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Prevalence of Back Pain in Postmenopausal Osteoporosis and Associations with Multiple Spinal Factors

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1. Introduction

Back pain is considered to be most prevalent musculoskeletal pain, particularly in elderly populations (Woo et al., 2009). The existing literature suggests a prevalence of chronic back pain among the elderly ranging from 7% to 58% (Edmond & Felson, 2000; Jacobs et al., 2006; Lavsky-Shulan et al., 1985; March et al., 1998), with differences attributable to a lack of concordance in terms of age stratification, definition, and methodology, but with consistently much higher rates in women than men (Jabobs et al., 2006; Woo et al., 2009). The reason why back pain is common among elderly women may be related to osteoporosis. As lower bone mineral density (BMD) and the rapid decline in BMD following menopause in women result in a greater prevalence of osteoporosis and vertebral fractures compared to men, osteoporosis is likely to represent a major cause of back pain among elderly women. However, although osteoporosis may be an underlying cause of back pain, especially in postmenopausal elderly women, the prevalence of back pain in this group has not been fully investigated.

Although back pain in osteoporosis is often attributed to vertebral fractures (Nevitt et al., 1998; Ulivieri, 2007), the intensity of pain is not always influenced by fracture status (Hübscher et al., 2010). Liu-Ambrose et al. demonstrated that osteoporotic women may experience back pain without a concomitant history of vertebral compression fractures (Liu-Ambrose et al., 2002). The cause of back pain in osteoporosis thus seems likely to be related to multiple factors.

Spinal alignment and mobility are important factors for spinal function and may be related to back pain. Loss of lumbar lordosis correlates well with the incidence of chronic low back pain in adults (Djurasovic & Glassman, 2007; Glassman et al., 2005). Patients with a less mobile spine may show more severe symptoms. In addition, we have previously demonstrated that back extensor strength is significantly associated with spinal mobility (Miyakoshi et al., 2005). However, to the best of our knowledge, simultaneous assessment of back pain and multiple spinal factors such as vertebral fractures, spinal alignment and mobility, as well as back extensor strength, has not yet been investigated in patients with osteoporosis.

The objectives of this study were thus: 1) to determine the prevalence of back pain in patients with postmenopausal osteoporosis who visited their practitioner; and 2) to evaluate

associations of back pain and vertebral fractures, spinal alignment, mobility, and back extensor strength in these patients.

2. Materials and methods

2.1 Patients

A total of 174 consecutive women with postmenopausal osteoporosis aged 50 years and older who visited their practitioner (orthopedic clinic) were enrolled in the present study. All these patients were the same patients who enrolled in our previous study assessing back extensor strength and quality of life (QOL) (Miyakoshi et al., 2007). Osteoporosis was diagnosed according to the criteria proposed by the Japanese Society for Bone and Mineral Research (JSBMR) (Orimo et al., 2001). Briefly, patients with BMD less than 70% of the young adult mean BMD or with fragility fracture were diagnosed as having osteoporosis. All participants were asked whether they had clinically relevant back pain, and BMD, number of vertebral fractures, angle of kyphosis, range of motion (ROM) of the thoracic and lumbar spine, and back extensor strength were evaluated. These variables were compared between subjects with back pain (BP group) and those without back pain (non-BP group). In the BP group, associations between intensity of back pain and other measured variables were further evaluated.

Exclusion criteria were as follows: 1) women with a history of metabolic bone disease, malignancy, or recent antiosteoporotic treatment (with exception of calcium); 2) patients with hip fracture; 3) patients who could not lie in a prone position; 4) chronic use of glucocorticoids; 5) a concomitant illness that would substantially influence the daily living (e.g., chronic pulmonary disease, asthma, angina, chronic congestive heart failure, stroke, blindness, etc.); 6) other diseases that might cause back pain (e.g., scoliosis, lumbar spondylolisthesis, lumbar disc disease, etc.); and 7) patients with documented vertebral fracture within the last 6 months. Patients enrolled in the present study thus showed chronic back pain that was not attributable to a fresh vertebral fracture.

2.2 Definition of clinically relevant back pain

Back pain was considered clinically relevant if the participant answered that pain had been moderately to severely bothersome, or if the participant needed any medical treatment (Miyakoshi et al., 2010; Nevitt et al., 1998). In this study, the definition of back was not limited to the narrow sense of the upper and middle back, and low back was also included, as patients with osteoporosis often complain of pain affecting both definitions and differentiating between these seems difficult (Satoh et al., 1988).

2.3 Evaluation of back pain intensity

Intensity of back pain was evaluated using the pain domain score of the Japanese Osteoporosis QOL Questionnaire (JOQOL) (Table 1) (Kumamoto et al., 2010; Takahashi et al., 2000); as all questions for this score are limited to back pain, all domain scores show significant correlations on test and retest (Kendall's τ = 0.691-0.818) (Kumamoto et al., 2010) and the score can be used as a continuous variable to evaluate correlations with other measured variables. The pain domain score of JOQOL contains 5 questions. Scores for each item range from 0 to 4, for a full score of 20. Pain intensity indicated in this study was calculated as 20 – estimated pain domain score of JOQOL. The pain intensity evaluated in this study thus ranged from 0 (no pain) to 20 (worst pain).

Question	Score (points)
How often have you had back or low back pain in the last week?	
Never	4
1. 1 day per week or less	3
2. 2-3 days per week	2
3. 4-6 days per week	1
4. Every day	0
If you have had back pain or low back pain, for how long did you have it in the daytime?	
1. No pain	4
2. 1-2 hours	3
3. 3-5 hours	2
4. 6-10 hours	1
5. All day	0
While you kept still, how severe was your back or low back pain?	
1. No pain	4
2. Mild	3
3. Moderate	2
4. Severe	1
5. Unbearable	0
When you moved, how severe was your back or low back pain?	
1. No pain	4
2. Mild	3
3. Moderate	2
4. Severe	1
5. Unbearable	0
Has the back or low back pain disturbed your sleep in the last week?	
1. Never	4
2. Once	3
3. Twice	2
4. Every other night	1
5. Almost every night	0
Total	20

*Reference from Kumamoto et al., 2010.

Table 1. Pain domain questions of the Japanese Osteoporosis Quality of Life Questionnaire (JOQOL)*

2.4 Evaluation of vertebral fractures

X-rays of the thoracic and lumbar spine in lateral views with the patient in a neutral/lateral decubitus position were taken with a film-tube distance of 1 m. Thoracic films were centered

on T8, while lumbar films were centered on L3 (Miyakoshi et al., 2003b). Anterior, central, and posterior heights of each vertebral body from T4 to L5 were measured using calipers (Miyakoshi et al., 2003b). Coefficient of variation for this measurement was 2-3% (Orimo et al., 1994). Vertebral fracture was considered present if at least one of the three height measurements (anterior, middle, or posterior) of one vertebral body had decreased by more than 20% compared with the height of the nearest uncompressed vertebral body (Orimo et al., 1994).

2.5 Measurement of spinal kyphosis angles and ROMs

Angles of kyphosis and ROM of the thoracic (T1-T12) and lumbar (L1-L5) spine were measured using a device for computerized measurement of surface curvature (SpinalMouse®; Idiag, Volkerswill, Switzerland) in an upright position and at maximum flexion and extension (Kasukawa et al., 2010; Miyakoshi et al., 2005). Details regarding this device have been provided elsewhere (Post & Leferink, 2004). The device consists of a mobile unit of 2 rolling wheels interfacing with a base station through telemetry. By sliding the mobile unit along the spinal curvature, sagittal spinal alignment is calculated and displayed on the computer monitor. Repeating this process with the patient in flexion and extension of the spine allows measurement of ROM (Post & Leferink, 2004). SpinalMouse® delivers consistently reliable values for standing curvatures and ROM (Mannion et al., 2004; Post & Leferink, 2004). Post and Leferink (Post & Leferink, 2004) reported that interrater intraclass correlation coefficients (ICCs) for curvature measurement with SpinalMouse® were greater than 0.92. Mannion et al. (Mannion et al., 2004) reported that intrarater ICCs ranged from 0.82 to 0.83, while interrater ICCs ranged from 0.81 to 0.86. In addition, our previous studies have shown that thoracic and lumbar angles of kyphosis and spinal ROM measured using the SpinalMouse® correlate strongly with those measured on spinal radiography ($r=0.804$, $r=0.863$, and $r=0.783$, respectively; $p<0.0001$) (Miyakoshi et al., 2004).

2.6 Measurement of BMD

BMD was measured by dual-energy X-ray absorptiometry (QDR-4500; Hologic, Bedford, MA). Measurements were obtained from anteroposterior projections of the second to fourth lumbar vertebrae, the femoral neck, and the whole body. The coefficient of variation for these variables in 5 corresponding measurements from 5 normal volunteers was less than 1.5% (Miyakoshi et al., 2007).

2.7 Measurement of back extensor strength

Isometric back extensor strength in prone position was measured using a strain-gauge dynamometer (Digital Force Gauge DPU-1000N; IMADA, Toyohashi, Japan) as previously described (Hongo et al., 2007; Limburg et al., 1991; Miyakoshi et al., 2005). Subjects were allowed one warm-up trial, followed by three successive maximal effort trials separated by 60-s rest periods (Hongo et al., 2007). Maximal force among the three trials was selected and documented. Coefficient of variation for this measurement was 2.3% (Limburg et al., 1991).

2.8 Data analysis

All data are presented as mean and standard deviation (SD). Statistical analysis was performed using StatView version 5.0 software (Abacus Concepts, Berkeley, CA). Statistical

differences between groups were compared using an unpaired t-test. Logistic regression analysis was used for analyzing significant risk factors for back pain. Correlations between pain intensity and other measured variables were analyzed using Pearson's correlation coefficient and simple regression analysis. Further analyses using multiple regression were conducted to determine which variables best correlated with back pain. Values of $P<0.05$ were considered statistically significant.

3. Results

In this study, among 174 patients with postmenopausal osteoporosis, 159 patients (91.4%) complained of back pain. Mean values for age and measured variables in the BP and non-BP groups are listed in Table 2. No significant differences were apparent between BP and non-BP groups with regard to age, BMDs, number of vertebral fractures, angles of thoracic and lumbar kyphosis, and thoracic and lumbar ROMs. However, back extensor strength was significantly lower in the BP group than in the non-BP group. Similarly, when univariate logistic regression analysis was performed with the presence of back pain as a dependent variable and the other estimated variables as independent variables, only back extensor strength was identified as an index significantly associated with the presence of back pain (Table 3).

In patients with back pain, correlations between pain intensity and measured variables were evaluated. Pain intensity showed a significant positive correlation with the number of vertebral fractures, and negative correlations with lumbar spinal ROM and back extensor strength (Table 4). However, no significant correlations were observed between pain intensity and age, BMDs of all measured sites, angles of thoracic and lumbar kyphosis, or thoracic spinal ROM. Based on these results, number of vertebral fractures, lumbar spinal ROM, and back extensor strength were selected as independent variables for multiple regression modeling of pain intensity. Multiple regression analysis for pain intensity revealed lumbar spinal ROM and back extensor strength as significantly associated with pain intensity (Table 5).

	BP (n=159)	Non-BP (n=15)	*P*
Age (years)	67.8±6.5	65.5±7.0	0.1819
Lumbar spine BMD (g/cm^2)	0.696±0.111	0.687±0.103	0.7757
Femoral neck BMD (g/cm^2)	0.550±0.087	0.542±0.070	0.7105
Whole-body BMD (g/cm^2)	0.818±0.075	0.812±0.047	0.7556
No. of vertebral fractures	1.2±1.7	0.3±0.5	0.0637
Thoracic kyphosis angle (degrees)	44.2±14.1	42.9±12.3	0.7326
Lumbar kyphosis angle (degrees)	-15.5±18.2	-23.7±16.8	0.0977
Thoracic spinal ROM (degrees)	17.5±12.8	19.7±19.7	0.5499
Lumbar spinal ROM (degrees)	51.3±17.6	57.3±14.6	0.2025
Back extensor strength (kg)	12.9±6.3	17.3±6.6	0.0130

Values represent mean ± SD. BP, patients with back pain; non-BP, patients without back pain; BMD, bone mineral density; ROM, range of motion.

Table 2. Comparison of estimated variables between osteoporotic patients with and without back pain.

	OR	95% CI	*P*
Age (years)	1.052	0.976-1.134	0.1845
Lumbar spine BMD (g/cm²)	2.044	0.015-269.925	0.7741
Femoral neck BMD (g/cm²)	3.289	0.006-1695.221	0.7086
Whole body BMD (g/cm²)	3.275	0.002-5461.831	0.7540
No. of vertebral fractures	2.107	0.949-4.680	0.0670
Thoracic kyphosis angle (degrees)	1.007	0.969-1.046	0.7308
Lumbar kyphosis angle (degrees)	1.033	0.994-1.074	0.0958
Thoracic spinal ROM (degrees)	0.988	0.951-1.027	0.5475
Lumbar spinal ROM (degrees)	0.980	0.951-1.011	0.2033
Back extensor strength (kg)	0.906	0.835-0.982	0.0166

OR, odds ratio; CI, confidence interval; BMD, bone mineral density; ROM, range of motion.

Table 3. Univariate logistic regression analysis for back pain in patients with osteoporosis (n=174).

	Correlation coefficient *(r)*	*P*
Age (years)	0.118	0.1391
Lumbar spine BMD (g/cm²)	-0.089	0.2643
Femoral neck BMD (g/cm²)	-0.090	0.2583
Whole body BMD (g/cm²)	-0.097	0.2258
No. of vertebral fractures	0.171	0.0312
Thoracic kyphosis angle (degree)	-0.043	0.5892
Lumbar kyphosis angle (degree)	0.139	0.0803
Thoracic spinal ROM (degree)	-0.109	0.1707
Lumbar spinal ROM (degree)	-0.264	0.0007
Back extensor strength (kg)	-0.268	0.0006

*Pain intensity ranged from 0 (no pain) to 20 (worst pain) was calculated from 20 minus estimated pain domain score of JOQOL. BMD, bone mineral density; ROM, range of motion.

Table 4. Correlations between pain intensity* and estimated variables in patients with osteoporosis and back pain (n=159).

	Coefficient *(r)*	*P*
Intercept	11.238	<0.0001
No. of vertebral fractures	0.132	0.4517
Lumbar spinal ROM (degrees)	-0.041	0.0179
Back extensor strength (kg)	-0.116	0.0142

*Pain intensity ranged from 0 (no pain) to 20 (worst pain), calculated as 20 minus the estimated pain domain score of JOQOL. ROM, range of motion.

Table 5. Multiple regression analysis for pain intensity* in patients with osteoporosis and back pain (n=159).

4. Discussion

4.1 Prevalence of back pain

Back pain is a major source of morbidity among patients with osteoporosis. Osteoporotic vertebral fractures usually cause acute, disabling, painful episodes at the fracture site. Such acute back pain subsides with fracture healing. However, after the fracture heals, the resulting increase in spinal kyphosis is likely to cause chronic back pain (Francis et al., 2008; Satoh et al., 1988). Increased spinal kyphosis is likely to induce abnormal stress on the supporting structures of the spinal column and may cause chronic back pain that usually develops while standing, walking, or doing other normal daily activities (Satoh et al., 1988). The back pain evaluated in the present study was considered to be chronic, because patients with documented vertebral fracture within the preceding 6 months were not included.

The prevalence of back pain, particularly chronic back pain, in patients with osteoporosis has not been fully investigated. Cockerill et al. (Cockerill et al., 2000) reported that the prevalence of back pain in the current and past year for women aged 50 years and over was significantly higher in women with single lumbar vertebral deformities (51.4% and 72.6%, respectively) than in women without vertebral deformity (39% and 60.6%, respectively) ($p<0.05$). Jacobs et al. (Jacobs et al., 2006) undertook a longitudinal study of 277 elderly subjects, finding that the prevalence of chronic back pain increased from 44% to 58% at ages 70 and 77 years, respectively, and this pain was associated with female sex at age 70 years and osteoporosis at age 77 years. More recently, Kuroda et al. (Kuroda et al., 2009) reported that back pain was observed in 28% of 818 Japanese postmenopausal women aged over 40 years (mean, 62.1 years) who visited their practitioner, and this back pain was associated with osteoporosis and vertebral fractures. In the present study, the prevalence of clinically relevant back pain was 91.4%. This percentage is higher than previously reported prevalences of back pain in osteoporosis (28-72.6%) (Cockerill et al., 2000; Jacobs et al., 2006; Kuroda et al., 2009), probably because all patients enrolled in the present study were visitors to an orthopedic clinic and might have had more musculoskeletal symptoms.

4.2 Factors associated with back pain and pain intensity

Previous studies have shown that vertebral fractures are associated with back pain and disability, with the strength of these associations increasing with the number and severity of fractures (Ettinger et al., 1992; Huang et al., 1996; Matthis et al., 1998). Increased spinal kyphosis caused by vertebral fractures is also known to induce back pain and disability in patients with osteoporosis (Miyakoshi et al., 2003a). In the present study, the number of vertebral fractures and angles of lumbar kyphosis tended to be higher in patients with back pain than in those without back pain, but no significant differences were identified ($p=0.0637$ and $p=0.0977$, respectively). However, in patients with back pain, the present study also showed a significant positive correlation between number of vertebral fractures and pain intensity ($r=0.171$, $p=0.0312$).

An important association between back pain and back extensor strength in patients with osteoporosis is indicated from the present study. Back extensor strength was significantly lower in patients with back pain compared to those without back pain, but other factors we evaluated showed no significant differences between groups. In addition, among patients with back pain, multiple regression analysis for pain intensity revealed back extensor strength and lumbar spinal ROM as significantly associated with pain intensity. Decreased back extensor strength may thus represent the most important factor contributing to back

pain and pain intensity in patients with osteoporosis. Subjects on acute back pain due to fresh vertebral fractures maybe could not perform the back extensor strength tests as good as non-acute pain subjects. However, because the back pain evaluated in the present study was considered to be chronic, all the patients could perform the strength tests without increasing the pain. Thus, we concluded that the weakness of back extensor is a very important factor for chronic back pain in patients with osteoporosis.

Back extensor strength reportedly shows a significant relation with spinal mobility (Miyakoshi et al., 2005), and decreased mobility of the spine is thought to lead to increased kyphosis and weakness of the paravertebral muscles, as well as the development of impaired physical function (Burger et al., 1997). Decreased back extensor strength may thus reduce mobility of the lumbar spine, and a less mobile lumbar spine may cause stiffness of the back muscles, resulting in back pain. As muscle strength is determined largely by muscle mass, particularly the cross-sectional area of muscle (Maughan, 2005), and because the muscle cross-sectional area of back extensor muscles (the erector spinae group) is larger at the lumbar spine level than at the thoracic spine level (Marras et al., 2001), total back extensor strength is largely influenced by lumbar extensor muscles rather than thoracic extensor muscles. The results of the present study are not inconsistent with this anatomical background. Weakness of the back extensor muscles, particularly the lumbar extensor muscles, is thought to be responsible for lumbar spinal mobility.

4.3 Other possible factors contributing to back pain in osteoporosis

The present study focused on back pain and multiple spinal factors in patients with osteoporosis. However, the etiology of back pain is more complex and more multifactorial than could be examined in this study. Prevalence of musculoskeletal pain is also known to be associated with various measures of socio-economic status, as well as comorbidities (Thomas et al., 1999; Woo et al., 2009). Severity of pain may also be influenced by psychological factors (Woo et al., 2009). In addition, elderly patients with osteoporosis sometimes show other painful spinal disorders such as spondylosis to varying extents (Miyakoshi et al., 2003b). Findings in the present study might also have been influenced, at least in part, by factors other than osteoporosis.

4.4 Study limitations

Limitations of the present study should be noted. First, the number of subjects in the present study was much smaller than in previous studies evaluating the prevalence of back pain (Cockerill et al., 2000; Jacobs et al., 2006; Kuroda et al., 2009). However, we would like to emphasize that this is the first study to simultaneously evaluate back pain and multiple spinal factors in patients with osteoporosis. Second, data could not be obtained from severely kyphotic patients with established osteoporosis who were too disabled to lie in a prone position because of increased back pain in this position. This was because the dynamometer for measuring back extensor strength in the present study needed the patient to lie in a prone position. Therefore, the results of the present study might be considered for patients with mild or moderate spinal deformity.

5. Conclusions

In conclusion, the prevalence of back pain among patients with postmenopausal osteoporosis ≥50 years old who visited their practitioner was 91.4%. Back extensor strength

was significantly lower in patients with back pain compared to those without back pain. Among subjects with back pain, intensity of back pain showed significant relationships with decreased back extensor strength and limited lumbar spinal mobility.

6. Acknowledgement

We wish to thank all the staff of Joto Orthopedic Clinic for their valuable assistance in conducting the study.

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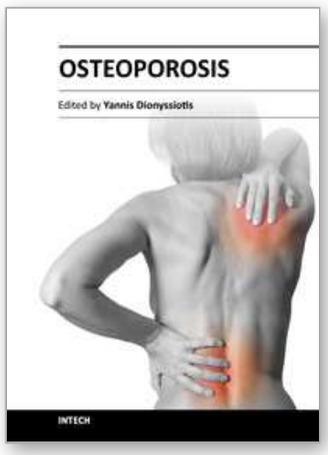

Osteoporosis

Edited by PhD. Yannis Dionyssiotis

ISBN 978-953-51-0026-3
Hard cover, 864 pages
Publisher InTech
Published online 24, February, 2012
Published in print edition February, 2012

Osteoporosis is a public health issue worldwide. During the last few years, progress has been made concerning the knowledge of the pathophysiological mechanism of the disease. Sophisticated technologies have added important information in bone mineral density measurements and, additionally, geometrical and mechanical properties of bone. New bone indices have been developed from biochemical and hormonal measurements in order to investigate bone metabolism. Although it is clear that drugs are an essential element of the therapy, beyond medication there are other interventions in the management of the disease. Prevention of osteoporosis starts in young ages and continues during aging in order to prevent fractures associated with impaired quality of life, physical decline, mortality, and high cost for the health system. A number of different specialties are holding the scientific knowledge in osteoporosis. For this reason, we have collected papers from scientific departments all over the world for this book. The book includes up-to-date information about basics of bones, epidemiological data, diagnosis and assessment of osteoporosis, secondary osteoporosis, pediatric issues, prevention and treatment strategies, and research papers from osteoporotic fields.

How to reference

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Naohisa Miyakoshi, Michio Hongo and Yoichi Shimada (2012). Prevalence of Back Pain in Postmenopausal Osteoporosis and Associations with Multiple Spinal Factors, Osteoporosis, PhD. Yannis Dionyssiotis (Ed.), ISBN: 978-953-51-0026-3, InTech, Available from: http://www.intechopen.com/books/osteoporosis/prevalence-of-back-pain-in-postmenopausal-osteoporosis-and-associations-with-multiple-spinal-factors

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