items measured. Sixty subjects reported in a previous paper [2] are included as subjects.

Bone mass analysis

Bone mass was measured at the right calcaneus with the quantitative ultrasound method (QUS) by using AOS-100 (Aloca Co., Ltd., Japan). The osteosono-assessment index (OSI) which was calculated from propagation speed of ultrasound (SOS) through the calcaneus and transmission index (TI) by the formula, [SOS^2 x TI], was used as an index of bone mass. In the present paper, OSIs are expressed in units of millions ($\times 10^6$).

Dietary assessments

Investigation sheets (questionnaire) of dietary intake (diet survey) for preventing life style related diseases were purchased from Top Business Co., Ltd., Japan, and used for the foods and nutrients intake survey. An outline of items in the questionnaire is reported in a previous paper [2].

Statistical analysis

The relation of OSI to bone mass-influencing factors such as intake of food, intake of nutrition and other items was attained by obtaining partial correlation coefficient. Comparison of average values of three groups (tertile of carbohydrate energy ratio) was done with a significance test of ANOVA (one-way layout). These tests were done with significance level of 5% or 1%. These statistical analyses were conducted by using Excel Statistics 2004.

Result and discussion

The result of measurement and the result of correlation between bone mass and anthropometric measurements

1) Physical constitution, the year of menarche, physical strength, and physical activity

Mean values of measured items of the 157 subjects are shown in Table 1. Averages with standard deviations for height, weight and BMI of the subjects nearly conformed with the averages of the national nutrition survey 2002 [4] for the same age group. The mean age of menarche of the subjects was also almost the same age as that of the national nutrition survey 2002. The average and standard deviation of values of bone mass index were 2.732 ± 0.282. The Z score, the percentage of the sample to the standard OSI of females in the same age, is 100.6%. These subjects had average bone mass. This indicates that the subjects, as a whole, have average characteristics. When the correlation coefficients of their OSIs to characteristics examined were calculated, significant positive correlations were observed between the OSI and weight ($r = 0.3024$, $p < 0.01$), BMI ($r = 0.2584$, $p < 0.01$).

2) Dietary habits

Food intake, in which each food was classified by food groups, of the studied subjects is shown in Table 2. Comparing food intake of the subjects with that of the average for females in Japan between the ages of 18 and

Table 1 Base line features of physical constitution and osteosono-index (OSI)

	Mean±SD
Age (years)	19.6±0.6
Menarche age (years)	12.1±1.3
Height (cm)	158.0±5.0
Body weight (kg)	52.1±8.1
BMI (kg/m^2)[1)]	20.9±3.0
Z-score (%)[2)]	96.9±10.2
OSI ($\times 10^6$)	2.732±0.281

The subjects were 157 female students in a junior college and university.

1) BMI: Body mass Index

2) Z-score: The percentage of the sample to the standard value of OSI (same age female mean)

Table 2 Intake of foods classified by food groups[1)]

	Mean±SD (g)
Milk and dairy products	152.2±148.3
Meats	94.1±76.7
Fish	46.1±34.0
Egg	43.0±41.1
Pulses	57.7±38.9
Dark green and yellow vegetables	143.3±103.5
Other vegetables	157.4±98.9
Fruits	90.9±91.9
Algae	3.1±3.4
Rice	276.1±104.7
Flour	74.2±49.5
Sugar	19.8±19.4
Potatoes	35.9±33.6
Confectioneries	144.2±176.2

The subjects were 157 female students in a junior college and university.

Table 3 Intakes of nutrients[1)]

	Mean±SD (g)
Energy (kcal)	1716±475
Protein (g)	62.1±21.6
Fat (g)	40.9±21.3
Carbohydrate (g)	254.1±64.0
Dietary fibers (g)	11.9±4.8
Vitamin A (μgRE)	1010±555
Vitamin D (μg)	6.3±4.2
Vitamin B1 (mg)	0.90±0.34
Vitamin B2 (mg)	1.27±0.50
Vitamin C (mg)	109±70
Iron (mg)	6.9±2.5
Calcium (mg)	540±251
Phosphorus (mg)	936±324
Magnesium (mg)	225±79
Equivalent salt (g)	9.8±1.8

The subjects were 157 female students in a junior college and university.

29 [4], milks and dairy products (abbreviated as milks in the following), meats, eggs, pulse, dark green and yellow vegetables, other vegetables and fruits were taken in nearly appropriate amounts. The reason why the studied subjects had better intake status for these food groups is most likely because they are studying nutrition. But there was trend toward insufficient intake of fish, algae and potatoes, and also a trend toward excessive intake of sugar and confectionaries.

Nutrients intake of the studied subjects are shown in Table 3. Comparing nutrients intake of the subjects with that of the average for females aged 18–29 in Japan [4], most nutrients were taken in an equal or greater amount than the average. But fat intake of the studied subjects was less than the recommended dietary allowance 2000 for females aged 18–29 [5]. They were deficient in dietary fiber, iron and calcium. This situation is part of general tendency in young people in Japan. Small amount food intake among the subjects is thought to be the cause of these results. Abstemious diet and little daily activity on the part of the subjects and restrained energy intake, caused, a tendency toward insufficient intake of these nutrients to develop. The correlation coefficients of their OSIs to the percentage of the standard intake (recommended dietary allowance) of major nutrients and to the energy intake proportions (energy ratios) of carbohydrate, fat or protein to the total energy intake were calculated. Significant negative correlations were observed between the OSI and the percentage of standard intake of nonalcoholic beverages ($r = -0.256$, $p < 0.01$) and between the OSI and the carbohydrate energy ratio (the energy intake proportion of carbohydrate to the total energy intake, $r = -0.234$, $p < 0.01$). No significant correlation between the OSI and the intake of the eight food groups, and between the OSI and the percentage of standard intake of all nutrients was observed. The CE ratio (carbohydrate energy ratio) which showed negative correlation with the OSI showed normal distribution.

The subjects were divided into a high CE group (65.0 % and more than 65.0% CE ratio), a medium CE group (ranging from 55.0% to 65.0% CE ratio) and a low CE group (less than 55.0% CE ratio), and comparison of the average values was done with a significance test of the ANOVA (one-way layout). The averages of the CE ratio of each group are 68.7%, 58.2% and 50.6%, respectively. The high and low CE groups accounted the about 20% of all subjects examined in the present paper. The OSI of the high CE group (2.640) was significantly ($p < 0.01$) lower than the OSI of the low CE group (2.841). This result suggests that there is a correlation between the carbohydrate energy ratio and low bone mass. Generally, a high carbohydrate energy ratio in a diet indicates undernutrition, because in this case insufficient intake of protein and fat brings about insufficient intake of vitamins and minerals. On the other hand, a low carbohydrate energy ratio and a high fat energy ratio of a diet exist a tendency toward excess intake of animal fat and protein, and consequently there are high risks of obesity, hyperlipidemia and arterioscleosis [6]. Appropriate range of the

energy ratio and the animal protein ratio (animal protein intake account for percentage of the total protein intake) in healthy adult were carbohydrate energy ratio 55-65%, fat energy ratio 20-25%, protein energy ratio 12-15% and animal protein ratio 40-50% [5]. Each energy ratio and the animal protein ratio of the high, medium and low CE groups of the subjects are shown in Fig 1. There were significant differences between high and low CE ratio groups in all the items. The high CE ratio group showed lower limits of appropriate ranges of all their items, and the low CE ratio group deviated slightly toward animal foods, and tended toward over-nutrition. Concerning the adequacy of major nutrients, intake of nutrients for the high CE group showed the lowest adequacy among the three CE energy ratio groups, with the exception of carbohydrates. And, all nutrients, except of vitamin A and B_2, taken in the high CE group were less than the 100% adequacy (Fig. 2).

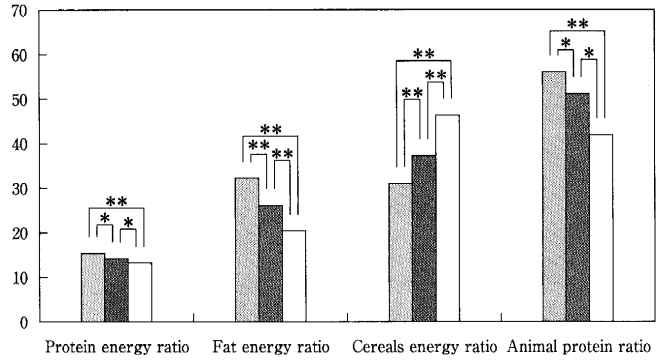

Fig. 1 Each energy ratio and animal protein ratio of the hight, medium and low carbohydrate energy ratio groups.
The subjects were 157 female students in a junior college and university.
- Low carbohydrate energy ratio group (carbohydrate energy ratio less than 55.0%, 2.841 OSIs, 32 peoples)
- Medium carbohydrate energy ratio group (carbohydrate energy ratio more than 55.0% and less than 65.0%, 2.7302 OSIs, 89 peoples)
- High carbohydrate energy ratio group (carbohydrate energy ratio more than 65.0%, 2.640 OSIs, 36 peoples)

*: $p < 0.05$ **: $p < 0.01$

The bone mass in young adults (estimated when bone mass is at its peak) is determined by genetic factors, sex, workload on bones and the nutritional intake, including calcium. It is, however, difficult to distinguish the effect of calcium intake on peak bone mass from that of energy and protein or other nutrients since calcium is associated with these nutrients in any diet [1]. The present study also showed no significant correlation between the bone mass and calcium or vitamin D. But, some significant correlation between bone mass and nutritional intake was obser-

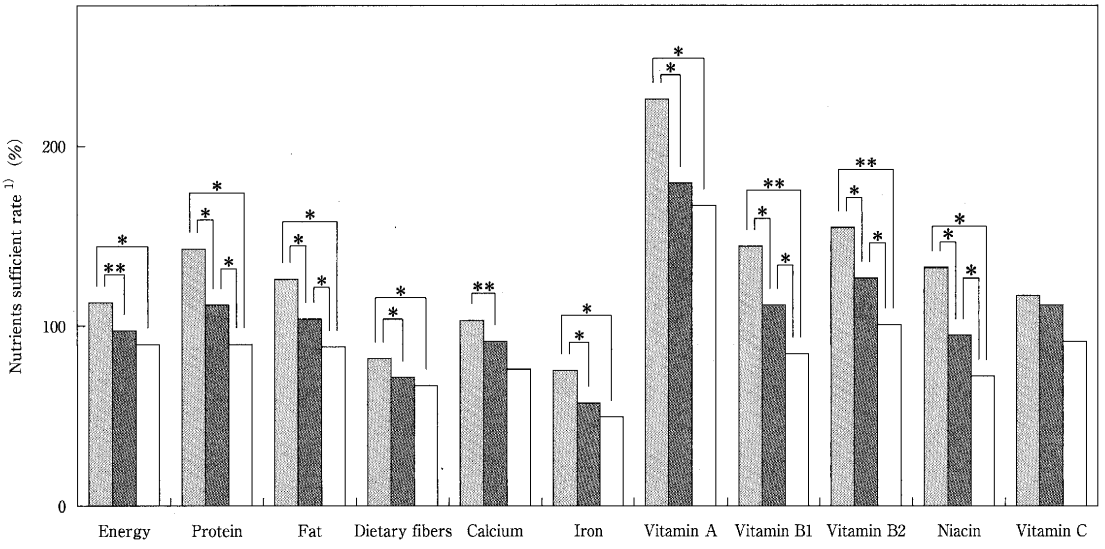

Fig. 2 Comparison of nutrients intake among three carbohydrate energy ratio groups.
The subjects were 157 female students in a junior college and university.
1) Nutrients sufficient rate: The percentage of the sample to the standard intake (recommended dietary allowance for females ages 18-29)
- Low carbohydrate energy ratio group (carbohydrate energy ratio less than 55.0%, 2.841 OSIs, 32 people)
- Medium carbohydrate energy ratio group (carbohydrate energy ratio more than 55.0% and less than 65.0%, 2.7302 OSIs, 89 people)
- High carbohydrate energy ratio group (carbohydrate energy ratio more than 65.0%, 2.640 OSIs, 36 people)

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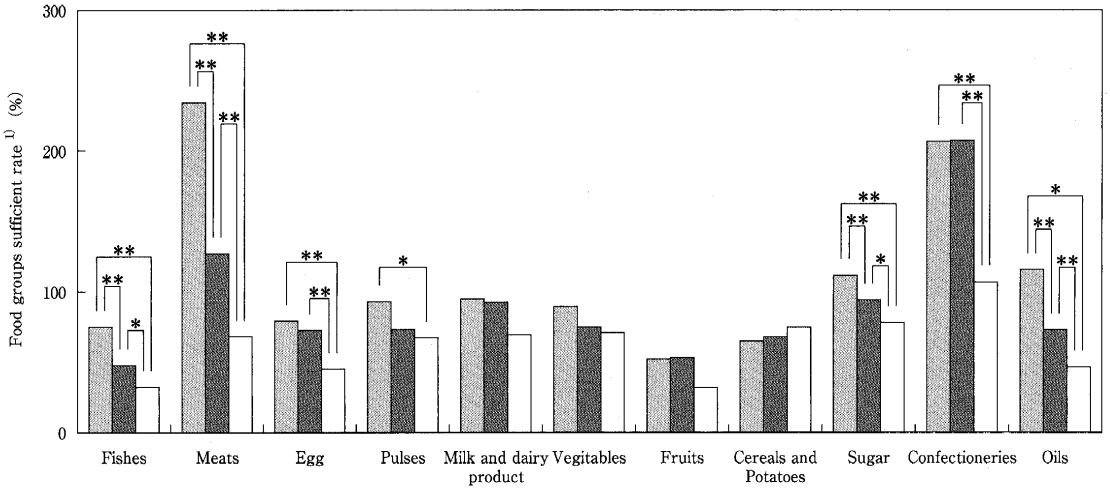

Fig. 3 Comparison of food groups intake among three carbohydrate energy ratio groups.
The subjects were 157 female students in a junior college and university.
Low carbohydrate energy ratio group (carbohydrate energy ratio less than 55.0%, 2.841 OSIs, 32 people)
Medium carbohydrate energy ratio group (carbohydrate energy ratio more than 55.0% and less than 65.0%, 2.7302 OSIs, 89 people)
High carbohydrate energy ratio group (carbohydrate energy ratio more than 65.0%, 2.640 OSIs, 36 people)
*: $p < 0.05$ **: $p < 0.01$

ved. The high CE ratio group which represented low bone mass showed generally high carbohydrate intake as the staple food and significantly low intake of fish, meats, eggs and beans, which are the only sources of good quality protein (Fig. 3). And in this situation almost all nutrients, including calcium, do not meet the 100% nutrient adequacy. As the result, the general low intake level of food and nutrients caused by an unbalanced diet due to high carbohydrate intake is thought to influence bone mass.

In conclusion, it is suggested that adolescent girls who have unbalanced eating habits with high carbohydrate intake, tend to have low bone mass due to the general low intake level of nutrients.

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References

1. R, Smith: Bone mineral. HUMAN NUTRITION and DIETICS 10th edition. CHURCHILL LIVINGSTONE (2000), 165-175.
2. Ko, S: The relation of bone mass to physical constitution, physical strength and dietary intake in female students of a junior college. CHUGOKUGAKUEN Journal (2002) **1**, 19-25.
3. Ko, S: The relation of bone mass to experience of fractures, diet, exercise and progress years of post-menarche in female junior college students. CHUGOKUGAKUEN Journal (2004) **3**, 1-6.
4. A Society for the research of Health and Nutrition; The national nutrition survey 2002. Daiichi-Syuppan (2004) (in Japanese)
5. A Society for the research of Health and Nutrition; A guide book for the dietary reference intakes. Daiichi-Syuppan (2000) (in Japanese)
6. J, Mann: Disease of the heart and circulation: the role of dietary factors in aetiology and manegement. HUMAN NUTRITION and DIETICS 10th edition. CHURCHILL LIVINGSTONE (2000), 689-714.

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