Factors Affecting Bone Mineral Density of Postmenopausal Japanese Women

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Key Words :
Bone mineral Density
Nutrition
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ABSTRACT

This study was performed on 53 postmenopausal women to evaluate how factors, such as the number of years after menopause and nutrition uptake status, are related with total bone mineral density (BMD), lumbar spine BMD, and broadband ultrasound attenuation (BUA) of calcaneus. The subjects were divided into 3 age groups: 20 subjects in the sixties, 24 subjects in the seventies, and 9 subjects in the eighties and older. As a result, in the group of the sixties, the number of years after menopause showed significant negative correlation with BMD, while significant correlation was not found in the groups of the seventies and the eighties and older. In BMD and nutrition uptake status, no significant correlation was found in the groups of the sixties and the seventies. On the other hand, in the group of the eighties and older, significant positive correlation was seen between total BMD and protein uptake ($r = 0.740$; $p < 0.05$) or vitamin B1 uptake ($r = 0.720$; $p < 0.05$), and also between lumbar spine BMD and calcium uptake ($r = 0.685$; $p < 0.05$), and further, between calcaneal BUA and iron uptake ($r = 0.893$; $n = 6$). These results suggest that the number of years after menopause exerts influence on BMD and/or BUA in the group of the eighties, while nutrition uptake status gives influence in the groups of the eighties and older.

I. Introduction

Worldwide, Japan has the longest overall life expectancy. In 2000, there were 21,870,000 Japanese citizens more than 65 years old (roughly one out of every six people, with an aging rate of 17.2%), and in the last 30 years there has been a dramatic spike in the rapid aging of society[1)]. This has led to unique medical issues. In postmenopausal women, especially, bone mineral density (BMD) and bone mineral content are known to decrease rapidly[2)], which can cause bone fractures and affect life expectancy in the elderly. In addition, there is a strong correlation between BMD and the mortality rates of women in their seventies[3)]. This kind of involutional osteoporosis is divided into two types based on its pathogenesis and characteristics: either postmenopausal osteoporosis (51-75 years old) caused by menopause-related factors and individual, or senile, osteoporosis (more than 70 years old) brought on by aging[4)]. Much remains unclear about the possible causes of senile osteoporosis. Some individuals more than 75 years old maintain their bone mineral density; clearly, factors that can prevent age-related BMD loss exist. Studied factors known to decrease BMD include body weight, lean mass, and fat mass[5)]; postmenopausal years[6-8)]; and nutrition uptake status[9-18)]. With regards to bone mineral density and nutrition, Huang et al.[9)] conducted a follow-up study on Caucasian women (45-77 years old) who had experienced a femoral neck fracture and found that the number of fractures was positively correlated with poor nutrition, blood albumin concentration, body weight, and a low body fat percentage. In addition, Yukawa et al.[10)] conducted a long-term longitudinal study of Japanese women (65-79 years old), in which certain nutrients and food, besides acting specifically on BMD, were found to improve women's overall nutritional status and effectively maintain bone mass. Previous reports, however, have focused little on women older than eighty[2-18)].

Accordingly, this study aimed to elucidate factors (other than aging) related to BMD in postmenopausal women and discover possible nursing interventions to help the elderly maintain BMD. To achieve these aims, total BMD, lumbar spine BMD, and the broadband ultrasound attenuation (BUA) of the calcaneus were measured, and their potential correlation with body weight, postmenopausal years, and nutrition intake status were analyzed.

II. Research Methods

A. Subjects

From April 1, 1999 to November 30, 2000, 24 students at A City University for the Elderly (16 in their sixties, 8 in their seventies, 0 in their eighties) and 29 nursing home residents (4 in their sixties, 16 in their seventies, 9 in their eighties) participated in this study, independent of their daily activities. A total of 53 postmenopausal women were involved (60-92 years old, average age of 71.8 ± 7.2 years, average weight of 49.9 ± 7.7 kg, average height of 149.8 ± 4.3 cm). Among those who had hormone replacement therapy and women who had premature menopause (younger than 40 years), those who had both ovaries removed were excluded.

B. Method for Measuring BMD

By using the Dual Energy X-ray Absorptiometry method (DEXA, Norlanzd XR-26, Norland, USA), total BMD and specific BMDS were measured. The lumbar spine (L2-L4) BMD was used as a diagnostic reference for osteoporosis and decrease in bone mass. In addition, the calcaneus' BMD was used as a marker for the risk of femoral neck fractures and vertebral compression fractures[19)]. The BUA, which reflects bone strength and BMD, of the calcaneus was measured using the ultrasonic method (Ubis3000, Diagnostic Medical Systems, France).

C. Methods of Survey by Questionnaire

The subjects who gave BMD and/or BUA measurements were sent an eating habits questionnaire and a medical questionnaire by mail (76 sent, 53 collected; overall response

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rate of 69.7%). The medical questionnaire was intended to analyze the number of postmenopausal years. The eating habits questionnaire asked subjects to fill in 3 days' worth of meals, and, using diet analysis software (Nankodo's NUTAS4 for Windows Version 1.05a), information about their average daily uptake of energy, protein, lipids, carbohydrates, calcium, phosphorus, iron, vitamin A, vitamin B1, vitamin B2, and vitamin C was collected and analyzed. When residents used the facility's cafeteria, calculations were performed based on the menu and how much was eaten.

D. Analysis

Data processing was performed using Halbou for Windows, Version 5.22. Postmenopausal women's BMD decreased markedly with age[2]. As there were relatively few reports on subjects older than 80 years old, there was also a relative lack of information regarding the correlation between their BMD and nutritional status[9-18]. Based on the classifications of involutional osteoporosis, three age groups were established, including 60-69 years old (sixties) where the primary causes of BMD loss were considered to be postmenopausal osteoporosis and menopause-related factors; 70-79 years old (seventies) where the primary causes of BMD loss were considered to be senile osteoporosis and aging; and 80-92 years old (eighties and older or eighties plus) where, although there were very few reports, primary causes of BMD loss were considered to be senile osteoporosis and aging. There were some particular site-specific bone mass variations when measuring BMD [20], so the three variables of total BMD, lumbar spine BMD, and BUA were used. The BMD and BUA measurements and the results from the medical and eating habits questionnaire were examined in a scatter plot using Pearson's correlation coefficient.

E. Ethical Considerations

For the execution of this study, the approval of the Hyogo Prefectural College of Nursing's Ethics Committee was obtained.

III. Results

A. Correlations of Subjects' Physical Characteristics with BMD and BUA

Table 1 shows the average and standard deviation for physical characteristics and measurements, as well as the number of people in the sixties, seventies, and eighties plus groups. In addition, measurements taken by the DEXA method for the 53 subjects are shown by age group in a scatter plot; Figure 1 shows total BMD, and Figure 2 shows lumbar spine BMD. The total BMD of healthy women as shown by Morita et al.[21] has an average value with ±1.5 SD, and the healthy lumbar spine BMD reference value as determined by the Japan Osteoporosis Society[22] also has a ±1.5 SD range. Most of the subjects were appropriately distributed within the ±1.5 SD value (statistics on approximately 74% are included).

Data related to correlations between both total BMD and lumbar spine BMD, and BUA are shown in Table 2 and divided into the sixties, seventies, and eighties plus age groups. Although total BMD and lumbar spine BMD's relationship to

Table 1. The Physical Characteristics and measurements

	Sixties		Seventies		Eighties Plus	
	Mean ± SD	n	Mean ± SD	n	Mean ± SD	n
Age (Years)	64.6 ± 2.7	20	73.3 ± 2.6	24	83.2 ± 4.3	9
Height (cm)	150.3 ± 4.3	20	149.5 ± 4.6	24	149.4 ± 3.9	9
Body weight (kg)	52.2 ± 6.8	20	49.0 ± 7.8	24	47.0 ± 9.4	9
BMI (kg/m^2)	23.4 ± 2.3	20	22.0 ± 3.5	24	20.9 ± 3.5	9
Total BMD (g/cm^2)	0.814 ± 0.075	20	0.743 ± 0.079	24	0.763 ± 0.078	9
Lumber spine BMD(g/cm^2)	0.800 ± 0.119	20	0.736 ± 0.166	24	0.723 ± 0.093	9
BUA (dB/MHz)	57.6 ± 5.0	17	54.4 ± 4.7	17	53.6 ± 3.7	6
postmenoposal years (Years)	16.3 ± 7.8	20	25.1 ± 4.0	24	34.5 ± 7.1	8

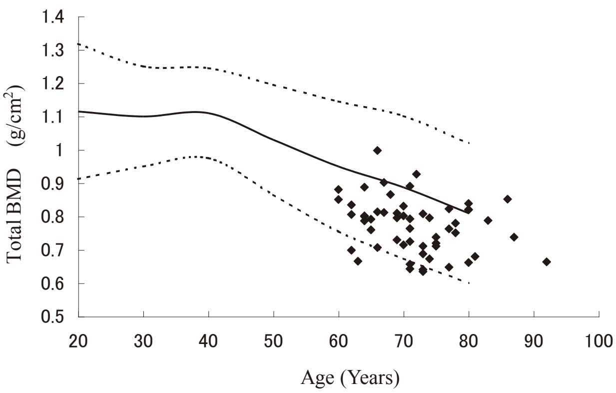

Figure 1. Age group in a scatter plot; total BMD

Measurements taken by the DEXA method for the 53 subjects are shown by age group in a scatter plot; total BMD. The total BMD of healthy women as shown by Morita et al.[21] has an average value with ±1.5 SD

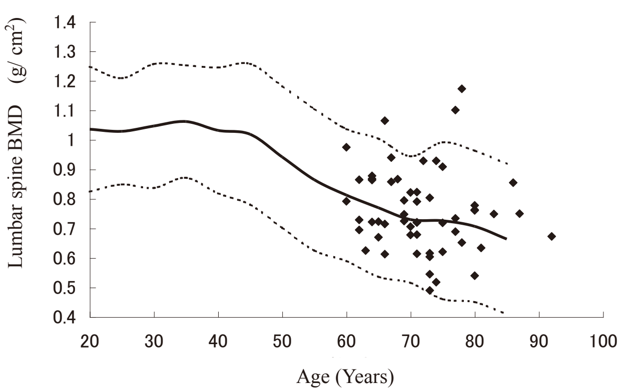

Figure 2. Age group in a scatter plot; lumbar spine BMD

Measurements taken by the DEXA method for the 53 subjects are shown by age group in a scatter plot; lumbar spine BMD. The lumbar spine BMD of the healthy lumbar spine BMD reference value as determined by the Japan Osteoporosis Society[22] also has a ±1.5 SD range. Most of the subjects were appropriately distributed within the ±1.5 SD value

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BUA showed significant correlations in the sixties age group ($r = 0.712$, $n = 17$, $p < 0.001$; $r = 0.658$, $n = 17$, $p < 0.01$), in the seventies age group, there was only a significant correlation with total BMD ($r = 0.694$, $n = 17$, $p < 0.01$). In the eighties plus age group, there was no significant correlation regarding any values. In all age groups, total BMD and lumbar spine BMD showed significant correlation with BUA ($r = 0.714$; $n = 40$, $p < 0.001$; $r = 0.450$; $n = 40$, $p < 0.01$). Correlation between subjects' physical characteristics and BMD and BUA are shown in Table 3.

In examining how the subjects' body weight related to BMD and BUA, the sixties group showed a significant positive correlation between body weight and total BMD, lumbar spine BMD, and BUA ($r = 0.523$, $n = 20$, $p < 0.05$; $r = 0.641$, $n = 20$, $p < 0.01$; $r = 0.617$, $n = 17$, $p < 0.01$). The seventies group showed a significant positive correlation between body weight and total BMD as well as BUA ($r = 0.647$, $n = 24$, $p < 0.001$; $r = 0.712$, $n = 17$, $p < 0.01$). In addition, lumbar spine BMD and body weight showed a positive correlation and a 10% lower risk of reduced density ($r = 0.399$, $n = 24$, $p < 0.1$). In the eighties plus group, however, no significant correlation was seen, and there was a negative correlation between BUA and body weight ($r = -0.508$, $n = 6$). These data correspond to the correlation between body weight and total BMD in Figure 3.

In examining subjects' postmenopausal years with relation to BMD and BUA, the sixties group showed a significant negative correlation with total BMD and lumbar spine BMD ($r = -0.496$, $n = 20$, $p < 0.05$; $r = -0.489$, $n = 20$, $p < 0.05$), but the seventies and eighties plus groups showed no significant correlation. The correlations between postmenopausal years and total BMD are shown in Figure 4.

B. Correlation between Nutrient Uptake and BMD and BUA

Table 4 shows the average values and standard deviations of each type of nutrient uptake for each age group. Whether each individual's nutrient uptake met the recommended amount (on the low end of healthy ranges, according to the Japanese Nutritional Requirements 6th Edition Revised[11],) of the average uptake values based on subjects of the same gender and age is displayed in the table. In addition, Table 5 shows the correlations between nutrition uptake and total BMD, lumbar spine BMD, and BUA.

There was no significant correlation between energy uptake and BMD or BUA in the sixties and seventies groups; however, in the eighties plus group, there was a positive trend between total BMD and energy uptake that showed a 10% or lower risk rate of reduced density ($r = 0.610$, $n = 9$, $p < 0.1$).

The sixties and seventies groups showed no significant correlation between protein uptake and BMD or BUA; however, the eighties plus group showed a significant positive correlation between protein uptake and total BMD ($r = 0.740$, $n = 9$, $p < 0.05$), and lumbar spine BMD showed a positive correlation with protein uptake. This correlation suggested a 10% or lower risk rate of reduced density ($r = 0.624$, $n = 9$, $p < 0.1$). Figure 5 shows the correlation between subjects'

Table 2. The Total BMD and Lumber Spine BMD's Relationship to BUA

		n	Total BMD (g/cm^2)	Lumber Spine BMD (g/cm^2)
BUA	Sixties	17	0.712 ***	0.658 **
	Seventies	17	0.694 **	0.215
	Eighties Plus	6	0.616	0.506
	Total	40	0.714 ***	0.450 **

* p<0.05 ** p<0.01 *** p<0.001

Table 3. The physical Characteristics and BMD and BUA

	Total BMD (g/cm^2)			Lumber Spine BMD (g/cm^2)			BUA (dB/MHz)		
	Sixties (n=20)	Seventies (n=24)	Eighties plus (n=9)	Sixties (n=20)	Seventies (n=24)	Eighties plus (n=9)	Sixties (n=17)	Seventies (n=17)	Eighties plus (n=6)
Body Weight (kg)	0.523*	0.647***	0.496	0.641**	0.399	0.418	0.617**	0.712**	-0.508
Postmenoposal Years (Years)	-0.496*	-0.233	0.147	-0.489*	-0.252	0.427	-0.267	-0.287	0.728

* p<0.05** p<0.01*** p<0.001

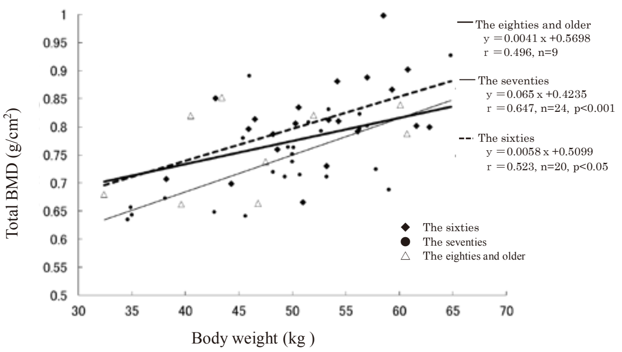

Figure 3. The correlation between body weight and total BMD

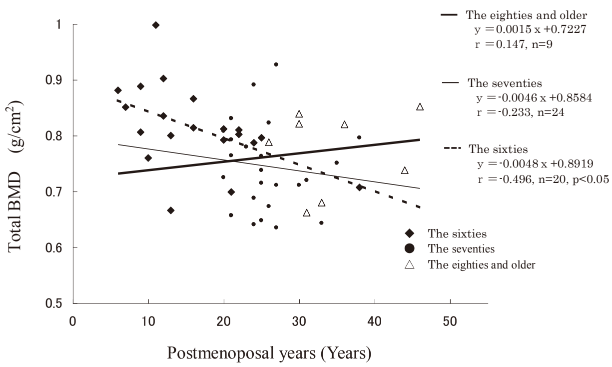

Figure 4. The correlation between Postmenoposal years and total BMD

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total BMD and protein uptake.

The average value of lipid uptake (as a percentage of total energy) was 23.8% for the sixties group, 26.3% for the seventies group, and 29.8% for the eighties plus group; the Japanese Nutritional Requirements 6th Edition Revised[11] recommends an upper limit of 25%, which both the seventies and eighties plus groups exceeded. No significant correlation between lipid and carbohydrate uptake and BMD or BUA was found in any age group.

The sixties and seventies groups showed no significant correlation between calcium uptake and BMD or BUA. In contrast, the eighties plus group showed significant positive correlation between calcium uptake and lumbar spine BMD ($r = 0.685$, $n = 9$, $p < 0.05$). Figure 6 shows the correlation between subjects' calcium uptake and lumbar spine BMD.

The sixties and seventies groups showed no significant correlation between phosphorus uptake and BMD or BUA; however, the eighties plus group showed a trend of a 10% or lower risk rate in regards to total BMD with increased phosphorous uptake ($r = 0.604$, $n = 9$, $p < 0.1$).

The sixties and seventies groups showed no significant correlation between iron uptake and BMD or BUA, but in the eighties plus group, there was a significant positive correlation between iron uptake and BUA ($r = 0.893$, $n = 6$, $p < 0.05$).

Table 4. Nutrient uptake for Age Group

	Sixties				Seventies				Eighties Plus			
	Mean	±	SD	n	Mean	±	SD	n	Mean	±	SD	n
Energy uptake (kcal / day)	1630	±	292	20	1560	±	420	24	1381	±	316	9
Total protein uptake (g / day)	65.6	±	10.9	20	62.1	±	15	24	58.4	±	10.6	9
Total lipid uptake (g / day)	43.2	±	12.8	20	45.6	±	17.5	24	43.1	±	12.4	9
Carbohydrate uptake (g / day)	240	±	46.0	20	220	±	58	24	189	±	68	9
Calcium uptake (mg / day)	582	±	177*	20	569	±	198*	24	568	±	91*	9
Phosphorus uptake (mg / day)	958	±	192	20	913	±	235	24	902	±	117	9
Iron uptake (mg / day)	10.1	±	2.5	20	9.7	±	2.4*	24	9.9	±	1.9*	9
Vitamin A uptake (IU / day)	2785	±	1921	20	2730	±	2070	24	3036	±	1299	9
Vitamin B1 uptake (mg / day)	0.90	±	0.20	20	0.84	±	0.24	24	0.85	±	0.17	9
Vitamin B2 uptake (mg / day)	1.20	±	0.28	20	1.13	±	0.34	24	1.19	±	0.22	9
Vitamin C uptake (mg / day)	107.2	±	46.7	20	100.6	±	39.2	24	102.4	±	45.7	9

*On the low of healthy ranges, according to the Japanese Nutrirional Requirements 6th Edition Revised

Table 5. Correlation between Nutrient Uptake and BMD and BUA

	Total BMD (g/cm²)			Lumber Spine BMD (g/cm²)			BUA (dB/MHz)		
	Sixties (n=20)	Seventies (n=24)	Eighties plus (n=9)	Sixties (n=20)	Seventies (n=24)	Eighties plus (n=9)	Sixties (n=20)	Seventies (n=24)	Eighties plus (n=9)
Energy uptake (kcal / day)	-0.025	0.101	0.610	-0.120	0.132	0.472	-0.049	0.023	0.419
Total protein uptake (g / day)	0.030	0.189	0.740*	0.167	0.143	0.624	0.481	-0.049	0.181
Total lipid uptake (g / day)	-0.067	0.123	0.147	-0.135	0.204	-0.075	0.056	0.110	0.079
Carbohydrate uptake (g / day)	-0.069	0.018	0.460	-0.148	0.045	0.428	-0.249	-0.069	0.424
Calcium uptake (mg / day)	0.119	0.036	0.618	-0.074	0.006	0.685*	-0.184	-0.090	0.145
Phosphorus uptake (mg / day)	0.205	0.094	0.604	0.076	0.087	0.591	0.288	-0.181	0.291
Iron uptake (mg / day)	0.291	0.030	0.550	0.155	0.136	0.310	-0.029	-0.227	0.893
Vitamin A uptake (IU / day)	-0.069	0.395	0.231	-0.046	0.377	0.290	-0.388	0.031	-0.045
Vitamin B1 uptake (mg / day)	0.396	-0.048	0.720*	0.235	0.187	0.644	0.171	-0.082	0.245
Vitamin B2 uptake (mg / day)	0.186	0.358	0.491	0.022	0.204	0.436	0.096	0.247	0.175
Vitamin C uptake (mg / day)	0.237	-0.103	0.459	0.145	0.171	0.259	-0.052	-0.153	0.432

* p<0.05** p<0.01*** p<0.001

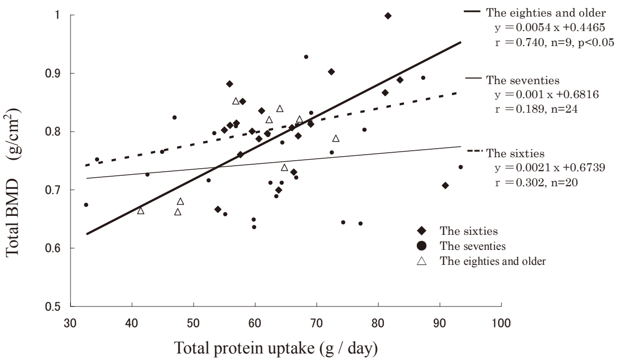

Figure 5. The correlation between total protein uptake and total BMD

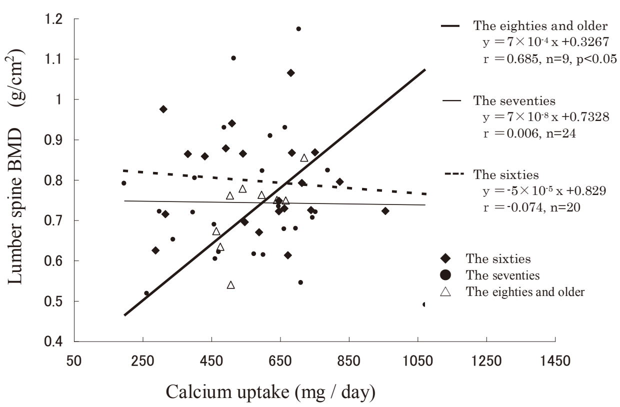

Figure 6. The correlation between calcium uptake and lumbar spine BMD

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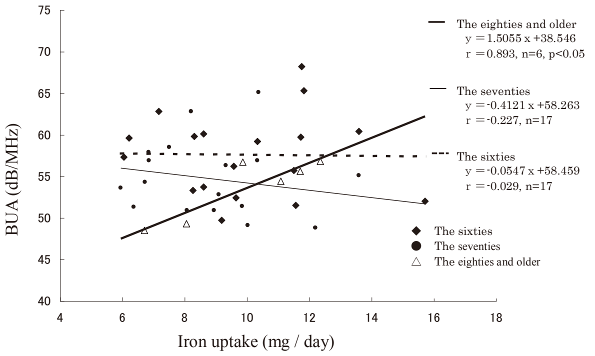

Figure 7. The correlation between iron uptake and BUA

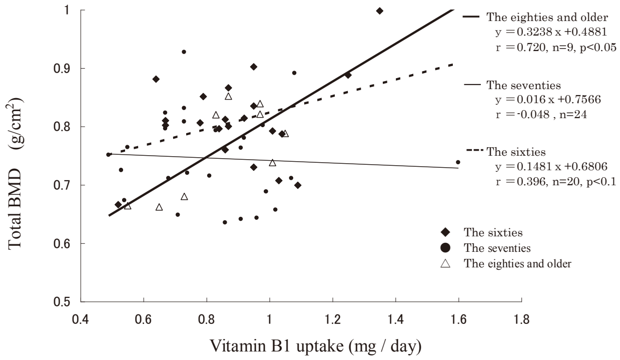

Figure 8. The correlation between vitamin B1 uptake and total BMD

Figure 7 shows the correlation between subjects' iron uptake and BUA.

The sixties and eighties plus groups showed no significant correlation between vitamin A uptake and BMD and BUA, but in the seventies group, there was a noticeably positive trend of a 10% or lower risk rate of decreased total and lumbar BMD as vitamin A uptake increased ($r = 0.395$, $n = 24$, $p < 0.1$; $r = 0.377$, $n = 24$, $p < 0.1$).

The sixties group showed a positive correlation between B1 uptake and a 10% or lower risk of total BMD decrease ($r = 0.396$, $n = 20$, $p < 0.1$). The seventies group showed no significant correlation, but the eighties plus group showed a significant positive correlation with total BMD ($r = 0.720$, $n = 9$, $p < 0.05$), as well as a trend of a 10% or lower risk rate of decreased BMD with regards to lumbar spine BMD ($r = 0.644$, $n = 9$, $p < 0.1$). Figure 8 shows the correlation between subjects' vitamin B1 uptake and total BMD.

The seventies group showed a positive correlation between increased B2 vitamin uptake and a 10% or lower risk rate of decreased total BMD ($r = 0.358$, $n = 24$, $p < 0.1$).

Regardless of age, there seemed to be no significant correlation between vitamin C uptake and BMD or BUA.

IV. Considerations

The purposes of this study were to elucidate factors besides aging that were related to BMD in postmenopausal women and to discover possible nursing interventions to help the elderly maintain BMD. Accordingly, 53 postmenopausal women's (61-92 years old) BMD and/or BUA was analyzed by age group and body region in order to reveal possible correlations with body weight, postmenopausal years, and nutritional uptake. The results showed a significant correlation between total BMD and BUA and body weight and postmenopausal years, but not nutritional uptake for women in their sixties; for women in their seventies, there was a significant correlation between body weight and total BMD and BUA, but not between postmenopausal years or nutritional uptake; and for women in their eighties, a significant correlation was found between total BMD/BUA and nutrient uptake, but not postmenopausal years or body weight. Each age group's BMD was affected by different factors, indicating the possibility of improving BMD through nursing interventions and improved nutrient uptake even for women 75 years and older.

A. Correlation between the Subjects' Physical Characteristics and BMD and/or BUA

Morita et al.[21] reported that the average BMD value of healthy women ranged within ±1.5 SD of the average, and the Japan Osteoporosis Society[22] defines healthy lumbar spine BMD values as within ±1.5 SD of the average. Most of the subjects' values were distributed within the ±1.5 SD value (statistics on approximately 74% were included). Therefore, the subjects of this study were considered representative of Japanese postmenopausal women.

The sixties group showed a significant correlation between total and lumbar spine BMD and BUA, the seventies group showed a significant correlation only between total BMD and BUA, and the eighties group showed no significant correlations between BMD, BUA, and physical characteristics. Of the measured values for various bone mineral densities, the lumbar spine BMD as determined by the DEXA method is currently used as a reference value for analyzing osteoporosis and quantifying bone mass decrease. Lumbar measurement in the elderly can sometimes be problematic, however, and result in an overestimation of bone mass as a result of degenerative spondylosis or aortic calcification. As a result, it is necessary to measure regions other than the lumbar region in the elderly[22]. In addition, since BMD has a great amount of site specificity, measuring two or more locations is generally desirable when using BMD to determine bone mass. In order to properly guard against a hip fracture, it is necessary to evaluate the femoral neck's BMD; however, the structure of the femur is complex, as it is a primarily cancellous, load-bearing bone. The calcaneus is often used for evaluation purposes, since involutional changes in other sites, such as the lumbar spine, are small, and the calcaneus' BMD is known to strongly correlate with risk of femoral neck fractures and vertebral compression fractures[19]. This study showed a significant correlation for all ages, although, when accounting for aging, there was a divergence between BUA and total BMD and lumbar spine BMD. Although it would be useful for predicting fractures to measure each bone's composition, the load it bears, and its unique metabolisms, such detailed evaluation is impossible. Instead, evaluations based on each bones' already recorded characteristics are required. Still, since few Japanese have used an ultrasound bone imagining scanner (UBIS) to determine these characteristics, further studies on interregional relationships are necessary.

To clarify body weight's relation to BMD and BUA, Huang et al.[9] performed a follow-up study on Caucasian women (45-77 years old) who had experienced a femoral neck fracture. They found that as body weight and body fat percentage decreased, the frequency of femoral neck fractures increased. As the calcaneus is a load-bearing bone with similar composition to

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the femoral neck, it reflects the BMD of the femoral neck[20]. The calcaneus is 95% cancellous bone, readily giving a sense of the bone's metabolism. When remodeling the bone, variations in muscle strength and gravity exerted on the skeleton need to be taken into account. In this study, the calcaneus showed a significant positive correlation with BMD in the sixties and seventies groups, except for the seventies group's lumbar spine BMD. In the eighties plus group, however, body weight and BUA showed a negative correlation coefficient. In other words, as body mass increased, bone mass decreased. Accordingly, maintaining bone mass in women older than 80 is difficult, as bone mass decreases in general and the lifelong effects of load and mechanical stress accumulate.

Additionally, according to Okano et al.[7] and Iki et al.[8], women's BMD decreases rapidly when the menstrual cycle starts to become irregular (menopause). According to our study, although the sixties and seventies groups' total BMD, lumbar spine BMD, and BUA appeared to be affected by postmenopausal years and body weight, the eighties plus group was not affected by those factors.

To classify involutional osteoporosis, aging appeared to be the primary factor affecting BMD and BUA in people older than years[4]. Accordingly, in this study, the effects of body weight and postmenopausal years on total BMD, lumbar spine BMD, and BUA varied by age group. The sixties group was affected by both postmenopausal years and body weight; the seventies group was not affected by postmenopausal years, and only certain regions were affected by body weight; and the eighties plus group was not affected by postmenopausal years. This means that until women surpass approximately 65 years of age, postmenopausal osteoporosis has diagnostic criteria similar to involutional osteoporosis[4].

B. Correlation between Nutrient Uptake and BMD and BUA

To clarify the relationship between BMD and nutrition, Huang et al.[9] performed a follow-up study on Caucasian women (45-77 years old) who had experienced a femoral neck fracture. The authors found that poor nutritional status or low levels of blood albumin concentration increased the risk of a femoral neck fracture. Yukawa et al.[10] also found, in a long-term longitudinal study of Japanese women up to 79 years old, that certain nutrients and food, when regularly consumed in a balanced diet as a variety of foodstuffs, improved the body's overall nutritional status, which helped maintain bone mass and BMD. In this study, the eighties plus group showed a correlation between nutritional uptake and total BMD, lumbar spine BMD, and BUA, similar to the results found in other studies focused on women in their seventies. In those studies, a positive correlation was seen between nutritional status and overall BMD. To date, however, no significant correlation between nutrition and BMD has been seen in women younger than 70. Since women can experience unpleasant symptoms in their early postmenopausal years until their seventies, it is thought nutrition may be unable to compensate for BMD loss between menopause and the seventh decade. This study also did not compare the different nutrient uptakes to each other, possibly overlooking individual nutrient contributions.

Excessive protein uptake promotes the release of calcium from bones, increasing calcium excretion through urination. This is thought to result in a decrease in bone mass[11]; however, in a report by Apell et al.[12], eating fruits and vegetables and sodium bicarbonate reduced the amount of calcium excreted through urination. The extent of this effect differed based on what other foods were consumed. It is also known that a low-protein state reduces bone mass[11]. The present study also showed that increasing protein uptake in the eighties plus group had a significant positive correlation with BMD, reinforcing the importance of avoiding a low-protein state.

According to Yukawa et al.[10] and Shono et al.[13], there is a positive correlation between BMD and lipid uptake. In the results of this study, however, BMD and BUA showed no significant correlation with lipid uptake or carbohydrate uptake. Subjects of this study in the seventies and eighties plus age groups, according to the recommended values of Japanese Nutritional Requirements 6th Edition Revised[11], had high total lipid uptake percentages and low protein and carbohydrate uptake values. Due to the subjects' poorly balanced diets, it is possible that they were not effectively using lipids to maintain bone mass. Further study to clarify the effects of the simultaneous ingestion of different nutrients is necessary.

The calcium uptake for each age group (sixties, seventies, and eighties plus) was 560-580 mg per day, which is less than the required amount of 600 mg per day. According to a study on fractures and calcium uptake by Fujiwara et al.[16], subjects who drank milk almost every day reduced their risk of femoral neck fracture to about half that of subjects who drank milk once a week or less. In this study, only the eighties plus group showed a significant correlation with lumbar spine BMD and calcium uptake. Calcium metabolism in the elderly can easily become negative (excretion exceeding absorption) because metabolism changes with age. Less calcium is absorbed as uptake simply decreases, less active vitamin D is present in the diet, and the lower intestine absorbs less calcium, causing a relative increase in calcium absorption from the bones. Calcium metabolism involves many components, including hormone influence, and it cannot be quantified simply by dietary uptake of calcium. If phosphorus and calorie uptake are small, calcium may be inefficiently absorbed. In the eighties plus group, in particular, further study of simultaneous ingestion of various foods should be conducted. In this study, all groups failed to consume the recommended daily amount of calcium; calcium is one of the few nutritional benchmarks that Japanese citizens do not often fulfill, and each age group needs a carefully controlled uptake.

According to Dainen et al.[13], iron uptake does not affect bone metabolism. The present study showed a positive correlation between BUA and iron uptake for the eighties plus group; however, the eighties plus group's BUA had little correlation with other bone mineral densities. In the future, larger studies should be conducted to determine true significance.

Yamagami et al.[17], found in their study elderly people living alone did not ingest enough of the necessary vitamins without taking vitamin supplements. In the present study, no average vitamin uptake values failed to meet the recommended values, suggesting that the subjects in this study did indeed have good nutritional status. This study shows that, even when living alone, proper vitamin uptake can be maintained as long as the necessary facilities and services are available, and it shows that nutritional habits necessary for maintaining bone mass can be improved.

Vitamin B1 is necessary for normal function of the central nervous system and peripheral nerves and is thought to activate mechanical stress. In this study, vitamin B1 uptake was shown to have a positive correlation with BMD in the

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eighties plus group and aided in bone mass maintenance as a result of mechanical stress.

To contextualize the results of this study, we first examined prior studies investigating total BMD, lumbar spine BMD, and BUA's correlation with body weight and postmenopausal years. Those results showed significant correlations between these factors on women in their sixties and seventies, but no correlation amongst women older than 80. This meant that some external factors must be important in women who were eighty or older. Accordingly, we then examined total BMD, lumbar spine BMD, and BUA's relation to nutrient intake. We saw no correlation between type of nutrient intake and total BMD, lumbar spine BMD, or BUA for women in their sixties and seventies; however, the total BMD, lumbar spine BMD, and BUA's were significantly positively correlated with protein, calcium, iron, and vitamin B1 intake in the eighty plus group. Nutrient uptake should certainly be considered a factor in maintaining BMD.

Overall, the BMD was affected in the following manner across age groups: women in their sixties were affected by postmenopausal years and body weight, those in their seventies were affected by their body weight, and those who were 80 years and older were affected by their nutritional uptake.

The results of our study did not agree with the preexisting literature based on nutritional surveys reporting nutrient relationship with BMD and BUA for women in their sixties and seventies. This may be because each nutrient uptake analysis only included its own, simple correlation with BMD and BUA, and correlations between different nutrient intakes could not be adequately considered because of the low number of subjects involved. In the future, to identify truly significant nutrients, the relationships between nutrients should be analyzed. In order to do this, larger studies that identify factors by multiple regression analysis should be conducted.

Maintaining BMD can protect against fractures caused by osteoporosis, and it is a known prognostic factor. It is hoped that the results of this study will be useful in maintaining the health of the elderly.

V. Conclusion

In this study, we examined factors that affect total BMD, lumbar spine BMD, and BUA in postmenopausal women (ages 60-92) by age group. Women in their sixties showed a positive correlation between body weight and total BMD, lumbar spine BMD, and BUA; women in their seventies showed a positive correlation between body weight and total BMD and BUA. Only women in their sixties showed a negative correlation between postmenopausal years and total BMD and lumbar spine BMD. With regards to nutrient uptake, a positive correlation between total BMD and protein and vitamin B1 uptake, lumbar spine BMD and calcium uptake, and BUA and iron uptake was only seen in the eighties plus group. Therefore, we believe that even for women eighty years and older, nursing interventions to help maintain bone mass are possible.

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