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□Original Article□

Bone Mineral Density and Affecting Factors in College Women*

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ABSTRACT

The purpose of this study was to investigate Bone Mineral Density(BMD) and affecting factors on BMD of college women in Seoul. The subjects were 47 healthy college women aged 18-25 years. Antrophometric and body fat measurements were performed by Bioelectrical Impedance Fatness Analyzer(Tanita TVF 202). Blood pressure and pulse frequency were measured. Dietary intakes and general living habits were examined through questionnaires and nutrient intakes were analyzed by Computer Aided Nutritional Analysis(CAN) program for professional. Serum total cholesterol, TG(triglyceride), HDL-cholesterol, total protein, albumin, GOT, calcium were measured by Spotchem(SP-4410). Serum osteocalcin and alkaline phosphatase(ALP) were measured to monitor bone formation. BMD of lumbar spine(L2-L4), right hip(neck, ward's triangle, trochanter) and right forearm were measured by Dual Energy X-ray Absorptiometry(DEXA). Muscle strength was measured by examining leg flexion strength(right and left), leg extension power(right and left), handgrip power(right and left) and back strength. All data were statistically analyzed by the SAS PC package program. BMD of college women was normal(by WHO, 1994). Their muscle strength was bad(by national fitness guidebook, 1995). Only a small number of them exercised(32.6% of subjects). There was no significant difference among BMD, muscle strength and % body fat($p<0.05$). There were significant differences between BMD and total cholesterol as well as TG and VLDL-cholesterol($p<0.05$). Total cholesterol was associated with decreasing BMD of the right forearm($p<0.05$). TG and VLDL-cholesterol are associated with increasing BMD of right hip ward's triangle($p<0.05$). There were significant differences among BMD, ALP and serum total protein. ALP was associated with decreasing BMD of the right forearm($p<0.05$). There were significant differences between BMD and Ca as well as between Na and K intakes $p<0.05$). Intakes of Na and K were associated with decreasing BMD of the right forearm(UD)($p<0.05$). There were significant differences between in BMD and pulse frequency and serum albumin($p<0.05$). Serum albumin is associated with increasing BMD of L2-L4($p<0.05$), right hip neck($p<0.05$). % Body fat, TG, VLDL-C, Ca intake, pulse frequency and serum albumin were associated with increasing BMD($p<0.05$). Intakes of Na and K, ALP, total cholesterol, total protein and height are associated with decreasing BMD($p<0.05$). Overall results indicate that Ca intake of subjects was low, and their protein and Na intakes were high. Therefore, subjects needed to increase Ca intake but to be moderate in protein and Na intakes in order to increase BMD. Body exercise was recommended to increase BMD as well. (*Korean J Community Nutrition* 1(2) : 98~107, 1999)

KEY WORDS : bone mineral density(BMD) · college women in Seoul · %body fat · muscle strength · osteocalcin · alkaline phosphatase(ALP).

Introduction

Osteoporosis has drawn a lot of attention since the average life span and the percentage of senior citizens recently increased and personal interest in health became intense. There is an increasing awareness and interest in osteoporosis among the people in Korea, and some causes of the disease have been discovered ; however, according to some reports(Kim et al. 1995), osteoporosis is not yet well recognized comparatively, and the nation wide statistics on osteoporosis patients is absent so far. Now that there are no secure and positive treatments for the patients of such a disease, precaution against the disease is considered the best. The best-known precaution is to maximize bone mineral density during the growth period and to protect dangerous factors of bone loss.

The major factors of bone density formation are divided into two : one is genetic factor and the other is environmental. The major environmental factors include life style, the amount of physical movement, dietary intake and so forth(Metz et al. 1993 ; Petra et al. 1994 ; Rowe

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1994 ; Welten et al. 1994). Adults are bound to have physiological bone loss as they grow older and the degree of bone loss depends on heredity, internal secretion, environmental factors and so on(Draft 1978 ; Drinkwater et al. 1984 ; Pollizer et al. 1989). In other words, genetic factors include gender, stem, family history, and aqueous contrastive gene of vitamin D. Internal secretive factors include the retardation of the first menstruation and early menopause. Besides, the environ-mental factors are said to be related to the lack of calcium intake, heavy drinking, high protein diet, high salt diet, and excessive intake of caffeines and lack of exercise.

While genetic factors play an important role in bone mass and quality in the Western society, what people have good nutrition, environmental factors such as Ca intake are considered critical of bone mass and quality in the Asian society, in which people have relatively poor nutrition(Hirota et al. 1992).

Dietary habits need to be well taken care of because a variety of handicaps can be caused by dietary nutrition factors in formulating the maximum bone density during a growing period and bringing about osteoporosis. College students are likely to be dependent on cheap starches or some foods that go with soft drinks because of their limited economic capacities(Jakovits et al. 1977). The young have formulated their poor dietary habits, skipping meals, eating frequent snacks, choosing foods wrongly with their poor nutrition knowledge. The excessive appearance-oriented attention of female college students encourages them to strive for extreme weight loss and have irregular dietary habits, and also causes serious health problems such as anemia(Hudson et al. 1988 ; NIH 1993 ; Wadden et al. 1992 ; Zwan et al. 1994). On the other hand, they often overeat in some cases : it may be defined as bulimia, which is a serious problem among female college students(Chang et al. 1988). General dietary habits of college students not only is a reflection of that of the past generation, but also informs potential dietary habits in their adulthood, which is the next step of their growth. Therefore, this study is designed to discover the level of bone density and related factors of female college students who will influence their future and dietary habits as well as reflect their past ones. Also, this study will contribute to the dietary improvements for increasing bone density, and hopefully be utilized for the development of public health.

Subjects and Methods

1. Subjects

Subjects for this study were 47 college students in Seoul, Korea. The anthropometric measurement, bone mineral density measurement and blood collection and questionnaire examination were conducted from October through December, 1998.

2. Dietary intakes

Dietary intakes were assessed by 3-day food record method. Nutrient intakes were analized by Computer Aided Nutritional analysis program for professonals(CAN-PRO 1997).

3. Sample preparation

Venous blood was collected into heparin non-treated syrnges after a twelve-hour fast.Blood samples were allowed to clot at room temperature for approximately 30 minutes. Blood samples was centrifuged at 3000rpm for 20 minutes at 4℃ to separate serum. The serum amples were frozen under nitrogen and stored at −80℃ until the analysis.

4. Analysis of serum GOT, total protein, albumin, total cholesterol, TG, and Ca

Serum GOT, total protein, albumin, total cholesterol, TG and Ca were measured on strips by SPOT CHEM (SP-4410 KDK Co. Japan). VLDL-cholesterol, LDL-cholesterol, and LDL/HDL were caculated by the Friedwald equation as follows :

1) VLDL-cholesterol = Triglyceride/5
2) LDL-cholesterol(mg/dl) = Total cholesterol − (VLDL-cholesterol + HDL-cholesterol)

5. Analysis of bone formation index

Bone biochemical markers are composed of bone formation index and bone absorption index. In the measurement of the bone formation index ; osteocalcin, and alkaline phosphatase were analyzed.

6. Measurements

Athropometric measurements were composed of height, body weight and body fat. The measurements were performed by Bio-electric Impedence Fatness Analyzer(Tanita TVF 202 Japan) at the Physiological Laboratory of Korea Sport Science Institute(KSSI)). Blood pressure and

Pulse rate were measured on the brachial artery by digital phygmomanometer(Hartman HG160 Digital, Germany).

7. Measurement of bone mineral density

Bone mineral density of lumbar spine, right hip, and right forearm were mearsured by Dual Energy X-ray Absorptiometry(DEXA Hologic QDR-4500C) at the National Fitness Center of KSSI.

8. Measurement of muscle strength

Hand grip power, Back strength(Takei 1270A Japan) and Leg flexion strength, Legextension power(Takei 1281 Japan) were measured at the Physiological Laboratory of KSSI.

9. Statistical analysis

Collected data were statistically analyzed by SAS(Statistical Analysis System) PC package. All data were expressed as mean±SE. Statistically significant differences were accepted at $p<0.05$. The correlation between bone density and related factors, Such as body fat, total cholesterol, triglycerides, VLDL-cholesterol, muscle strength, osteocalcin, ALP, the intakes of protein, ca, Na, serum total protein, albumin, age, height, weight, GOT and pulse- is obtained by Pearson's Correlation Coefficient.

Results and Discussion

1. General Characteristics and Anthropometric Measurements

The subjects in this study were between18 to 25 years of age, and the average age was 20.1±1.0. The average height was 160.9±3.3cm, and the average pulse(time/minute) was 77.5±6.8. Compared with Korean adult standard stature, the height and pulse were normal. Body mass index(kg/m^2), or 19.1±1.1, and body fat(%), or 24.3±3 were revealed to be normal even though the body mass index is lower than that of a female college student, 22.0±0.8(Kim et al. 1997). The Systolic Blood Pressure, 115.3.±7.2mmHg, and the Diastolic Blood Pressure, 72.2.±4.8mmHg were normal ; however, they appear to be higher than those of Kim(1997), namely, 103.2.±3.1mmHg, and 65.4±2.2mmHg. The average weight, 51.8±3.8kg tends to be lower than the standard weight, 53kg of Korean adult standard stature(Table 1).

2. The investigation of Dietary Intakes

The dietary intakes were analyzed by Computer Aided Nutritional Analysis Program(CAN-Pro, 1997, Table 2) after three days of food-records. Daily intakes of energy and protein were 1,701.6±486.1kcal(83.9% of RDA), and 90.9±23.5g respectively while the protein intake was higher than that of the Recommended Dietary Allowances for Koreans, or 60g. Animal protein intake was 31.4±13.5g, and vegitable protein 59.4±122.8g ; dietary lipid intake was 49.5±21.1g and carbohydrate intake 249.3±74.7g, dietary cellulose intake was 4.6±2.1g. Ca intake, 472.1±247.7mg, and was 65.1% of RDA. Among them, animal protein Ca intake was 245±206.0mg, and plant protein Ca intake was 227.2±101.3. P intake was 916.0±320.0mg, and was 126.6% of RDA. The Ca : P ratio was 1 : 2. This showed that Ca intake was low and P intake was high. Iron intake was 10.6±4.9mg, 58.6%

Table 1. General characteristics of college women

Variables	Mean±SE[1]	Normal Value[2]
Age(years)	20.1±1.0	20 – 29
Height(cm)	160.9±3.3	160
Weight(kg)	51.8±3.8	53
BMI(kg/m^2)[3]	19.1±1.1	18.5 – 24.9
Body fat(%)	24.3±3.0	21 – 24
Blood pressure(mmHg)		
Systolic	115.3±7.2	<135
Diastolic	72.2±4.8	<85
Pulse frequency(count/min)	77.5±6.8	70

1) SE=standard error 2) Normal Value=Standard of Korea
3) BMI(Body mass index)=weight(kg)/height(m^2)

Table 2. Average daily nutrient intake of college women

Nutrient	Intake	%RDA
Energy(kcal)	1,701.6± 486.1	83.9
Protein(g)	90.9± 123.5	147.9
Animal protein(g)	31.4± 13.6	
Plant protein(g)	59.4± 122.8	
Fat(g)	49.6± 21.1	
Cabohydrate(g)	249.3± 74.7	
Fiber(g)	4.6± 2.1	
Ca(mg)	472.1± 247.7	65.1
Animal Ca(mg)	245.0± 206.0	
Plant Ca(mg)	227.1± 101.3	
P(mg)	916.0± 320.0	126.6
Fe(mg)	10.6± 4.9	58.6
Na(mg)	3,870.5±1,923.5	
K(mg)	1,983.5± 692.0	

of RDA, which was regarded as a low intake. Sodium intake was 3,870.5±1,923.5g and was higher than RDA.

While the subjects in this study had 147.9% of RDA in protein intake, 83.9% of RDA in energy intake, and 65.1% of RDA in Ca intake, the results of Yoo's case showed that the protein intake was 100.9% of RDA, energy intake was 86.1% of RDA, and 74.3% of RDA in Ca intake (Yoo et al. 1998) In this study, the protein intake was high.

Protein affects body Ca and bone metabolism through the change of kidney function. That is to say, several studies on animals(Howe et al. 1983 ; Petitto et al. 1984) and humans(Koo 1982 ; Lutz et al. 1981 ; Zemel et al. 1981) have reported that high protein diet in the growing period increases the amount of Ca excretion through urine, affecting the structure and function of kidney and enhances Ca resorption from bone structure in order to maintain the level of blood Ca evenly. So the subjects should reduce the protein intake because the tendency to high protein intake increased Ca excretion of urine and and Ca resorption of bone, and that may induce bad influence on bone metabolism. And then the Ca intake must be emphasized and increase so as to reach peak bone density.

3. The Clinical Analyses of blood

Serum total cholesterol was 167.2±21.5mg/dl, Triglyceride 74.3±18.4mg/dl, VLDL-Cholesterol 14.9±4.9mg/dl, HDL-cholesterol 51.2±8.0mg/dl, LDL-Cholesterol 98.8±23.7mg/dl, and the LDL-cholesterol/HDL-cholesterol ratio was 1.9±0.6. These results indicated that the lipid composition of the subjects was normal.

Serum total protein was 8.9±0.5g/dl, and albumin 5.1±0.3g/dl. The total protein was a little higher than the normal range, and albumin within the normal range. Serum GOT was 20.7±3.31IU/L, and serum Ca 8.7±0.4mg/dl. The serum GOT was on the normal range although it was higher than the GOT of Kim's study, 16.1IU/L(Kim et al. 1997). Likewise, the serum Ca was on the normal range, but it was still lower than serum Ca of Yoo's case, 9.3mg/dl(Yoo et al. 1998). The comparison between the normal range and the results was shown in Table 3.

4. The Analysis of Bone Formation Index

Bone formation indices, serum Alkaline Phosphatase (ALP) and Osteocalcin were 68.0±9.2unit/ml and 6.88±2.72ng/ml respectively, which were within the normal range. That was the same level of adults. The subjects in this study were in the stage where their bone formation was more significant than their bone loss and their bone mass was increasing(Matkovic 1991).

Table 3. Serum total cholesterol, triglyceride(TG), VLDL-cholesterol (VLDL-C), HDL-cholesterol(HDL-C), LDL-cholesterol(LDL-C), Total protein, Albumin, GOT of college women

	Mean±SE[1)]	Normal Value[2)]
Total cholesterol(mg/dl)	167.2±21.5	130–230
TG(mg/dl)	74.3±18.4	50 150
VLDL-C(mg/dl)	14.9± 4.9	
HDL-C(mg/dl)	51.2± 8.0	50–60
LDL-C(mg/dl)	98.8±23.7	130
LDL-C/HDL-C	1.9± 0.6	
Total protein(g/dl)	8.9± 0.5	6.7–8.3
Albumin(g/dl)	5.1± 0.3	3.8–5.1
GOT(IU/L)	20.7± 3.3	0–35

1) SE=standard error
2) Normal Value=Standard of Korea(79 ~ 83)

Table 4. Serum ALP(alkaline phosphatase) and osteocalcin of college women

	Mean±SE[1)]	Normal Value[2)]
Serum ALP(unit/ml)	68.0 ±9.2	30–130
Serum osteocalcin(ng/ml)	6.88±2.72	5– 25

1) SE=standard error
2) Normal Value=Standard of Korea

5. BMD Measurement

Bone density was measured in the Lumbar Spine, Right Hip, and Right Forearm. Regional average bone densities were as follows : lumbar spine(L2-L4) is 0.964±0.082g/cm, total right hip 0.893±0.065g/cm, the neck of right hip was 0.847±0.079g/cm, Trochanter 0.656±0.069g/cm, Inter trochanteric region 1.015±0.106g/cm, Ward's Triangle 0.784±0.093g/cm, and right for-earm total was 0.583±0.02g/cm(Table 5).

Many of the subjects in this study had over 90% BMDC of lumbar spine and right hip, and over 100% BMD of the right forearm total. These results suggest that they were higher than those standard BMD of WHO (1994). However, the density of right hip Inter was as low as 88% BMD and increased risk of osteopenia but as regarded to age of subjects in this study, Still their bone didn't reach peak bone mass yet. Lumbar spine had the normal bone density, but about 30% of the subjects were observed to had scoliosis.

There are three factors in defining intensity of bone :

Table 5. BMD(Bone mineral density) of college women

Region	BMD[1]±SE[2]	T(%)	Z(%)
Lumbar spine(L2-L4)	0.964±0.085	−0.829±0.0686(90.6%)	−0.586±0.0716(90.3%)
Right hip[3]			
(Total)	0.893±0.084	−0.721±0.0715(91.4%)	−0.687±0.0685(90.9%)
(Neck)	0.847±0.097	−0.447±0.0953(94.7%)	−0.537±0.0862(93.4%)
(Trochanter)	0.656±0.069	−0.677±0.0810(90.8%)	−0.854±0.0759(91.7%)
(Inter)	1.015±0.106	−0.898±0.0953(88.5%)	−0.441±0.0736(89.2%)
(Ward's triangle)	0.784±0.114	−0.064±0.1003(98.2%)	−0.028±0.1000(99.3%)
Right forearm[4](Total)	0.583±0.036	0.323±0.0604(103.3%)	0.322±0.0587(103.2%)

1) unit=g/cm2 2) SE=standard error 3)Right hip=Neck+Trochanter+Inter trochanteric reagion
4)Right forearm=1/3(Radius+Ulna[R] 1/3 : 1/3 distal)+Mid(Mid-distal)+UD(Ulna distal : Ultra distal)
*Age and sex matched T=peak born mass Z=age matched

bone mass, bone quality, and geometry. Even, a problem in one of the three factors may cause a problem of the intensity of bone. Fractures of osteoporosis are a signal of an extremely low intensity of bone. Scoliosis is a problem of bone geometry and means that there is an increase in the danger of bone fracture.

The regional averages of bone density in Yoo's case was the following : lumbar spine(2−4) is 0.99g/cm, hip neck 0.85g/cm, hip trochanter 0.69g/cm, hip ward's triangle 0.85g/cm(Yoo et al. 1998). The measurements of lumbar spine and hip neck were similar to those of this study, but the measurements of hip trochanter and hip ward's triangle were higher than those of this study.

Also, daughter(the average age : 27.4) in the study of Lee's on Mother and Daughter Bone Density have lumbar spine(2−4), 1.19g/cm, hip neck, 0.89g/cm, hip trochanter, 0.92g/cm, and hip ward's triangle 0.89g/cm (Lee et al. 1996). The bone densities of females aged from 17 to 34 in Lee's study(lumbar spine : 2−4, 1.21g/cm, hip neck : 0.92g/cm, hip ward's triangle : 0.89g/cm, hip trochanter : 0.86g/cm) were higher than those of this study.

Bone density reaches its peak as it increases from puberty to the late twenties. Although there is no concrete agreement on exactly when females reach peak bone density, it can be said that the bone density of the current female college students continues to grow(Meema et al. 1976 ; Son 1996).

It is reported that females generally reach peak bone density at the ages of about 20−25, which increases until their late twenties or the age of 30, complete the peak bone density from about 30 to 34, and maintain it till at the ages of 35−40(Matcovic et al. 1991). There are reports that peak bone density has a great deal of effects on bone loss and the danger of fracture due to aging (Kim 1994). It was also reported that physiological bone loss progresses gradually with aging, but the degree of the bone density can be changed by a variety of influential factors, particularly, the amount of peak bone density.

The outcome of bone density measurement in this study shows that the level of bone density of the subjects in this study was within normal range, but was located in a lower part of the body than those of Yoo, Lee and others(Lee & Lee 1996 ; Lee et al. 1996 ; Yoo et al. 1998). Furthermore, the fact that some 30% of the subjects in this study had scoliosis and can predict that the danger of fracture will enhance when the physiological bone loss is in gradual progress with aging. A great amount of Ca intake, weight training, and adjustment of spine are required so that the bone density of the subjects in this study can reach the peak, taking it into account that they are in the age in which bone formation takes place.

6. The Measurement of Muscle Strength

The measurements of muscle strength are as follows (Table 6) : leg flexion strength is 17.83±2.68(kg)(right) and 17.95±3.09(kg), leg extension power 37.09±5.36 (right) and 35.77±5.19(kg), hand grip power 25.71±3.26(kg)(right) and 24.64±3.17(kg), and back strength is 65.14±11.22(kg). The muscle strength of the subjects in this study was marked as "bad" measured by the criteria of the National Fitness Guidebook(KSSI 1995). Muscle contraction brings about bone formation by providing physical stress that is concentrated on bone regionally (Layon 1984 ; Layon 1992).

Also, the mechanism of bone density increase by muscle strength causes osteoblastic activity and promotes bone metabolism by creating bending and loading stress that are endowed with bone by physical stimulus causing the electric potential difference of the regional osteocyte (Cho 1998).

The role of muscle strength became obvious in the recent study. Dolye et al. reported that there is a significant correlation between the weight of lumbar spine 3 and that of lumbar muscle strength, a similar correlation between female bone density of lumbar spine and back strength after menopause(Dolye et al. 1970). They also summarized that lumbar spine, proximal femur, and extensor of the body are closely related with one another. They suggest that muscle weight is an important factor in deciding the bone weight when lumbar spin, proximal femur, and extensor exert their strength on the area where bone and muscle are connected. Therefore, it can be assumed that there are correlative relationship between lumbar spine and back strength, between lumbar spine and proximal femur, between lumbar spine and leg extension power in this study.

A study on tennis players such as Huddeleston et al. indicates that the bone density of an usually employed arm is higher than that of an unemployed arm(Hyddeleston et al. 1980). This outcome allows us to learn the importance of bone stimulus given by muscle contraction, but this correlation is not very clear in the results of the research on muscle strength of the particular area and the bone density of that area in female subjects.

Table 6. Muscle strength of college women

Region	Mean±SE[1)]
Leg flexion strength(kg)	
Right	17.83± 2.68
Left	17.95± 3.09
Leg extension power(kg)	
Right	37.09± 5.36
Left	35.77± 5.19
Hand grip power(kg)	
Right	25.71± 3.26
Left	24.64± 3.17
Back strength(kg)	65.14±11.22

1) SE=standard error

It is generally said that the more muscle strength is, the more bone formation and bone density are. In this study, their muscle strength was low, though their bone density was normal. And the subjects are still in the period that their bone formation is in progress. Therefore, their bones and muscles should be properly stimulated by weight training.

The correlation between Various related Factors and BMD

1. The correlation between body fat, total cholesterol, T.G. and BMD

The relation between body fat and bone density discloses that the correlative relationship between lumbar spine and right hip, between the bone density of the right forearm and body fat failed to show the similar correlation at $\alpha=0.05$, but the bone density of MID.

These relations support the reports that the more body fat is, the higher bone density(Stacie et al. 1995), and the bone density of obese females is higher than that of thin females namely, as weight training hardens bones, so weight gravity of heavy weight is created to harden bone in obesity case(Layon 1984, 1992).

The correlative relations between total blood cholesterol and TG, between VLDL-cholesterol and bone density showed that the Right forearm total and the total cholesterol had a malignant correlation($r=-0.369$, $p<0.05$) ; ward's triangle, TG, and VLDL-cholesterol have a benign correlation, respectively($r=0.347$, $p<0.05$)(Table 7).

2. The correlation between muscle strength and BMD

The correlation between muscle strength and bone density represents that the relationship between the bone densities of lumbar spine, right hip, and right forearm

Table 7. Pearson's correlation coefficint among BMD, % Body fat, To-

	BMD(L2-L4)	RHT	RHN	RHW	RHTR	RHI	RAT	RA1/3	RAMID	RAUD
% Body fat	0.038	0.151	0.169	0.158	0.212	0.104	0.061	0.238	0.259	0.227
Total cholesterol	0.184	−0.041	−0.024	0.112	−0.080	−0.038	−0.369*	−0.066	−0.121	−0.143
TG	0.053	0.210	0.347*	0.122	0.109	0.202	−0.089	−0.063	−0.024	−0.038
VLDL-C	0.053	0.210	0.347*	0.122	0.109	0.202	−0.089	−0.063	−0.024	−0.038

*p<0.05
BMDL2-L4 : Lumbar spine 2−4
BMD RHT : Right hip total BMD
RHN : Right hip neck BMD
RHW : Right hip ward's triangle BMD
RHTR : Right hip trochanter BMD
RHI : Right hip inter BMD
RAT : Right forearm total BMD
RA1/3 : Right forearm Radius+Ulna[R] 1/3 BMD
RAMID : Right forearm MID BMD
RAUD : Right forearm UD BMD

and muscle strength, failed to show a significant correlation in $p<0.05$(Table 8).

The muscle contraction creates bone formation by providing physical stress that is focused on bone regionally. Also, Sinaki et al.(1986) stated that there is a notable correlation between the bone density of female lumbar spine after menopause and back strength, and there is a close relationship between the bone density of lumbar spine and right hip and extensor of body(Halle et al. 1990 ; Sinaki et al. 1986). Huddelcston et al.(1980) suggested that the bone density of a mainly employed arm is higher than that of an unemployed arm. However, there were not correlative relationships between lumbar spine and back strength, and between hip and leg extension power as was indicated in Table 8.

As there was a remarkable difference in the bone densities between one group of people who work out regularly more than three times a week in a long term period and the other who don't in the studies of Park's and Lee's(Lee et al. 1997 ; Park et al. 1997 ; Park 1998), there was no significant difference in the degrees of muscle streng-th, because the muscle strength of the subjects in this study was evaluated as "bad" according to the standard of National Fitness Guidebook, and the regular and irregular work-out period was less than three months. Therefore, muscle strength didn't put a great influence on bone density, and the correlation between bone density and muscle strength is considered to be insignificant.

3. The correlation between osteocalcin, alkaline phosphatase(ALP) and BMD

The relationship of osteocalcin, ALP, and bone density shows that bone density and osteocalcin have no important correlation at $\alpha<0.05$, but the relationship of right forearm total, bone density, and ALP($r=-0.475$, $p<0.05$) was malignant.

It is generally known that serum osteocalcin in females tends to grow gradually as they get older until they are 30 years old or so, and serum osteocalcin becomes about twice as much as the bone replacement starts augmenting drastically after menopause(Kim 1996). The reason why serum osteocalcin is in high concentration is considered that bone formation is established to counteract bone loss after menopause. Additionally, the higher the index of bone formation, the higher the index of bone absorption ; the thickness of serum osteocalcin is higher than the normal range, and the correlation between the index of bone metabolism and that of bone formation is significantly high. Alkaline phosphatase is formulated in osteoblast(Hong et al. 1999), secreted and isolated into the blood as an index that can predict the progress of bone creation(Han 1998). It increases in females after menopause(Kim 1996), and decreases when the inhibitor of bone absorption is utilized. Besides, it increases in renal osteodystrophy, hyperpara thyroidsim, hyperthyroidism, osteomalacia and so forth ; this study, however, represents the fact that there are malignant relationships between the density of right forearm total and ALP, and between the bone density of UD and ALP is related to the enhancement of ALP after menopause, even though it failed to indicate a high numerical value as an index of bone formation even in the period of bone formation of females' in their twenties. Table 9 shows the relationship between bone density, osteocalcin, and ALP.

4. The correlation of the intakes of protein, potassium, and sodium, serum total protein, albumin, and BMD

The relationship between the intakes of protein, Ca, K and BMD showed that there were malignant correlative

Table 8. Pearson's correlation coefficint between BMD and muscle strength

	BMD(L2-L4)	RHT	RHN	RHW	RHTR	RHI	RAT	RA1/3	RAMID	RAUD
Hand grip power(Right)	0.045	−0.167	−0.061	−0.131	−0.120	−0.210	0.094	0.056	−0.012	0.051
(Left)	0.198	−0.081	−0.044	−0.093	−0.092	−0.096	0.175	0.162	0.088	0.064
Back strength	0.000	−0.041	−0.103	−0.069	−0.138	0.012	−0.077	−0.097	−0.200	0.082
Leg flexion strength(Right)	0.213	0.044	−0.012	0.067	−0.038	0.077	0.081	0.071	−0.097	0.004
(Left)	0.157	0.013	−0.036	0.001	−0.070	0.057	−0.104	0.009	−0.063	−0.088
Leg extension power(Right)	−0.019	−0.004	−0.118	−0.021	−0.065	0.008	−0.007	0.051	−0.065	−0.021
(Left)	0.053	0.025	−0.052	−0.002	−0.015	0.032	0.156	0.025	−0.024	0.115

$p<0.05$
BMDL2-L4 : Lumbar spine 2−4 BMD
RHT : Right hip total BMD
RHN : Right hip neck BMD
RHW : Right hip ward's triangle BMD
RHTR : Right hip trochanter BMD
RHI : Right hip inter BMD
RAT : Right forearm total BMD
RA1/3 : Right forearm Radius+Ulna[R] 1/3 BMD
RAMID : Right forearm MID BMD
RAUD : Right forearm UD BMD

relationships between the K intake and the BMD of Right Forearm UD($r=-0.343$, $p<0.05$), between the Na intake and the BMD of Right Forearm UD($r=-0.350$, $p<0.05$). However, there was no notable relationship of the BMD of other areas, protein, Na, Ca, and K at $p<0.05$. There were benign relations between blood albumin and lumbar spin(1-4)($r=0.35$, $p<0.05$), between blood albumin and right hip neck($r=0.33$, $p<0.05$) (Table 10).

High salt intake is known for promoting bone absorption(Koo 1982), because the more salt intake, the more Na excretion of urine, and then the excretion of Ca will increase with Na excretion. Despite the fact that the mechanism of the change of Ca excretion has not clearly recovered, it may be considered that the second potassium excretion is elevated because the increase of Ca intake caused by high Ca intake brings about an increase of sodium and H_2O in renal distal flow, which helps increase renal tubule flow(Seung 1995). Furthermore, protein affects body Ca and bone metabolism through the transformation of kidney function(Luts et al. 1981 ; Zemel et al. 1981). In other words, several studies on animals and human bodies reveal that when females have high protein intake in their diets(Howe et al. 1983 : Petitto et al. 1984), this dietary habit affects the structure and function of kidney and increases Ca excretion of urine and finally, enhance the Ca reabsorption from bone structure in order to maintain the level of blood Ca evenly. However, there is little research on K. As a result, the Ca intake plays an important role in bone formation, the more Ca intake, the more intense the bone density. The fact that the intakes of protein and Na of the subjects in this study were higher than those of the recommended amount could infer the increase of Na excretion of urine and Ca excretion, which would be considered to enhance the second K excretion. Also, the high of blood total protein was a cause of the decrease of bone density, but albumin was considered to indicate the nutritional state of protein.

5. The correlation of age, height, weight and BMD

The correlation between age, height, weight and BMD showed that there was no correlation between the BMD, age and weights of the subjects in $p<0.05$(Table 11).

There was a tendency that the older females become, the higher their bone densities were : the taller and heavier they were, the higher their bone densities were(Cho 1998). It is said that weight increase affects the bone density of the spine. As weight training hardens bone, so the weight gravity of heavy weight hardens bone in the case of obesity. However, the fact that the ages and weights of the subjects were not correlated at $p<0.05$.

Summary and Conclusions

This study was conducted to investigate the level of fe-

Table 9. Pearson's correlation coefficint among BMD, osteocalcin and ALP

	BMD(L2-L4)	RHT	RHN	RHW	RHTR	RHI	RAT	RA1/3	RAMID	RAUD
Osteocalcin	-0.064	-0.092	0.050	-0.151	-0.069	-0.133	-0.076	-0.024	-0.228	-0.139
ALP	-0.123	-0.030	-0.002	0.026	0.120	-0.050	-0.474*	-0.138	-0.141	-0.277*

*p<0.05
BMDL2-L4 : Lumbar spine 2-4 BMD
RHT : Right hip total BMD
RHN : Right hip neck BMD
RHW : Right hip ward's triangle BMD
RHTR : Right hip trochanter BMD
RHI : Right hip inter BMD
RAT : Right forearm total BMD
RA1/3 : Right forearm Radius+Ulna[R] 1/3 BMD
RAMID : Right forearm MID BMD
RAUD : Right forearm UD BMD

Table 10. Pearson's correlation coefficint among BMD, nutrient intakes, serum total protein and serum albumin

	BMD(L2-L4)	RHT	RHN	RHW	RHTR	RHI	RAT	RA1/3	RAMID	RAUD
Protein	0.039	-0.131	0.011	0.077	-0.125	-0.179	-0.096	-0.136	-0.150	0.081
Serum total protein	0.016	0.097	0.156	0.065	-0.126	0.121	-0.273	-0.068	-0.133	-0.141
Serum albumin	0.358*	0.260	0.338*	0.230	0.053	0.281	-0.001	0.019	0.026	0.005
Ca	-0.068	-0.000	0.020	-0.033	-0.008	0.012	0.266	0.267	0.320	0.024
K	-0.080	0.051	0.062	0.078	0.042	0.090	-0.219	-0.113	-0.189	-0.343
Na	-0.088	-0.027	-0.030	-0.136	-0.066	0.032	0.181	-0.056	-0.142	-0.350

*p<0.05
BMDL2-L4 : Lumbar spine 2-4 BMD
RHT : Right hip total BMD
RHN : Right hip neck BMD
RHW : Right hip ward's triangle BMD
RHTR : Right hip trochanter BMD
RHI : Right hip inter BMD
RAT : Right forearm total BMD
RA1/3 : Right forearm Radius+Ulna[R] 1/3BMD
RAMID : Right forearm MID BMD
RAUD : Right forearm UD BMD

Table 11. Pearson's correlation coefficint between BMD and general characteristics

	BMD(L2-L4)	RHT	RHN	RHW	RHTR	RHI	RAT	RA1/3	RAMID	RAUD
Age	0.144	−0.046	−0.166	−0.108	−0.053	0.044	−0.111	0.114	−0.026	0.013
Height	0.105	−0.149	−0.069	−0.133	−0.252	−0.142	−0.116	0.117	−0.147	−0.254
Weight	0.096	0.072	0.098	0.081	0.106	0.065	−0.008	0.222	0.132	0.035

*$p<0.05$
BMDL2-L4 : Lumbar spine 2 – 4 BMD
RHT : Right hip total BMD
RHN : Right hip neck BMD
RHW : Right hip ward's triangle BMD
RHTR : Right hip trochanter BMD
RHI : Right hip inter BMD
RAT : Right forearm total BMD
RA1/3 : Right forearm Radius+Ulna[R] 1/3 BMD
RAMID : Right forearm MID BMD
RAUD : Right forearm UD BMD

male college students' bone density, the correlation between the level of female college students' bone density and various influential factors. It was conducted to 47 female college students who are in their first year to their senior year from October, 1998 to December, 1998. The dietary intake measurement, anthropometric measurements, bone density, muscle strength measurement, and blood analysis were conducted. The results of the experiment on the correlation between the level of female college students' bone density and various influential factors are as follows :

1) The subjects were average 20.1 years old, 160.9cm tall, and 51.8kg weigh. Their body fat was 24.7%, blood pressures were 115.3±7.2mmHg(systolic pressure), 72.2±4.8mmHg(diastolic pressure). The number of pulse is 77.5±6.78 time/minute.

2) The intakes of protein and salt were higher than those of the recommended amount, but the Ca intake was 65.1% of RDA.

3) The outcome of clinical blood experiment showed that the total amount of protein, 8.9±0.5g/dl was somewhat higher than the normal range. Other factors levels of total cholesterol, TG, the portion of VLDL-cholesterol, HDL-cholesterol, LDL-cholesterol, LDL/HDL, blood albumin, GOT, and the concentration of Ca, and the analysis were normal, which indicate that the subjects were in good condition.

4) Muscle strength was lower than that of National Fitness Guidebook.

5) Osteocalcin, or an index of bone formation and ALP were normal, and BMD was in the normal range with the 90% of T-score.

6) The correlation between BMD and related factors reveals that there were benign relations of body fat, T.G., Ca intake, blood albumin, GOT and BMD($p<0.05$) ; there were malignant relations between ALP, total cholesterol, blood total protein, Na intake, Ca intake, height, pulse and BMD($p<0.05$).

As could be shown in the above, the bone density of the subjects were normal, but their muscle strength, or an environmental factor of BMD were lower than the average. Also, the intakes of protein and salt were higher than those of the recommended amount, but the Ca intake appeared to be very low(65.1% of RDA). The fact that the benign relations between Ca intake, blood albumin and BMD ; the malignant relations between the concentration of ALP, blood total protein, the intakes of Na and Calcium, Height and BMD were predicted to have a bad influence on the BMD after menopause. Therefore, female college students were well advised to take more and more Ca so that they could reach peak bone density, to be moderate in taking protein and salt, and to do exercise that could cause the stimulus of bone formation. Finally, there should be in-depth research on the related factors of bone density in the future.

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