**The impact of lumbar spinal stenosis, knee osteoarthritis and loss of lumbar lordosis on quality of life: findings from the Katsuragi Low Back Pain Study**

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**Abstract**

**Introduction:** Musculoskeletal diseases and spinal malalignment are widely known to be associated with poorer quality of life (QOL) in the elderly. However, few general population cohort studies have been conducted to date focusing 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 analysed 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-point for poor quality of life.

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

**Conclusion:** In a free-living Japanese population, the odds of poor quality of life are increased by LBP, LSS, KOA and certain spinal radiographic features, loss of LL and increased SVA. The odds of poor quality of life were greatest in those with the diagnoses of LSS or KOA. From spinal radiographs, decreasing LL and increased SVA were also predictors of poor QOL.

**Keywords**

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

**Introduction**

As a result of population ageing and increasing life expectancy in many countries, including Japan, susceptibility to musculoskeletal disorders is increasing1.Musculoskeletal disorders represent the fourth largest contributer to disease burden in older people worldwide, after cardiovascular disease, malignant neoplasms and chronic respiratory diseases 2. Both osteoarthritis and conditions affecting the spine, such as lumbar spinal stenosis, are widely reported to be associated with poorer quality of life (QOL), disability, and mortality 3. Knee osteoarthritis (KOA), lumbar spinal stenosis (LSS) and osteoporosis (OP) are the three major musculoskeletal diseases which can lead to a condition known as the “locomotive syndrome”, characterized by pain, a limitation of the range of joint mobility, deformation, reduced balance capability and a slower pace of walking 4. The socioeconomic impact of these diseases is substantial; at present, 4.5 million elderly (aged 65 or older) people in Japan require nursing care services 5, and this is set to increase dramatically as by 2055 the elderly are predicted to account for 40.5% of the country’s population 4.

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 quality of life. Studies quantifying the link between quality of life and the degree of spinal malalignment, through loss of lumbar lordosis and increasing thoracic kyphosis, are also lacking. Thoracic kyphosis predicts an increased risk of mortality, low back pain (LBP), back muscle strength, difficulties with the activities of daily living, and other adverse health outcomes such as abdominal compression and impaired pulmonary function 6. 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 quality of life of the individuals affected.

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 quality of life and LBP, LSS, KOA and spinal radiographic features including lumbar lordosis (LL), thoracic kyphosis (TK) and sagittal vertical axis (SVA).

**Methods**

**Participants**

Participants are residents of Katsuragi Town in Wakayama Prefecture. Annual health examinations for older people are organized by the local government, which includes a physician consultation. All residents are notified by the 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 organised by our university hospital from August 2014. From this existing population cohort, we recruited participants to the Katsuragi Low Back Pain Study in August 2014.

The 353 participants underwent careful phenotyping for musculoskeletal health, in addition to cardiovascular risk assessment, cognitive and depression assessments, and quality of life assessments. All assessments took place on the same day. In all participants we conducted 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 (DXA; 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 g/cm2 1,6. In Japan, OP at the femoral neck was defined as a BMD of <0.546 g/cm2 and <0.515 g/cm2 for male and female 1,6.

The study was conducted with the approval of the ethics committees of the our university.

**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 quality of life. In a study of 1200 Japanese people an ODI value of 12 has been previously shown to separate individuals with low back pain with disability from those without 9. We therefore used a cut-point of 12 on the ODI to differentiate those with or without poor quality of life.

**Assessment of low back pain/knee pain**

An orthopedic surgeon (YI) asked the following questions regarding low back pain and knee pain, respectively, to which participants responded “yes” or “no” 10. “In the past month, have you had low back pain 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 (VAS) (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 radiograph 11. Radiographic KOA was scored by an experienced orthopedic surgeon (MT). The severity of radiographic KOA was determined according to Kellgren-Lawrence (KL) grading 12 as follows: KL0, normal; KL1, slight osteophytes; KL2, definite osteophytes; KL3, joint or intervertebral space narrowing with large osterphytes; 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 al 11. 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 coeffecients (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 and 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 tool 13. 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**

Participant’s demographic characteristics were summarized using means (SDs) and counts (n, %) separately for those graded as having poor quality of life (ODI **>**12, (cases)) and those with a good quality of life (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 the 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). Odds ratios 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. The prevalence of KOA was significantly different between the sexes, being higher in women (Men: 12.5%, Women: 17.8%, P=0.006). The overall prevalence of OP 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 a poor quality of life 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 quality of life 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 quality of life. In terms of spinal radiographic features, decreasing LL (OR 1.02 per 1o decrease in LL, p=0.047 and increasing SVA (OR 1.09 per 1cm increase in SVA, p=0.013) significantly increased the odds of poor quality of life. Adjustment for sex, age and BMI increased the strength of the association between LSS and poor quality of life 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 and other than SVA remained significant (Model 3). In particular, LSS and KOA were associated with over a four-fold increase in risk of being a case (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 quality of life were attenuated by adjustment for the other predictors (including KOA), whereas associations between KOA and poor quality of life 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 Oswestry Disability Index. In this cohort, we found that people with a poorer quality of life tended to be older, and have a higher BMI. LSS was associated with an over 4 fold-, and KOA with an 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 thoracic kyphosis 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 quality of life. Second, through our recruitment method of consenting members of the population attending for 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, as those enrolling in a healthcare based study may not have been representative of the population. Third, owing to the small size of the study sample (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, as the recruitment strategy did not target elderly people living in care homes. However, the direction of the effect would have been likely to reduce the estimated prevalence of these conditions in the current study.

In our study, LSS and KOA were associated with a higher odds of poor QOL 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 quality of life 14.

It is interesting that BMD was not associated with QOL in this study, despite osteoporosis (OP) being one of the primary musculoskeletal diseases leading to the “locomotive syndrome” 4. However, this is perhaps unsurprising as 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 80 15. 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 stopped work at the time of their examination.

In terms of radiographic features, decreasing LL was associated with greater odds of poor quality of life, which persisted after adjustment for all the same confounders. SVA was associated with an increased odds of poor quality of life also, though the effect became non-significant after adjustment for all the same confounders. Interestingly, in our study, the degree of thoracic kyphosis was not associated with poorer QOL, neither 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 balance 16 when people stand, provided they do not have vertebral fractures.

On review of the current literature, there is 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 exercised designed to improve sagittal balance by improving back muscle strength and thoracic ROM improved quality of life 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 quality of life.

There is also evidence from randomised controlled trials that back muscle strength training was associated with a significant improvement in quality of life 20. Studies have linked lumbar lordosis to the quantity of lumbar muscle which contributes a high percentage of overall back muscle, which may be an explanatory factor in the way that exercise interventions have been shown to improve lumbar lordosis and quality of life 21.

Many reports have described associations between low back pain and lumbar degenerative changes, with disc space narrowing being 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 health 22. Savinainen et al.23 reported that the musculoskeletal capacity in subjects with a higher workload was poorer than that in the subjects with a low 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 had an influence on a large proportion of the spinal health in our population. It is possible that there may have been occupational effects on quality of life measures in our population, but unfortunately the sudy 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 quality of life 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 quality of life. We have shown that the odds of poor quality of life appears 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 quality of life. 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 be able to reduce the risk of LBP, LSS and KOA, hence reducing the burden of these conditions on QOL in future generations.

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| **Table 1. Data for study participants** |
|  | **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/m2)** | 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/cm2)** |  |  |  |
|  **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 |
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| **Table 2. Associations between predictors and risk of being a case (ODI > 12)** |  |  |  |
|   | **Model 1** | **Model 2** | **Model 3** |
| Predictors | 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** |  |  |  |  |  |  |  |  |  |
|  **aLL (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 |
|  **bSVA (+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 SVAModel 1: unadjusted Model 2: adjusted for sex, age and BMIModel 3: adjusted for the other predictors as well as sex, age and BMI |