

The Impact of Lumbar Spinal Stenosis, Knee Osteoarthritis, and Loss of Lumbar Lordosis on the Quality of Life: Findings from the Katsuragi Low Back Pain Study

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Abstract:

Introduction: Musculoskeletal diseases and spinal malalignment are associated with poorer quality of life (QOL) in the elderly. However, to date, few general population cohort studies have focused on these conditions together. Our objectives were to clarify the associations between musculoskeletal degenerative diseases and/or spinal malalignment with QOL measures in a group of Japanese older adults.

Methods: In this cross-sectional study, we analyzed data from 334 individuals recruited from the local population (120 men, 214 women; mean age 62.7 years; range 40-75). Low back pain (LBP) was assessed by questionnaire, and lumbar spinal stenosis (LSS) was diagnosed using a validated lumbar spinal stenosis support tool. Knee osteoarthritis (KOA) was diagnosed by the presence of clinical knee pain plus radiographic KOA. Spinal radiographs were used to assess the degree of lumbar lordosis (LL) and sagittal vertical alignment (SVA). QOL assessment was performed using the Oswestry Disability Index (ODI). A score of 12 was used as a cut-off point for poor QOL.

Results: Overall, 107 (32.0%) participants had an ODI > 12 (cases), and the remaining 227 individuals were designated controls. LBP, LSS, KOA, and LL were associated with poorer QOL, both in basic models and models adjusted for age, sex, and BMI. Associations persisted after adjustment for other musculoskeletal outcomes.

Conclusions: In a free-living Japanese population, the poor QOL odds are increased by LBP, LSS, KOA, and certain spinal radiographic features, loss of LL, and increased SVA. Poor QOL odds were greatest in those diagnosed with LSS or KOA. From spinal radiographs, decreased LL and increased SVA were also predictors of poor QOL.

Keywords:

Locomotive syndrome, low back pain, lumbar spinal stenosis, knee osteoarthritis, spinal alignment

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Introduction

As a result of aging populations and increasing life expectancy in many countries, including Japan, susceptibility to musculoskeletal disorders is increasing¹⁾. Musculoskeletal disorders are the fourth largest contributor to disease burden in older people worldwide, after cardiovascular disease, ma-

lignant neoplasms and chronic respiratory diseases²⁾. Both osteoarthritis and conditions affecting the spine, such as lumbar spinal stenosis (LSS), are widely reported to be associated with poorer quality of life (QOL), disability, and mortality³⁾. Knee osteoarthritis (KOA), LSS, and osteoporosis (OP) are the three major musculoskeletal diseases which can lead to a condition known as the “locomotive syn-

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drome," characterized by pain, a limitation of the range of joint mobility, deformation, reduced balance capability and slower walking pace⁴⁾. The socioeconomic impact of these diseases is substantial; at present, 4.5 million elderly (aged 65 or older) people in Japan require nursing care services⁵⁾, and this is set to increase dramatically: by 2055, the elderly are predicted to account for 40.5% of the country's population⁴⁾.

Few general population cohort studies to date in Japan have studied the conditions of knee osteoarthritis and lumbar spinal stenosis at the same time, and quantified their contribution to poor QOL. Studies quantifying the link between QOL and the degree of spinal malalignment, through loss of lumbar lordosis (LL) and increasing thoracic kyphosis, are also lacking. Thoracic kyphosis predicts an increased risk of mortality, low back pain (LBP), back muscle strength, difficulties with daily living activities, and other adverse health outcomes such as abdominal compression and impaired pulmonary function⁶⁾. We believe that it is critical to develop a comprehensive understanding of these conditions - not only through treating geriatric musculoskeletal disorders, but also by understanding how these diseases complicate or lead to each other, and impact the QOL of affected individuals.

The Katsuragi Low Back Pain Study is a population-based cohort established in a region of Japan with a large number of elderly residents. Through this study, we aimed to clarify the relationship between poor QOL and LBP, LSS, KOA, and spinal radiographic features including LL, thoracic kyphosis (TK) and sagittal vertical axis (SVA).

Materials and Methods

Participants

Participants are residents of Katsuragi Town in Wakayama Prefecture. Annual health examinations for older people are organized by the local government, including a physician consultation. All residents are notified by letters from the government, and approximately 25% (about 4,500) participate in the annual health examinations. From this group, 353 people provided written informed consent to join a cohort study organized by our university hospital in August 2014. From this existing population cohort, we recruited participants to the Katsuragi Low Back Pain Study.

The 353 participants underwent careful phenotyping for musculoskeletal health, in addition to cardiovascular risk assessment, cognitive and depression assessments, and QOL assessments. All assessments took place on the same day. For all participants we obtained physical measurements (body height, weight, blood pressure, body fat ratio), an interview-based confirmation of occupation and past medical history, and dual-energy X-ray absorptiometry (Prodigy for Bone Health; GE Healthcare Japan Corp. Tokyo) to assess lumbar spine and proximal femur bone mineral density (BMD). In this study, osteoporosis (OP) was defined according to the World Health Organization definition of $T=-2.5$

SD. In Japan, lumbar spine OP was defined as L2-4 BMD of $< 0.714 \text{ g/cm}^2$ ^{1,6)}. In Japan, OP at the femoral neck was defined as a BMD of $< 0.546 \text{ g/cm}^2$ and $< 0.515 \text{ g/cm}^2$ for male and female^{1,6)}.

The study was conducted with the approval of the university ethics committee.

The Oswestry disability index (ODI)

The ODI is an index derived from the Oswestry Low Back Pain Questionnaire^{7,8)}, used by clinicians and researchers to quantify the level of disability in LBP. The index scores range from 0 (lowest level of disability) to 100 (highest level of disability). A score of 12 was used as a cut-point for poor QOL. In a study of 1200 Japanese people with an ODI value of 12 were previously shown to separate individuals with LBP with disability from those without⁹⁾. We therefore used a cut-point of 12 on the ODI to differentiate those with or without poor QOL.

Assessment of low back pain/knee pain

An orthopedic surgeon (YI) asked the following questions regarding LBP and knee pain, respectively, to which participants responded "yes" or "no"¹⁰⁾. "In the past month, have you had LBP on most days?" "In the past month, have you had knee pain on most days?"

In order to further assess LBP, the same orthopedic surgeon used a visual analogue scale (scale 1-100) to assess the most intense LBP experienced during the past month.

Radiographic assessment

LL (L1-5), TK (T1-12), and SVA were measured using a whole spinal lateral standing radiograph¹¹⁾. Radiographic KOA was scored by an experienced orthopedic surgeon (MT). The severity of radiographic KOA was determined according to Kellgren-Lawrence (KL) grading¹²⁾ as follows: KL0, normal; KL1, slight osteophytes; KL2, definite osteophytes; KL3, joint or intervertebral space narrowing with large osteophytes; KL4, bone sclerosis, joint or intervertebral space narrowing, and large osteophytes. The same observer re-assessed a random sample of 50 of the X-rays after more than a period of one month, blinded to the original rating.

SVA is a widely accepted measure of spinal alignment, and was measured from spinal radiographs using the method described by Schwab et al¹¹⁾. SVA is defined as the horizontal offset from the postero-superior corner of S1 to the vertebral midbody of C7.

The intra-observer reliability with intraclass correlation coefficients (ICCs) were 0.85 for LL, 0.77 for TK, and 0.80 for SVA; kappa was 0.81. Moreover, the inter-observer reliability with ICCs were 0.81 for LL, 0.89 for TK, and 0.91 for SVA; kappa was 0.79.

Assessment of LSS and KOA

In order to assess LSS, the same orthopedic surgeon evaluated all participants using a validated LSS support

tool¹³). Participants with leg symptoms who were scored seven or higher were determined to have LSS. In order to diagnose KOA, both knee pain and radiographic KOA scoring 2 or higher on the KL scale were required.

Statistical analysis

Participants' demographic characteristics were summarized using means (SDs) and counts (n, %) separately for those graded as having poor QOL (ODI > 12, (cases)) and those with good QOL (ODI < 12, (controls)). Differences in categorical and continuous variables between cases and controls were analyzed using chi-squared and t-tests, respectively. The effects of predictors such as LBP, LSS, KOA, and radiographic features on ODI were assessed, using logistic regression modeling, before and after adjusting for demographics and predictors and were summarized by odds ratios (ORs) and 95% confidence intervals (CIs). ORs were adjusted for potential confounders (age, sex, and BMI) in

addition to the other musculoskeletal predictors. Statistical analyses were performing using JMP version 10 (SAS Institute Japan; Tokyo, Japan).

Results

The overall prevalence of LBP, LSS, and KOA was 33.2%, 6.6%, and 22.7% respectively. KOA presence was higher in women (Men: 12.5%, Women: 17.8%, P=0.006). Overall OP prevalence was 2.3%. In terms of radiographic spinal features, there was no significant difference in the degree of TK between the sexes, but the severity of LL was significantly greater in women compared to men, whereas the SVA was significantly greater in men than women.

In total, 107 (32.0%) of participants were demonstrated to have poor QOL according to our criteria (ODI ≥ 12 (cases)); the remaining 227 individuals were used as controls in our analysis (Table 1). The musculoskeletal outcomes (LBP, LSS, KOA, LL, and SVA), which differed significantly between cases and controls, were used as predictors.

Table 2 shows the association between LBP, LSS, KOA, and radiographic features, including LL and SVA, and QOL status. In the unadjusted analyses (Model 1), LBP (OR 3.79, p < 0.0001), LSS (OR 4.46, p 0.0007), and KOA (OR 4.24, p < 0.0001) were significantly associated with increased odds of poor QOL. In terms of spinal radiographic features, decreasing LL (OR 1.02 per 1° decrease in LL, p=0.047 and increasing SVA (OR 1.09 per 1 cm increase in SVA, p=0.013) significantly increased the odds of poor QOL. Adjustment for sex, age and BMI increased the strength of the association between LSS and poor QOL to OR 4.46 (95% CI 1.87, 11.4) to OR 4.77 (95% CI 1.93, 12.7). After adjustment for the other musculoskeletal predictors, as well as sex, age, and BMI, the associations between all predictors other than SVA remained significant (Model 3). In particular, LSS and KOA were associated with over a four-fold increase in risk (LSS: OR 4.1 95% CI 1.56, 11.29, KOA: OR 4.97, 95% CI 2.54, 9.94) after adjustment for age, sex, BMI, and all other predictors. Associations between LBP and LSS and poor QOL were attenuated by adjustment for the other

Table 1. Study Participant Data.

	Cases (N=107)	Controls (N=227)	Pvalue
Sex			
Males	33 (30.8%)	87 (38.3%)	0.183
Females	74 (69.2%)	140 (61.7%)	
Age [mean (SD)] (years)	64.4 (7.9)	61.9 (8.9)	0.014
BMI [mean (SD)] (kg/m ²)	23.4 (3.7)	22.1 (3.2)	0.002
LBP	58 (54.2%)	54 (23.8%)	<0.0001
LSS	15 (14.0%)	8 (3.5%)	0.004
KOA	32 (30.2%)	21 (9.3%)	<0.0001
BMD (g/cm ²)			
Femoral Neck	0.88 (0.14)	0.88 (0.15)	0.82
Lumbar	1.12 (0.23)	1.10 (0.21)	0.44
Radiographic features			
LL (L1-5) (°)	33.8 (12.4)	36.9 (13.0)	0.047
TK (T1-12) (°)	36.7 (12.6)	36.6 (10.7)	0.91
SVA (cm)	2.59 (3.8)	1.6 (3.1)	0.013

LBP: low back pain, LSS: lumbar spinal stenosis, KOA: knee osteoarthritis, BMD: bone mineral density, LL: lumbar lordosis, TK: thoracic kyphosis, SVA: sagittal vertical axis

Table 2. Associations between Predictors and Risk of Being a Case (ODI>12).

Predictors	Model 1			Model 2			Model 3		
	OR	95% CIs	P	OR	95% CIs	P	OR	95% CIs	P
LBP	3.79	2.34-6.21	<0.0001	3.78	2.29-6.30	<0.0001	3.2	1.86-5.65	<0.0001
LSS	4.46	1.87-11.4	0.0007	4.77	1.93-12.7	0.001	4.1	1.56-11.29	0.003
KOA	4.24	2.31-7.91	<0.0001	4.2	2.26-8.00	<0.0001	4.97	2.54-9.94	<0.0001
Radiographic features									
^a LL (L1-5) (-1°)	1.02	1.00-1.04	0.047	1.02	1.00-1.04	0.038	1.02	1.00-1.05	0.021
^b SVA (+1cm)	1.09	1.02-1.18	0.013	1.09	1.01-1.18	0.025	1.07	0.98-1.16	0.138

LL: lumbar lordosis, SVA: sagittal vertical alignment

^aOdds ratio per 1° decrease in LL, ^bOdds ratio per 1cm increase in SVA

Model 1: unadjusted

Model 2: adjusted for sex, age and BMI

Model 3: adjusted for the other predictors as well as sex, age and BMI

predictors (including KOA), whereas associations between KOA and poor QOL was strengthened by this adjustment.

Discussion

In a study of 334 Japanese older people (mean age 62.7 (8.65) years), we have shown that LBP, LSS, KOA, and decreasing LL were significantly associated with poor QOL as defined by the ODI. In this cohort, we found that people with poorer QOL tended to be older and have higher BMI. LSS was associated with an over four-fold, and KOA with almost five-fold increased odds of poor QOL as compared to those without, after adjustment for potential confounding factors such as sex, age, BMI, and other musculoskeletal conditions. BMD and TK were not shown to be associated with QOL in this population. SVA was not shown to be an independent predictor of poor QOL following adjustment for all the same confounders.

Certain limitations to this study should be acknowledged. First, this is a cross-sectional study, meaning causal attributions cannot be made between musculoskeletal health outcomes such as LBP, LSS, KOA, or radiographic features of reduced LL and poor QOL. Second, since we recruited consenting members of the population getting an annual health check to take part in a research study, random sampling cannot be ensured. This may limit the generalizability of these findings through selection bias since those enrolling in a healthcare-based study may not have been representative of the population. Third, owing to the small study sample size ($n=334$), the effect estimates are of low precision and could have occurred through chance, information or selection bias. Fourth, ODI does not always reflect the whole QOL but the QOL related to LBP. Finally, the study findings would only apply to individuals living independently since the recruitment strategy did not target elderly people living in nursing homes. However, the direction of the effect would have probably reduced the estimated prevalence of these conditions in the current study.

In our study, LSS and KOA were associated with higher odds of poor QOL more than all the other predictors. This is in keeping with other studies, suggesting that those with LSS and/or KOA in general have poorer physical health status compared to those without and, as a result, suffer a poorer QOL¹⁴.

It is interesting that BMD was not associated with QOL in this study even though osteoporosis (OP) is one of the primary musculoskeletal diseases leading to "locomotive syndrome"⁴). However, this is perhaps unsurprising given the mean age of the cohort was 62.5 years (40-75), and the prevalence of OP in the Japanese population increases rapidly from age 80¹⁵). Therefore, it is likely that very few of our participants would have suffered fractures leading to musculoskeletal disability, back pain or kyphosis at the time of the study. In fact, as many Japanese industries have an age of retirement almost 65 years, almost half of our participants would not have retired at the time of their examina-

tion.

In terms of radiographic features, decreasing LL was associated with greater odds of poor QOL, which persisted after adjustment for all the same confounders. SVA was associated with increased odds of poor QOL also, though the effect became non-significant after adjustment for all the same confounders. Interestingly, in our study, the degree of TK was not associated with poorer QOL, nor was it associated with advancing age. Consequently, our findings suggest that a radiographic LL measurement is the most suitable marker for QOL among radiographic features for spinal alignment. The SVA measurement is likely to be of less value in an elderly population as the knee angle may compensate for sagittal balance¹⁶) when people stand, provided they do not have vertebral fractures.

A review of the current literature indicates scarce evidence from population-based cohorts that LL is associated with poorer health. Imagama et al.¹⁷) reported that LL and back muscle strength were related to decreasing QOL in elderly men. The current study is the first to evaluate the influence of LL to determine the relationship with QOL in a population-based cohort including both genders. A further study by Imagama et al.¹⁸) reported that an exercise designed to improve sagittal balance by improving back muscle strength and thoracic ROM improved QOL measures in men. Miyakoshi et al.¹⁹) showed that worsening back muscle strength was the most important factor contributing to a decline in spinal range of movement in postmenopausal women, indicating the importance of both back muscle strength and lumbar range of movement in determining QOL.

Evidence from randomized controlled trials also associate back muscle strength training with a significant improvement in QOL²⁰). Studies have linked LL to the quantity of lumbar muscle, which contributes a high percentage of overall back muscle. This may explain why exercise interventions have been shown to improve LL and QOL²¹).

Many reports have associated LBP with lumbar degenerative changes. Disc space narrowing is the most commonly used marker of lumbar disc degeneration. One study suggested that individuals with a degenerative disc may be at greater risk of poor health²²). Savinainen et al.²³) reported that the musculoskeletal capacity in subjects with a higher workload was poorer than that in the subjects with a lower workload. A difference in trunk extension strength was detected between these two groups, which is known to be associated with decreasing LL. Heavy manual work is also significantly associated with disc degeneration. Katsuragi is a rural city, and the patient population comprises a high percentage of farmers, hence heavy manual work may have affected spinal health in our population. There may have been occupational effects on QOL measures in our population; unfortunately, the study questionnaire was not specifically designed to characterize occupational risk factors for QOL. Similarly, the questionnaire did not allow us to assess nutritional risk factors for musculoskeletal measures and QOL outcomes.

In conclusion, we have demonstrated, in a population of older men and women, to our knowledge for the first time, associations between several musculoskeletal diseases, spinal radiographic features, and QOL. We have shown that the odds of poor QOL appear strongest in those with LSS or KOA among the musculoskeletal diseases. Among the spinal radiographic measures, decreasing LL was also a significant predictor of poor QOL. Further research is required to examine whether targeted exercise and nutritional interventions, aimed at improving muscle strength and reducing the burden of occupational activity, may reduce the risk of LBP, LSS and KOA, hence reducing the burden of these conditions on QOL for future generations.

Disclaimer: Mamoru Kawakami is the Editor of Spine Surgery and Related Research and on the journal's Editorial Committee. He was not involved in the editorial evaluation or decision to accept this article for publication.

Conflicts of Interest: The authors declare that there are no relevant conflicts of interest.

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