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Sagittal spinopelvic alignment in the standing position associated with low back pain in patients with knee osteoarthritis

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Objective: To examine whether or not sagittal spinopelvic alignment is independently associated with low back pain (LBP) in patients with knee osteoarthritis (KOA).
Materials and Methods: We enrolled 134 Japanese patients with KOA who presented at our hospital between 2013 and 2016. Age, sex, body mass index (BMI), knee pain, knee extension passive range of motion (PROM), maximum knee extension strength, and knee alignment (knee flexion angle in the standing position) were measured. Sagittal spinopelvic alignment was assessed by radiographically measuring angles of lumbar lordosis (LL) and pelvic tilting (PT). Patients were divided into the LBP (score >0, n = 42) and non-LBP (score= 0, n = 92) groups according to the scores of the Roland-Morris Disability Questionnaire.
Results: BMI, PT, and knee alignment were significantly greater, and PROM and LL significantly smaller, in the LBP group than the non-LBP group. Multivariate logistic analysis revealed that BMI, PT, and LL were significantly and independently associated with LBP in patients with KOA.
Conclusion: Spinopelvic alignment is significantly and independently associated with LBP in patients with KOA. Although our findings provide useful information for LBP prevention, further studies are warranted to elucidate underlying mechanisms.

Key words: osteoarthritis, knee, low back pain, standing position, lordosis

Introduction

Patients with knee osteoarthritis (KOA) have been reported to suffer not only from knee pain and limited joint mobility but also from difficulty or disability in performing daily living activities including walking.[1] In addition, most patients with KOA develop low back pain (LBP),[2,3] which may lead to further impairment of activities of daily living and reduced physical activity and function. Many studies have investigated LBP, a common major health problem, with respect to its risk factors. Causal factors of LBP in the general population include age,[4,5] obesity (body weight),[6-9] work activities and environments,[10] and psychological stress.[11] In clinical settings, several studies have shown that abnormal sagittal spinopelvic alignment, such as decreased lumbar lordosis (LL)[12-15] and increased pelvic tilting (PT),[13] is associated with LBP in patients with spinal diseases including lumbar degenerative disc disease, spinal deformity, and patients with mechanical type LBP. However, few reports have examined risk factors associated with LBP in patients with KOA. In particular, the relationship between LBP and sagittal spinopelvic alignment in this patient population is still unclear, while knee pain[16] and knee malalignment as assessed radiographically have been shown to correlate with abnormal spinopelvic alignment.[17] In this study, we aimed to examine whether patient characteristics, knee symptoms and function, and sagittal spinopelvic alignment are associated with LBP in patients with KOA.

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Materials and Methods

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Research Ethics Committee of Kitasato University Kitasato Institute Hospital (No. 12007).

Participants

Participants of this cross-sectional study were 162 Japanese patients with bilateral or unilateral KOA who presented at our hospital due to knee pain between December 2013 and February 2016. All participants provided written consent to participate in this study. Patients with previous spinal surgery, compression fractures from L1 to S1, and/or spondylolisthesis that would affect sagittal spinopelvic alignment were excluded from this study. Those with lower limb fractures, secondary KOA, and/or a previous knee surgery were also excluded.

Measurements

Patient characteristics: Data including age, sex, height, weight, and body mass index (BMI) were obtained from clinical records. An anterior-posterior radiograph of the knee was taken for each patient, and the severity of KOA was assessed by a knee surgeon using the Kellgren-Lawrence (KL) grading system.[18] The KL grading system is a validated method used to classify joints according to five KL grades ranging from grade 0 (normal) to grade 4 (most severe).[18]

Knee pain: A visual analogue scale (VAS) was used to assess average pain intensity over 48 hours.[19] The scale consists of a 100 mm horizontal line ranging from 0 (no pain) to 100 (intolerable pain). Patients were asked to mark a vertical line at a point that corresponded to the severity of their pain.[20]

Low back pain: The prevalence of LBP was assessed using the Roland-Morris Disability Questionnaire (RDQ), a self-rated health status measure. It was designed to be completed by patients to assess pain-related physical disability due to LBP. RDQ scores range from 0 (no disability) to 24 (maximum disability),[21] and patients were divided into two groups according to their scores: the LBP group (RDQ score >0) and the non-LBP group (RDQ score =0).

Range of motion and knee extension strength: Knee extension passive range of motion (PROM) was measured in the supine position using a standard universal goniometer. Maximal knee extension strength was measured using a hand-held dynamometer (μTas F-1; Anima, Tokyo). Patients sat on a bench, and the dynamometer was fixed to a rigid bar. Knee extension strength was measured twice for all patients, with the knee joint angle fixed at 90 degrees of flexion and the hip joint angle set at approximately 90 degrees of flexion. Data are presented as relative to body weight.[22]

Sagittal spinopelvic alignment and knee alignment in the standing position: Lateral radiographs of the lumbar spine and pelvis were taken in the standing position with the arms resting on a support. During the measurement, patients were asked to extend the knee to its maximum, while positioning the hips perpendicular to the film.[23] The LL and PT angles were measured by one observer on radiographs using OsiriX (Pixmeo, Geneva, Switzerland) software as shown in Figure 1. LL was defined as the angle between

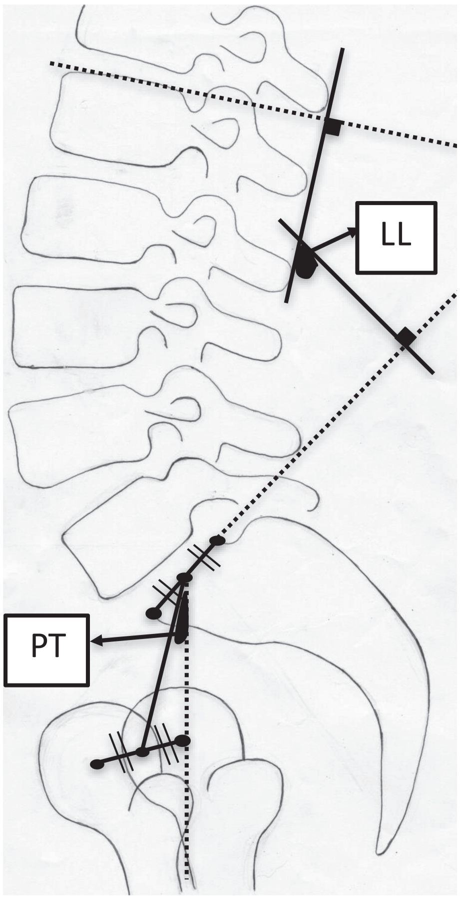

Figure 1. Measurement of lumbar lordosis (LL) and pelvic tilting (PT) angles

LL was defined as the angle between the superior endplate of the L1 and S1, and PT was defined as the angle between a line connecting the midpoint of the sacral plate to the femoral head axis (i.e., midpoint of the bilateral femoral head centre) and the vertical line.[23]

the superior endplate of the L1 and S1. PT was defined as the angle between a line connecting the midpoint of the sacral plate to the femoral head axis (i.e., the midpoint of the bilateral femoral head center) and the vertical line.[24] LL and PT are two of the most common and reliable parameters used to assess sagittal spinopelvic alignment in routine practice.[13,24-26]

Knee flexion angle was measured in a neutral standing position with a standard universal goniometer.

Statistical analyses

For patients with bilateral KOA, data on the more severely affected knee according to the KL grade were used for analysis. If both knees had the same KL grade, limited knee extension PROM, or knee pain VAS was taken into consideration in determining which knee had more severe KOA. Differences in patient characteristics, knee pain VAS, knee extension PROM and strength, knee alignment, and spinopelvic alignment (LL and PT) between the LBP and non-LBP groups were assessed for significance using the unequal variance *t*-test and Pearson's χ^2 test. Moreover, the effect sizes for the unequal variance *t*-test were calculated using Cohen's d: $d > 0.8$ represents a large effect, $0.8 \geq d > 0.5$ represents a medium effect, $0.5 \geq d > 0.2$ represents a small effect, and $d \leq 0.2$ represents no effect.[27] Multivariate analysis was performed using a logistic regression model to estimate independent factors for LBP. In order to eliminate the potential of overfitting, given the small sample size (134 patients), independent variables for the logistic regression model were reduced to several composite characteristics with a P value of <0.2 difference between the LBP and non-LBP groups in both tests. Moreover, given the potential for overfitting, we used the stepwise logistic regression model, after reducing independent variables. All data were analysed using IBM SPSS Statistics ver. 21 (IBM, Armonk, NY, USA). $P < 0.05$ was considered statistically significant.

Results

Of 162 patients with KOA, 134 patients (34 males, 100 females) were enrolled in the present study, excluding 28 patients with old lumbar spine fractures, spondylolisthesis, and previous knee surgery. There were 42 patients (31.3%) in the LBP group and 92 patients (68.7%) in the non-LBP group (Figure 2); mean RDQ score in the LBP group was 6.1 ± 4.3. The mean age, height, weight, and BMI of all patients were 71.7 ± 7.7 years, 156.0 ± 9.3 cm, 61.3 ± 13.0 kg, and 25.2 ± 4.1 kg/m^2, respectively. The KL grades were: 1 in 12 patients, 2 in 24, 3 in 46, and 4 in 52.

Patient characteristics and mean values of knee pain VAS, knee extension PROM and strength, and sagittal alignment in the standing position for both the LBP and non-LBP groups are summarized in Tables 1 and 2. BMI (P = 0.005, d = 0.54), PT (P = 0.001, d = 0.62), and knee flexion angle in the standing position (P = 0.038, d = 0.39) were significantly greater in the LBP group than in the non-LBP group. Knee extension PROM (P = 0.044, d = 0.43) and LL (P = 0.001, d = 0.63) were significantly smaller in the LBP group than in the non-LBP group.

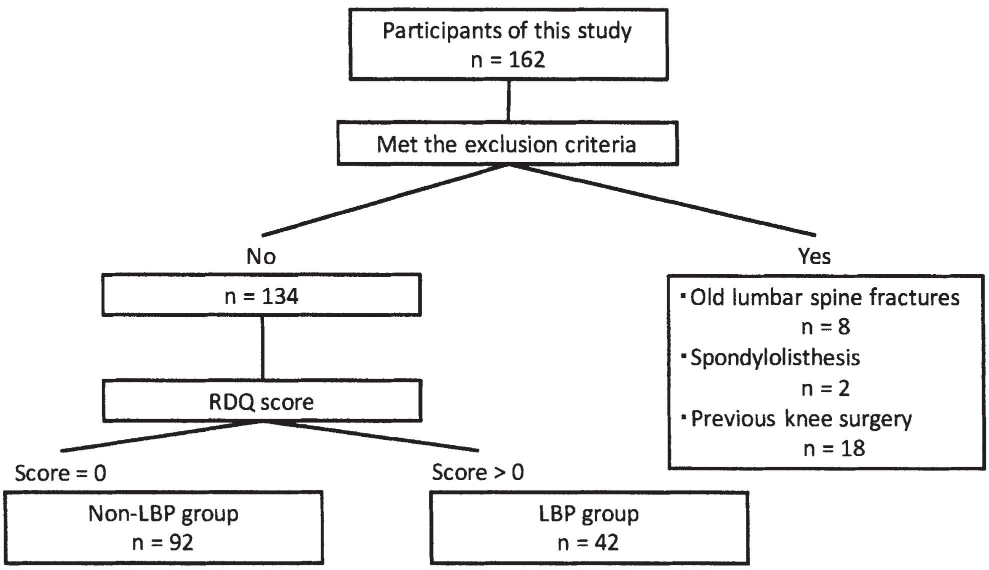

Figure 2. Flowchart of participant enrolment in this study

LBP, low back pain; RDQ, Roland-Morris Disability Questionnaire

Table 1. Patient characteristics in the LBP and non-LBP groups

		LBP group (n = 42)	Non-LBP group (n = 92)	P value	d
Sex (n)	Male	8	26	0.179	
	Female	34	66		
Age (years old)		70.7 ± 8.4	72.2 ± 7.4	0.300	0.19
Height (cm)		154.9 ± 10.2	155.9 ± 8.9	0.557	0.11
Weight (kg)		64.4 ± 14.0	59.8 ± 12.4	0.061	0.35
BMI (kg/m^2)		26.7 ± 4.2	24.5 ± 3.9	0.005	0.54
KL grades (n)	Grade 1	2	10	0.339	
	Grade 2	5	19		
	Grade 3	17	29		
	Grade 4	18	34		

Data are mean ± standard deviation (SD). (n), number of patients; LBP, low back pain; BMI, body mass index; KL grades, Kellgren-Lawrence Grading Scale; (d), Cohen's d (d > 0.8 represents a large effect, 0.8 ≥ d > 0.5 represents a medium effect, 0.5 ≥ d > 0.2 represents a small effect, and d ≤ 0.2 represents no effect.[27])

Table 2. Knee parameters and sagittal alignment in standing position in LBP and non-LBP groups

		LBP group (n = 42)	Non-LBP group (n = 92)	P value	d
The knee pain	VAS (mm)	60.6 ± 26.9	54.8 ± 26.9	0.873	0.03
PROM	PROM of the Knee extension (°)	-9.4 ± 7.7	-6.7 ± 5.4	0.044	0.43
Strength	Knee extension strength (%BW)	32.5 ± 13.2	34.1 ± 15.5	0.577	0.10
Sagittal alignment	Lumbar lordosis (°)	42.4 ± 13.4	49.8 ± 11.0	0.001	0.63
	Pelvic tilting (°)	21.9 ± 7.8	17.1 ± 7.4	0.001	0.62
	Knee flexion angle (°)	11.0 ± 8.7	8.2 ± 6.1	0.038	0.39

Data are mean ± standard deviation (SD). LBP, low back pain; VAS, visual analogue scale; PROM, passive range of motion. %BW, relative to body weight; (d), Cohen's d (d > 0.8 represents a large effect, 0.8 ≥ d > 0.5 represents a medium effect, 0.5 ≥ d > 0.2 represents a small effect, and d ≤ 0.2 represents no effect.[27])

Table 3. Multivariate logistic analysis

Variable	Odds ratio	95% CI	P value
BMI	1.127	(1.022−1.242)	0.016
PT	1.058	(1.002−1.117)	0.043
LL	0.959	(0.926−0.994)	0.020

BMI, body mass index; LL, lumbar lordosis; PT, pelvic tilting; CI, confidence interval

Other measurements showed no significant differences between the two groups. Independent variables for the logistic regression model with P values of <0.2 difference between the LBP and non-LBP groups included: sex, weight, BMI, knee extension PROM, LL, and PT (Tables 1, 2). Stepwise multivariate logistic analysis revealed that BMI (odds ratio [OR] = 1.127, 95% confidence interval [CI] = 1.022－1.242; P = 0.016), PT (OR = 1.058, 95%CI = 1.002－1.117; P = 0.043), and LL (OR = 0.959, 95%CI = 0.926－0.994; P = 0.020) were significantly and independently associated with LBP in patients with KOA (Table 3).

Discussion

We examined factors associated with LBP in patients with KOA. The key finding of this study was that spinopelvic alignment (i.e., LL and PT) is significantly and independently associated with LBP in patients with KOA. To our knowledge, this study is the first to characterize the relationship between spinopelvic alignment and LBP in patients with KOA.

In a previous study, Wang et al.[17] investigated associations between spinopelvic alignment, knee alignment, and LBP in a neutral standing position. They found no significant relationship between spinopelvic alignment and LBP, although knee malalignment (i.e., severe KOA) was significantly associated with spinopelvic malalignment in patients with severe KOA.[17] The association between spinopelvic malalignment and LBP was not significant, likely due to the small sample size of their study.[17] Moreover, confounding factors including age and BMI were not sufficiently adjusted for, and no detailed information regarding the severity of LBP was provided. In the present study, we assessed the prevalence of LBP based on the scores of the RDQ, which can clarify whether or not patients had disability in daily activities due to LBP. Thus, the severity of LBP might have been greater in our patients compared to those enrolled in the previous study, and the differences in the prevalence and severity of LBP might have contributed to the varying results. In addition, the effect sizes found in the analysis regarding PT and LL were interpreted as a medium effect according to Cohen's d, which indicates that a sufficient sample size is obtained to examine the difference in spinopelvic alignment between the LBP and non-LBP groups in this study.

While BMI and obesity have been shown to correlate significantly with LBP in the general population as well as in clinical settings, the mechanism leading to the development of LBP remains unclear. Suri et al.[2] reported that symptomatic KOA (e.g., knee pain and limited joint mobility) is associated with LBP in patients with KOA.[2] Therefore, we performed multivariate analysis to examine whether or not spinopelvic alignment is independently associated with LBP using adjusted knee pain (e.g., VAS), knee extension PROM, and knee extension strength as confounders of the logistic regression model. After adjusting for these confounders, BMI and spinopelvic alignment (both LL and PT) were significantly and independently associated with LBP in patients with KOA. Regarding the impact of PT and LL on LBP, McGill reported that activities such as bending forward and load lifting, when performed with the spine flexed as compared with relaxed (unflexed), straight spine, caused a decrease in LL and increase in PT, thereby contributing to further increases in lumbar load as indicated by the moment of force and force at the lumbosacral disc.[28] In addition, a previous study has shown that a decrease in lumbar lordosis is associated with LBP in people without knee or hip OA and spine disease.[15] Accordingly, patients who showed decreased LL and increased PT while standing might be at increased risk of developing LBP, relative to those without spinopelvic malalignment.

On the other hand, symptomatic KOA, as indicated by knee pain (e.g., VAS), knee extension PROM, and knee extension strength, was not associated with LBP in the present study. While our patients had mild (KL grade 1) to most severe (KL grade 4) KOA, a significant difference was only observed in knee extension PROM between the LBP and non-LBP groups. Moreover, the mean values of VAS, knee extension PROM, and knee extension strength indicated mild symptoms of KOA in both groups. Although several studies have investigated the association between the severity of KOA and LBP,[2,3] a consensus has not been reached with regard to whether the severity of KOA is directly or indirectly associated with the prevalence of LBP. Our multivariate analysis revealed that the severity of KOA might not be directly associated with LBP in patients with KOA. Therefore, sagittal spinopelvic alignment should be periodically assessed, regardless of KOA severity, in the management of patients with KOA. Moreover, in light of previous reports, as well as the present study, there may be a need to prescribe stretching exercises for flexibility and resistance exercises for strengthening trunk and/or leg muscles to improve spinopelvic malalignment[29] to prevent LBP in patients with KOA.

There are three limitations to this study. First, due to the cross-sectional study design, we were not able to determine whether spinopelvic malalignment, or an increase in BMI or LBP, was the primary presenting symptom. Second, this study did not address osteoarthritis of the spine; therefore, LBP related to spine deformities was not taken into consideration, although patients with lumbar compression fractures and spondylolisthesis were excluded. Third, since spinopelvic alignment was only assessed in a static standing position, the effect of dynamic spinopelvic movement on LBP, and the mechanism leading to LBP, could not be determined. Further investigation that focuses on spinopelvic alignment during walking or other work activities is warranted to clarify the reason patients with KOA develop LBP. Moreover, the relationship between changes in spinopelvic alignment and the prevalence of back pain in patients with KOA ought to be examined longitudinally. Spinopelvic alignment (i.e., lumbar lordosis and pelvic tilting) is significantly and independently associated with LBP in patients with KOA. Although these findings provide useful information for LBP prevention, further studies are warranted to elucidate the underlying mechanisms of this malady.

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