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ORIGINAL ARTICLE

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Positive relationship between bone mineral density and low back pain in middle-aged women

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Abstract There have been a large number of epidemiological studies demonstrating various primary factors that cause musculoskeletal disorders in middle-aged and older women. However, the relationship between low back pain and bone mineral density is not well documented, and no evidence for any direct relationship between the two has been found. To investigate the relationship, we conducted a cross-sectional study, on a population of 2,244 Japanese women aged 25–85 years who were participating in a regional health screening program. Information on lifestyle, reproductive characteristics and the presence of current low back pain was collected by self-administered questionnaires, and bone mineral density at the distal radius was measured. We found increasing bone mineral density to be significantly associated with low back pain in middle-aged women using a logistic regression analysis. Exercise and smoking were also significantly associated with low back pain. This association remained even after entering other lifestyle and reproductive factors into the final model. Accordingly, high bone mineral density would seem to be as important a public health problem as low bone mineral density and osteoporosis when considering the musculoskeletal symptoms and disabilities that appear in middle-aged women.

Keywords Low back pain · Bone mineral density

Introduction

Musculoskeletal disorders play a major role in the health profile of the general population [2]. In particular, low back pain (LBP) remains an important public health problem in that it is one of the most important symptoms that most middle-aged and older people experience at some point in their life [5], and it is one of the most frequent complaints encountered clinically. Its associated costs for society are substantial and show a yearly increase, and probably have a significant impact on medical and social resources in all industrialized nations [2]. According to a recent report by the Ministry of Health and Welfare of Japan, LBP is one of the most frequent complaints among middle-aged and older Japanese people. It would also seem that this age group has a tendency to suffer a higher prevalence of LBP than other age groups [8, 13, 17, 28].

Bone mineral density (BMD) measurements of the lumbar spine in middle-aged and older people are frequently affected by deformities and degenerative changes, leading to a falsely elevated spinal BMD on assessment of bone mass [35], whereas the distal radius is much less affected by such age-related conditions. Levels of bone density in both the lumbar spine and the distal radius are correlated [1, 31], and radial BMD has been shown to be useful for predicting both vertebral deformity [31] and degenerative changes [22, 35] of the lumbar spine. A recent longitudinal study reported that the forearm appeared to be the site that afforded the best agreement between measurements of cross-sectional estimated and longitudinal age-related changes in BMD [37], suggesting that radial

BMD is useful for an accurate assessment of bone mass status in a study group encompassing a wide range of ages.

Osteoporosis is a condition of diminishing bone content and increasing damage to the bone architecture [11], and the prevalence of vertebral deformity rises with age [9]. Many studies have been conducted on the various primary factors causing musculoskeletal disorders, and a positive association between vertebral deformity and LBP has been demonstrated in elderly people [6, 9, 14, 15, 20]. In spite of a large number of epidemiological surveys on the prevalence of LBP or BMD measurements in the general population, a relationship between the two has not been well documented, and the authors of several studies have even concluded that they were unable to find any evidence for such a relationship [4, 14, 24]. The purpose of this study was to investigate whether the BMD value and other risk factors could be associated with the occurrence of LBP.

Materials and methods

Population and BMD measurements

A regional health screening program for osteoporosis was conducted in Fukuoka Prefecture from 1997 to 1998. The region is located in the south-western part of Japan, and includes both urban and rural areas, with a population of about 5 million. People were informed of this program in advance, through public information services and other publicity. A total of 2,700 women voluntarily participated, undergoing examinations that included the measurement of BMD and anthropometric indicators.

BMD was measured for each participant at the distal one-third of the non-dominant radius, using dual-energy X-ray absorptiometry (DXA) (DCS-600; Aloka Co., Tokyo, Japan). A single radiographer was in charge of all the BMD measurements. The coefficient of variation of the apparatus was within 1.0%.

Questionnaire

Information on lifestyle, medical history, reproductive characteristics, and current subjective symptoms was collected from the entire study population using extensive self-administered questionnaires prior to screening examinations. The questionnaire regarding lifestyle included items on:

- Number of exercise hours per week (<1; 1–2; 3–4; >4)
- Levels of occupational physical activity (light; moderate; heavy; very heavy)
- Milk consumption per week
- Smoking and drinking habits (never; former; current)

Subjects were questioned regarding whether they had any current LBP. Although subjects with current LBP were also asked to report whether the referred pain occurred when they were at rest, in motion, or standing for a long time, we integrated these responses and defined all such pain as the presence of LBP, irrespective of its trigger. Severity and duration of the symptoms were not categorized in this questionnaire.

The questionnaire regarding medical history consisted of items on:

- Diseases (endocrine abnormalities in parathyroid and thyroid glands, rheumatoid arthritis, renal disease, liver disease, gastrointestinal disease, diabetes and others), including information on medication and whether currently under treatment
- Prior surgical operations (gastrectomy, ovariectomy and others)

Reproductive characteristics were assessed by response to the questions about:

- Age at menarche
- Menstrual status (regular; irregular; none)
- Number of parities
- Age at menopause
- Type of menopause (natural; artificial)

Selection of study subjects

The study population was constructed by selecting women with no medical history known to affect bone metabolism on the basis of information obtained through the questionnaires. The names of diseases and the number of subjects excluded were as follows: endocrine abnormalities in parathyroid and thyroid glands (n=73), rheumatoid arthritis (n=28), renal disease (n=36), liver disease (n=75), gastrointestinal disease (n=90), diabetes (n=62). Subjects who had undergone gastrectomy (n=40) and ovariectomy (n=148) were also excluded. Every subject who had a history of medication, using corticosteroids, diuretics, calcitonin, or others, was included among the number of patients with diseases mentioned above, and these were excluded from the study population en masse. There were no women who had undergone hormone replacement therapy.

Ultimately, 456 out of 2,700 women were excluded from the study, and the remaining 2,244 women, aged 25–85 years (mean 51.4 years) were included in the study. Because of the wide range of ages among the study population, subjects were divided into three groups: group 1: younger women (25–44 years, n=719); group 2: middle-aged women (45–64 years, n=1,153); group 3: older women (over 65 years, n=372).

Statistical analysis

Because of their skewed distribution, lifestyle variables were dichotomized based on what appeared to be a threshold effect from observation of their frequency distribution:

- Seldom (<3) and regular (≥3) for exercise hours per week
- Non-physical labor (light or moderate) and physical labor (heavy or very heavy) for occupational physical activity
- Non-imbibers (<7 cups/week) and imbibers (≥7 cups/week) for milk consumption

A comparison was made on selected characteristics concerning potential risk factors of LBP between subjects with and those without LBP, using Student's t-test or chi-square test, where appropriate. Logistic regression analysis was undertaken for statistical assessment of the association of LBP with the independent variables, using Statview Software 5.0 (SAS Institute Inc., Cary, N.C., USA), and odds ratios and 95% confidence intervals were calculated.

Results

Table 1 gives physical and lifestyle characteristics and menstrual status in each group. The proportion of exercise and milk consumption tended to increase as the group became older, whereas the proportion of current smoking and drinking habits tended to decrease as the group became older. In group 2, women had a higher prevalence (18.2%) of physical labor than in the other two groups. There were no postmenopausal women in group 1, whereas there were no premenopausal women in group 3.

Table 1 Physical and lifestyle characteristics and menstrual status in 2,244 women. Values of continuous variables are expressed as mean±SD, and those of dichotomous variables are expressed as percentages (*BMI* body mass index, *BMD* bone mineral density)

	All women (*n*=2,244)	Group 1 (age 25–44) (*n*=719)	Group 2 (age 45–64) (*n*=1,153)	Group 3 (age 65–) (*n*=372)
Physical status				
Age (years)	51.4±12.7	36.3±5.4	55.0±5.8	69.2±3.8
Height (cm)	153.3±5.4	156.0±5.1	152.8±4.9	149.7±5.2
Weight (kg)	52.6±7.1	52.4±7.3	53.3±6.9	51.2±7.2
BMI (kg/m^2)	22.4±2.8	21.5±2.7	22.8±2.7	22.8±2.8
BMD (g/cm^2)	0.582±0.095	0.655±0.049	0.573±0.081	0.465±0.071
Lifestyle				
Exercise (≥3 h per week) (%)	9.3	7.5	9.4	12.2
Physical labor (%)	14.3	8.1	18.2	14.0
Smoking (%)	3.7	6.4	2.6	1.9
Drinking (%)	26.2	33.4	25.2	15.3
Milk consumption (≥7 cups per week) (%)	46.7	38.2	47.3	61.6
Menstrual status				
Age at menarche (years)	13.9±1.9	12.7±1.3	14.2±1.7	15.4±2.0
Parity (times)	2.5±1.1	2.4±1.2	2.4±0.7	3.0±1.7
Menopause (%)	54.5	0.0	73.8	100.0
Age at menopause (years)	49.9±3.4		50.0±3.3	49.7±3.5
Years since menopause	11.1±7.4		7.5±4.8	19.4±5.4

Table 2 gives the mean values and standard deviations for the selected characteristics in each group stratified by the presence of LBP, and it also shows *P*-values for comparison between women with and those without LBP. It was found that 23.3% of the population had LBP at the time of the survey, and the rates increased as the group became older: group 1, 17.5%; group 2, 25.6%; group 3, 27.4%. In group 1, women with LBP were significantly older than those without. There was no significant difference in physical characteristics or the proportion of physical labor between women with and those without LBP in each group. In group 2, BMD was significantly higher and the proportion of exercise was significantly lower among women with LBP than among those without, but this relationship was not observed in group 1 and group 3. In group 2 and group 3, women with LBP showed a tendency to have greater proportion of smoking, but the difference was statistically insignificant. In group 3, women with LBP showed a tendency to have greater proportion of drinking, but the difference was statistically insignificant.

In group 1 and group 3, the association of LBP with BMD or other independent variables was statistically insignificant in the univariate analysis, with the exception of age only in group 1; consequently, a multivariate model could not be designed in group 1 and group 3. In group 2, BMD and exercise, which were statistically significant in the univariate analysis, were included in a multivariate model. Physical labor and smoking, considered to be risk

Table 2 Characteristics in each group stratified by the presence of low back pain (LBP), and comparison between women with and those without LBP. Values of continuous variables are expressed as mean±SD, and those of dichotomous variables are expressed as percentages

	Group 1 (age 25–44)			Group 2 (age 45–64)			Group 3 (age 65–)		
	LBP(–) (*n*=593)	LBP(+) (*n*=126)	*P* Value	LBP(–) (*n*=858)	LBP(+) (*n*=295)	*P* Value	LBP(–) (*n*=270)	LBP(+) (*n*=102)	*P* Value
Age (years)	36.1±5.5	37.4±4.6	0.02	55.0±5.8	55.1±5.8	0.86	69.0±3.7	69.7±4.1	0.08
Height (cm)	155.9±5.1	156.4±5.2	0.31	152.8±4.8	152.8±5.1	0.91	149.8±4.9	149.5±6.0	0.24
Weight (kg)	52.3±7.1	52.9±8.0	0.37	53.3±6.9	53.3±6.9	0.84	51.0±7.5	51.6±6.1	0.45
BMI (kg/m^2)	21.5±2.8	21.6±2.7	0.76	22.8±2.7	22.8±2.7	0.92	22.7±3.0	23.1±2.4	0.24
BMD (g/cm^2)	0.655±0.049	0.653±0.047	0.61	0.570±0.083	0.583±0.075	0.02	0.466±0.071	0.461±0.069	0.52
Exercise (≥3 h per week) (%)	7.9	5.6	0.37	10.5	6.2	0.02	12.3	12.0	0.94
Physical labor (%)	7.6	10.4	0.30	17.9	19.0	0.65	13.3	15.8	0.54
Smoking (%)	6.4	6.4	0.99	2.1	4.1	0.07	1.1	3.9	0.08
Drinking (%)	33.6	32.8	0.87	25.1	25.4	0.91	13.3	20.6	0.08

Table 3 Association between low back pain and various risk factors in 1,153 women aged 45–64 years, expressed as odds ratios (OR) and 95% confidence intervals (CI)

Explanatory factor	OR	95%CI
Age (years)	1.03*	1.00–1.06
BMI (kg/m^2)	0.99	0.94–1.05
BMD (g/cm^2)	1.40**	1.14–1.73
Exercise (≥3 h per week)	0.52*	0.30–0.88
Smoking	2.19*	1.03–4.68

* *P* <0.05; ** *P* <0.01

factors for LBP, were also chosen, and then smoking remained as an independent variable in the final model. Ultimately, the independent variables included in the final model, adjusted for age and body mass index, were BMD, exercise and smoking. The results of logistic regression analysis are shown in Table 3, expressed as odds ratios (OR) and 95% confidence intervals (CI). The relative risk of LBP was 1.40 for an increase of 0.1 g/cm^2 in BMD (95% CI=1.14–1.73). Exercise was shown to be a preventive factor of LBP (OR=0.52), and an increased risk of LBP among smokers was also shown (OR=2.19). These associations remained even after entering other lifestyle and reproductive factors in the final model.

Discussion

Our data showed that a higher BMD at the distal radius is a predictive factor associated with the increasing prevalence of LBP in middle-aged women. To our knowledge, this is the first study to confirm such a relationship. In fact, very few studies have investigated this relationship. One previous study failed to identify any significant association between back pain and radial bone mineral content in middle-aged women [4]. A few former studies reported that back pain was not related to BMD in middle-aged and elderly women, although this conclusion was demonstrated by BMD measurement at the lumbar spine [14, 24]. It was shown in a cross-sectional investigation that the prevalence of back pain with osteoporotic hip fracture was only half, or even less than half, that in a control group of the same age [38]. This study of Zetterberg et al. was similar to ours in that both studies discuss the relation of LBP to bone status; however, their study population consisted of old patients, and lacked quantitative analysis on the basis of accurate BMD measurements.

The prevalence of LBP in the general population has been the subject of numerous studies, but the rates reported have varied. This discrepancy is due to various factors, including changes in both the duration and the severity of pain from day to day, and it can be explained by differences in the way the studies define LBP cases, bearing in mind the episodic nature of many cases of LBP [28]. A questionnaire that asks about the current existence of LBP, providing information on point prevalence, is likely to underestimate the true occurrence of this symptom [28], and naturally, the rate will be lower than the 1-year or 1-month period prevalence. In the results of the present study, the overall proportion reporting LBP was 23.3%, and this rate is similar to the point prevalence reported in previous studies [5, 13, 36].

Recent studies reported that LBP was significantly associated with a higher work-related physical activity and a lower level of exercise [19, 25]. The increased risk of LBP among smokers is well known [27, 34], and the effects of nicotine on the intervertebral disc in rabbits have been experimentally proved [16]. Our results demonstrated a significant relationship between LBP and both exercise and smoking among middle-aged women in accordance with previous reports.

Vertebral deformity is one of the cardinal manifestations of osteoporosis, the prevalence of which increases with age [26]. In the results of the European Vertebral Osteoporosis Study, it was suggested that LBP and disability could be attributed to vertebral deformities [6, 15], and that the strength of the association increases with the increasing number and severity of the deformities [20]. However, osteoporosis with vertebral deformity is generally not very common among middle-aged women [26], and as such it is difficult to regard such a condition as the main cause of LBP in this age group.

Cross-sectional surveys have demonstrated that signs of disc degeneration on magnetic resonance imaging (MRI) and radiographs are associated with LBP in the middle-aged [19, 32]. The prevalence of degenerative changes of the lumbar spine increases markedly with age. In a survey of the general population, osteophyte formation and disc degeneration of the lumbar spine were found in most middle-aged women [18, 23]. A recent MRI study suggested that the degree of disc degeneration varied among individuals under 40 years of age, whereas most of the discs were markedly degenerated among those over 60 years of age; moreover, disc degeneration was closely associated with facet joint osteoarthritis [10]. The current study is limited, in that it did not conduct morphological investigations of musculoskeletal disorders causing LBP. However, our results would seem to suggest that a large proportion of LBP among middle-aged women can not be attributed to vertebral deformity due to low BMD, suggesting other causes. This leads us to believe that high BMD and the correlated degenerative conditions could exert a harmful influence.

Many authors have reported that in women with vertebral osteophytes or intervertebral disc degeneration, the BMD values were found to be significantly higher than in unaffected subjects, although almost all the measurement sites of BMD that proved this relation were either in the lumbar spine or the femur [3, 21, 29], the exception being reports by von der Recke et al. and Nanjo et al., where measurements were taken at the distal radius [22, 35]. It is suggested that higher bone mass may increase bone stiffness, and thereby increase loading of articular cartilage, leading to cartilage damage [30]. A longitudinal study showed that patients with a rapid rate of joint space narrowing of the hip were characterized by elevated BMD of the hip and the lumbar spine [12]. These facts seem to suggest that a predisposing factor of systemic high BMD may be involved in lumbar degenerative changes that cause LBP.

In this study, the relationship between high BMD and LBP was not clarified among women aged over 65 years. Osteoporosis and osteoarthritis are both common conditions with a high prevalence in the elderly. Although an inverse relationship between osteoporosis and osteoarthritis has been suggested, these two degenerative conditions may certainly coexist [7, 21]. Women in whom osteoporosis and osteoarthritis coexisted were significantly older than those having osteoarthritis or vertebral deformity independently [33], suggesting one of the reasons for a lack of association between BMD and LBP among women aged over 65 years. It can be assumed that there are some differences in the primary factors causing LBP between the middle and the upper age groups, with changes in the condition of the lumbar spine occurring gradually.

Since this study is a cross-sectional study, which could be a limitation, causality cannot be inferred from the differences in BMD between women with and without LBP. Further prospective cohort studies, including examination of radiographs or MR images, are necessary in order to fully investigate a causal relationship between high BMD and both lumbar degenerative changes and LBP.

It is likely that public concern about spinal disorders with aging have focused principally on low BMD and its correlation with vertebral deformity, whereas cases with a higher BMD have received less attention, thus underrating the attendant problems. However, when considering the clinical symptoms and subsequent limitations in the daily activities of middle-aged women, the problem of a higher BMD needs to be dealt with seriously, since a high BMD and the correlated degenerative diseases would seem to be as important a public health problem as a low BMD and osteoporosis. When appropriately managing patients with regard to BMD and the correlated degenerative conditions, it is necessary to consider the pathogenesis of these conditions and how they relate to each other, especially in cases where the treatment for one could theoretically increase the risk for the other; moreover, it is important to find an optimum range of bone mass, provided by age-related values.

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