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Leg dominance affects the appearance of osteoarthritis of the lumbar facet joints at L5–S

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ABSTRACT

The influence of leg dominance on lumbar intervertebral joint deformity and osteoarthritis remains poorly understood, particularly across different age groups. A clearer understanding of this relationship could improve rehabilitation strategies and patient outcomes. This study investigated 109 patients with spinal disorders who had not undergone spinal surgery and underwent computed tomography after myelography between May 2023 and January 2024 at our hospital. Lateral lumbar radiographs in a neutral standing position were used to evaluate lumbar lordosis (L1–S), lower lumbar lordosis (L4–S), pelvic incidence, and sacral slope. Hand and leg dominance were self-reported before admission, and observed leg dominance (determined by the leg used to climb onto a platform) was recorded. Lumbar facet joint osteoarthritis at each disk level was assessed using computed tomography imaging. Most participants reported right-side dominance for both the hand (101 participants, 92.7%) and leg (98 participants, 90%). Concordance between hand and leg dominance was observed in 102 (93.6%) participants. The most pronounced difference in osteoarthritis prevalence between the dominant and nondominant-leg sides at L5–S occurred among participants aged 45–64 years. Osteoarthritis on the dominant-leg side developed earlier (after age 40) than on the nondominant-leg side, where it emerged approximately a decade later. These findings suggest that leg dominance plays a role in lumbar facet joint degeneration, underscoring the need for further research and clinical consideration.

Keywords: dominant leg, gait, L5–S, nondominant leg, lumbar facet joint osteoarthritis

INTRODUCTION

Leg function is essential for various movements, including walking and stair climbing. Repetitive lower limb motion creates asymmetrical force distribution between the dominant and nondominant legs, with limb dominance serving as a stronger predictor of force asymmetry than foot posture.[1] Additionally, pelvic tilt varies between the dominant and nondominant legs during standing balance.[2]

Research has explored the relationship between spine health and leg dominance, identifying an

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association between spondylolysis and leg dominance in soccer players.[3] Another study examined the coordination between the thoracolumbar spine and pelvis during gait,[4] demonstrating that the lumbar spine counteracts pelvic obliquity and assists with hip abduction/adduction in the coronal plane. However, to the best of our knowledge, no studies have specifically investigated how lumbar intervertebral joint deformity correlates with leg dominance across different age groups. Understanding this relationship could inform rehabilitation approaches and preventive strategies.

We hypothesized that leg dominance influences spinal degeneration and that age-related facet joint degeneration progresses differently on the dominant and nondominant sides. This study aimed to assess the relationship between leg dominance and lumbar facet joint osteoarthritis.

MATERIALS AND METHODS

Ethics statement

This study was approved by Chubu Rosai Hospital ethics committee on human research (approval no. 202201-05), and informed consent was obtained from all participants.

Participants

Patients diagnosed with spinal disorders who visited our hospital and underwent computed tomography (CT) after myelography between May 2023 and January 2024 were recruited. Diagnoses were confirmed via magnetic resonance imaging (MRI), and myelography was performed to guide treatment planning. Exclusion criteria included the absence of whole-spine radiography, unknown leg dominance, and a history of spinal or lower-extremity joint surgery.

Data collection and radiographic assessments

Demographic data, including age, sex, body mass index (BMI), and spinal disease classification, were collected. Lumbar spine radiographs were taken in a neutral standing position. Lumbar lordosis (LL), lower (L4–S) lumbar lordosis (L–LL), pelvic incidence, and sacral slope (SS) were measured using lateral lumbar radiography. The depth of L5 within the pelvis was evaluated using coronal standing radiographs. The vertical distance between the midpoint of the L5 pedicles and the intercristal line was measured.[5] Based on published protocols, "deep-seated L5" was classified as follows: intercristal line intersection zone 1, 2, or 3 (above the L5 pedicles) were defined as "deep-seated L5 (+)," whereas zone 4 or 5 (at or below the level of both L5 pedicles) were classified as "deep-seated L5 (−)."

Determination of leg dominance

The dominant hand and leg of each participant were self-reported before admission. Leg dominance was assessed following a published protocol[6], which involved asking participants: "If you were to kick a ball at a target, which leg would you use?" This has been identified as the most reliable for assessing leg dominance, as it aligns with observed dominance in four bilateral mobilizing tasks and two unilateral stabilizing tasks. Notably, it demonstrated a 100% agreement rate for both men and women and was the most stable task among bilateral mobilizing assessments (95.2% for men and 100.0% for women).

Observed leg dominance was assessed by instructing participants to halt in front of an inspection table and climb onto a platform (Fig. 1). Concordance was defined as the match between self-reported and observed leg dominance and was analyzed across three age groups (≤44, 45–64, and ≥65 years).

Fig. 1 Evaluation of leg used to climb onto the platform

Determination of lumbar facet joint osteoarthritis

CT imaging is superior to MRI for evaluating facet joints due to its greater accuracy in depicting bone structures.[7,8] Each participant underwent myelography followed by multidetector-row CT[9] using a 64-line multislice CT unit (Light Speed VCT; GE Healthcare Bio-Sciences, Piscataway, New Jersey). Images were acquired at each disk level from L1–2 to L5–S.

Lumbar facet joint osteoarthritis was classified as follows: Grade 0, normal; Grade 1, mild degenerative disease; Grade 2, moderate degenerative disease; and Grade 3, severe degenerative disease.[8,10] A prior study[8] reported a moderate interobserver agreement (0.6) and a significantly higher intraobserver agreement (kappa, 0.70 ± 0.77) for facet joint osteoarthritis classification. Based on these grades, participants were categorized into two groups: Group 1 (Grades 0 and 1, unclear osteoarthritis) or Group 2 (Grades 2 and 3, clear osteoarthritis). The prevalence of osteoarthritis at each lumbar facet joint level was analyzed by age group.

Statistical analyses

Data are presented as mean values with standard deviations. Statistical analyses were conducted using SPSS version 22 (SPSS Inc, Chicago, Illinois). Differences between groups were assessed using the chi-square test or an unpaired *t* test.

A multivariate logistic regression model was employed to identify risk factors for osteoarthritis at the L5–S facet joint on the dominant-leg side. The dependent variable was the presence of osteoarthritis at this joint. Covariates included age, sex, BMI, and radiographic pelvic parameters. Odds ratios and 95% confidence intervals (95% CIs) were calculated using a proportional odds model.

A receiver operating characteristic (ROC) curve analysis was performed to determine the optimal age cutoff for predicting osteoarthritis at the L5–S facet joint on both the dominant and nondominant sides. A p value of <0.05 was considered statistically significant.

RESULTS

A total of 136 patients without prior spinal surgery were recruited. Of these, 27 were excluded, leaving 109 participants for final analysis (Table 1).

Table 1 Demographic data

	Value
Case, no.	109
Age	63.5 ± 15.5
Sex (male/female)	55/54
BMI (kg/m^2)	25.2 ± 5.5
Right dominant hand, no. (%)	101 (92.7)
Right dominant leg, no. (%)	98 (90.0)
PI (°)	51.02 ± 11.3
SS (°)	27.26 ± 10.5
LL (°)	36.9 ± 17.2
L-LL (L4-S) (°)	24.6 ± 11.0
Disease	
Lumbar disc herniation, no. (%)	50 (46)
Lumbar spinal stenosis, no. (%)	38 (35)
Degenerative cervical myelopathy, no. (%)	16 (14)
Juxta facet cyst, no. (%)	3 (3)
Ossification of the ligamentum flavum, no. (%)	1 (1)
Scoliosis, no. (%)	1 (1)

BMI: body mass index
PI: pelvic incidence
SS: sacral slope
LL: lumbar lordosis
L-LL: lower lumbar lordosis

The majority of participants were right-hand and right-leg dominant, with hand and leg dominance aligning in 102 (93.6%) participants. Five participants exhibited right-hand and left-leg dominance, while two had left-hand and right-leg dominance.

The most prevalent diagnosis was lumbar disk herniation, with 80.7% of participants presenting with lumbar disease. The overall concordance rate between self-reported and observed leg dominance was slightly above 50% and was highest in the youngest age group (Table 2). When analysis was restricted to participants with lumbar disease, a similar trend was observed, with the highest concordance in the youngest age group (Table 2).

Table 2 The match rate between the dominant leg side and the side of leg to climb up the platform

	All	≤ 44 y	45 y – 64 y	65 y ≤
All disease the match rate	58.3% (49/84)	71.4% (10/14)	50% (12/24)	58.7% (27/46)
Lumbar disease the match rate	54.5% (42/77)	69.2% (9/13)	50% (10/20)	52.3% (23/44)

Incidence of osteoarthritis of the facet joint at each lumbar disk level

The incidence of osteoarthritis in the lumbar facet joint was significantly different between the dominant and nondominant-leg sides only at the L5–S1 disk level (Fig. 2), with a difference of approximately 15%. The prevalence of facet joint osteoarthritis increased with age and progressively from the L1–2 to L3–4 levels on both the dominant and nondominant sides (Fig. 3). At the L4–5 and L5–S1 levels, a similar trend of increasing osteoarthritis prevalence with age was observed. Notably, among participants aged 45–64 years, the incidence at the L4–5 level was higher on the nondominant side than on the dominant side (Fig. 3).

Onset of osteoarthritis of the lumbar facet joint at the L5–S level

Osteoarthritis of the lumbar facet joint was first observed after 40 years of age on the dominant-leg side and gradually increased with age. In contrast, onset occurred after 50 years of age on the nondominant side, with prevalence rates becoming nearly equivalent around 70 years of age (Fig. 4). The ROC curves (Fig. 5) revealed that the threshold value cutoff and area under the curve were lower for the dominant-leg side than for the nondominant side (Table 3). Moreover, the prevalence of lumbar facet joint osteoarthritis was significantly higher on the dominant side than on the nondominant side in the 45–64 and ≥65 age groups (Table 4).

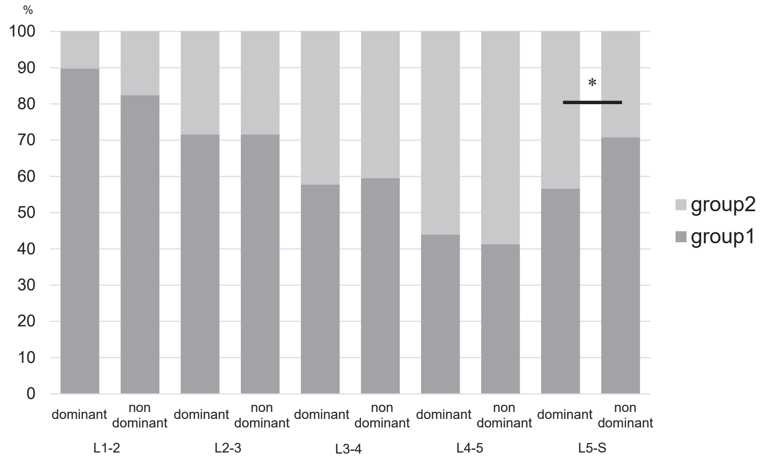

Fig. 2 Percentage of osteoarthritis of the lumbar facet joint in each intervertebral joint
*p<0.05 by chi-square test.

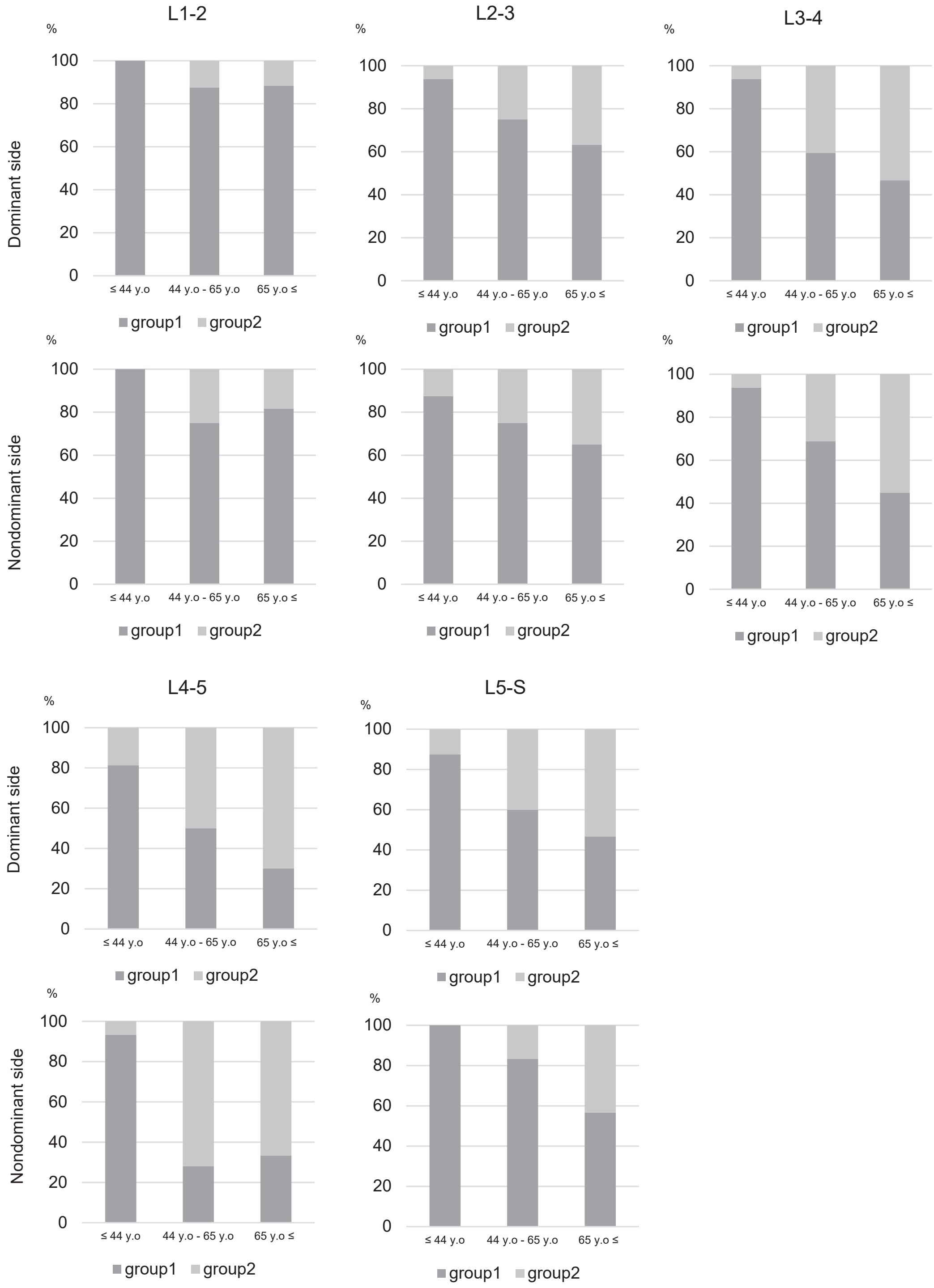

Fig. 3 Percentage of osteoarthritis of the lumbar facet joint in relation to age at the levels L1–2 to L5–S

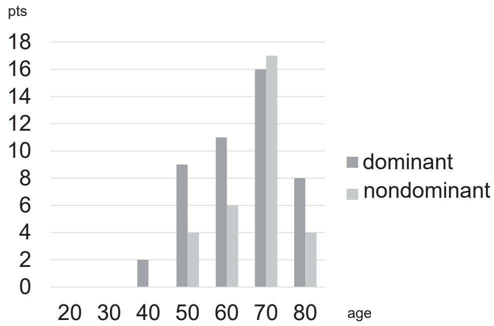

Fig. 4 Prevalence of osteoarthritis of the lumbar facet joint at the L5–S level in relation to age

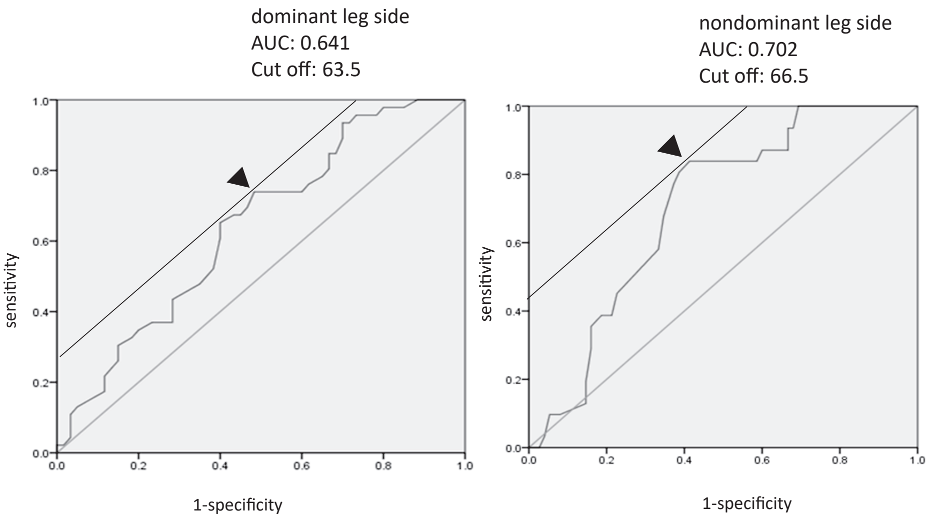

Fig. 5 Receiver operator characteristic curve analysis for age of osteoarthritis of the lumbar facet joint on both sides

Black arrowheads indicate the best threshold value.

Table 3 AUC, threshold values, sensitivity and specificity for each leg side

	AUC	Threshold value	Sensitivity	Specificity
Dominant leg side	0.64	63.5	0.74	0.52
Nondominant leg side	0.70	66.5	0.84	0.59

AUC: area under the curve

Table 4 Comparison of the number of cases with the osteoarthritis of lumbar facet joint at L5–S on each leg side

	Dominant	**Nondominant**	***P* value**
45 y – 64 y			
Group 1	18	25	0.006*
Group 2	12	5	
65 y ≤			
Group 1	28	34	0.001**
Group 2	32	26	

*p<0.01, **p<0.001.
Group 1, unclear osteoarthritis of lumbar facet joint; Group 2, clear osteoarthritis of lumbar facet joint.

Osteoarthritis of the facet joint on the dominant-leg side at the L5–S level

Sex and mean age differed significantly between Groups 1 and 2 (Table 5), whereas no significant differences were found in BMI or radiological factors. Multivariate logistic regression analysis identified age as a significant predictor of facet joint osteoarthritis on the dominant-leg side at the L5–S1 level (odds ratio = 1.04, $p < 0.05$).

Table 5 Multivariate logistic regression analysis of potential predictors of the osteoarthritis of facet joint related factors on the dominant leg side at L5–S

				Multivariate logistic regression analysis		
	Group 1	Group 2	*P* value	Odds ratio	95% CI	*P* value
Age	59.7 ± 17.6	68.5 ± 11.3	0.004**	1.04	1.007 – 1.071	0.016*
Sex (male/female)	36/24	18/28	0.033*	0.53	0.235 – 1.212	0.133
BMI	24.6 ± 5.5	25.6 ± 5.6	0.16	–	–	–
PI	49.9 ± 10.5	52.7 ± 12.1	0.51	–	–	–
SS	27.6 ± 11.2	27.4 ± 9.7	0.29	–	–	–
LL	37.6 ± 17.5	37.2 ± 16.7	0.57	–	–	–
L-LL	24.2 ± 11.2	25.7 ± 10.5	0.65	–	–	–
Deep seated L5 (+/–)	37/23	30/16	0.71	–	–	–

*p<0.05, **p<0.01.
Group 1, unclear osteoarthritis of lumbar facet joint; Group 2, clear osteoarthritis of lumbar facet joint.
BMI: body mass index
PI: pelvic incidence
SS: sacral slope
LL: lumbar lordosis
L-LL: lower lumbar lordosis
CI: confidence interval

DISCUSSION

Able-bodied individuals typically exhibit leg dominance, with distinct functional roles for the dominant and nondominant legs. The high prevalence of right-leg dominance in this study aligns with previous research,[11] indicating that the findings are unlikely to be biased. However, self-reported leg dominance was consistent with observed dominance in only 60% of cases. Notably, osteoarthritis of the lumbar facet joint was more common on the dominant-leg side in participants aged 45–64 years, with an earlier onset compared with the nondominant side.

Determining leg dominance is complex as it varies by task type.[12] A previous study found that asking individuals, "Which leg would you use to kick a ball?" accurately identifies leg dominance for bilateral mobilization tasks in healthy adults.[6] The match rate between the dominant-leg side and the leg used to climb onto the platform was approximately 70% in younger participants but decreased to 50% in those older than 45 years. The lower overall match rate in our study could be attributed to the fact that the average age of participants in their study[6] was <40 years. However, our findings showed a similarly high match rate in participants younger than 45 years. Differences in lower limb muscle strength between the dominant and nondominant sides have been documented.[13] We hypothesize that aging may reduce these differences and weaken the superiority of the dominant leg. Our results indicate that joint deformity at the L5–S facet joint begins to appear in individuals aged 45 years or younger, suggesting a possible association between stepping out with the dominant leg and L5–S joint deformity at this age.

There are limited studies on the relationship between leg dominance and joint deformity. One report[14] described a higher incidence (58%) of total hip arthroplasty on the right side among patients with primary coxarthrosis. In right-leg-dominant patients, arthroplasty rates were nearly equal between the right and left hips (50.7% vs 49.3%). However, in left-leg-dominant patients, right hip arthroplasty was significantly more common (76.8%) than left hip arthroplasty (23.2%). This disparity suggests that uneven daily loading on the legs, particularly in left-leg-dominant individuals, could impact the pelvic periarticular joints and gait function.

Previous studies have established a link between hip function and gait, both of which contribute to daily activities that exert repetitive stress on the lumbosacral and hip joints.[15] The frequency of micro-repetitions likely varies between the dominant and nondominant-leg sides, potentially leading to joint deformity on the side used more frequently. Leg dominance is defined as the leg primarily used for mobility, while the nondominant leg provides support.[16] Previous studies on able-bodied gait using temporal and kinematic data have shown that the symmetrical or asymmetrical behavior of the lower legs does not differ significantly between the dominant and nondominant sides.[17] In contrast, DeVita et al[18] reported that the dominant leg generates between 56% and 61% of the total positive work during walking at a natural speed. Limb dominance during gait has been identified as a stronger predictor of asymmetry in force generation than foot posture.[1] Additionally, studies have indicated that the dominant-side upper and lower limbs possess greater muscle strength due to habitual use.[13]

Assuming that the leg used to climb onto a platform is the same leg used to initiate walking or ascend stairs, the dominant leg is likely used more frequently in daily activities. Considering previous studies, it can be inferred that the habitual use of the dominant leg creates asymmetric forces on the pelvic periarticular joints.

The pelvis moves in three planes during normal gait to facilitate smooth and efficient motion.[19] In the frontal plane, the pelvis remains approximately neutral at initial contact, with the bilateral anterior superior iliac spines level. Upon contact, the pelvis drops on the same side for less than 20% of the gait cycle before rising again. When the opposite foot contacts the ground, the pelvis returns to a neutral position. Thus, the pelvis is raised on the swing-phase side.

Research indicates that as the pelvis moves during gait, the spine compensates, with peak lumbar spine abduction coinciding with peak pelvic loading in the early stance phase. The lumbar segment then gradually moves into adduction, reaching peak adduction at toe-off.[4] Given the movement of the pelvis and lumbar spine on the swing-leg side, the pelvis and lumbar spine are expected to experience compression from mid-swing to the end of the swing phase, with increased loading on the L5–S facet joint on the pelvic side (Fig. 6A–C).

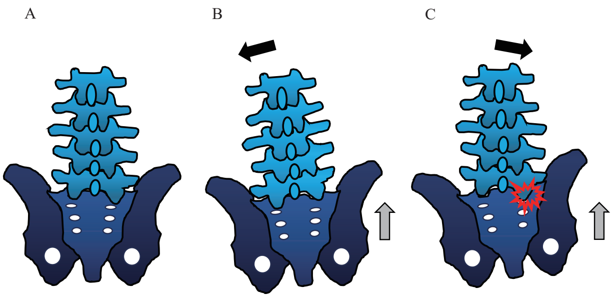

Fig. 6 Pelvis and lumbar spine during gait
Fig. 6A: Double-support phase
Fig. 6B: Early swing phase
Fig. 6C: Middle to the end of the swing phase
Black arrows indicate the direction of lumbar spine movement. Gray arrows show the direction of pelvis movement.

Kogo et al[2] reported that, in a standing posture, the pelvis is inclined forward more significantly on the dominant-leg side than on the nondominant-leg side. Consequently, in the sagittal plane, the L5–S facet joint is expected to experience greater loading on the dominant-leg side (Fig. 7).

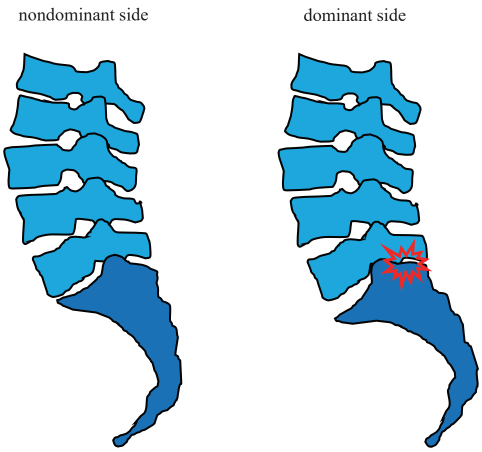

Fig. 7 Pelvis and lumbar spine in the standing position

Osteoarthritis of the lumbar facet joint is highly prevalent, with one study reporting evidence of the disease in over 50% of adults younger than 30 years, 97% of individuals aged 50–59 years, and 100% of those over 60 years.[20] Moreover, age-related degenerative changes in the lumbar facet joints have been observed even in individuals without lumbar spinal disorders.[21] The present study also identified notable lumbar joint deformities in participants younger than 45 years. However, previous studies have not provided clear left-right comparisons, and no association between osteoarthritis and leg dominance has been established. Our findings suggest that osteoarthritis of the lumbar facet joint at the L5–S level develops approximately 10 years earlier on the dominant-leg side than on the nondominant-leg side.

Several studies have examined the association between deep-seated L5 and L5–S deformities, indicating that a deep-seated L5 may contribute to the progression of degenerative lumbar scoliosis.[22] In this study, we investigated whether deep-seated L5, a known risk factor for L5–S joint deformity, was associated with the dominant-leg side. However, no significant correlation was found. Previous research has demonstrated that deep-seated L5 does not provide protection against L5–S disk degeneration.[5,23] Nevertheless, its impact on osteoarthritis of the lumbar facet joint at the L5–S level remains uncertain. The question of whether deep-seated L5 offers any protective effects on the L5–S1 disk remains controversial,[24] necessitating further research.

This study has several limitations. First, the sample size was small, and we are continuing to recruit participants to expand the dataset and further investigate the relationship between leg dominance and spinal health. Second, the study did not assess the relationship between leg dominance and osteoarthritis of the facet joint in the context of specific lumbar diseases. Third, lower limb and back muscle strength were not measured despite their relevance to walking mechanics. Future research should incorporate muscle strength assessments to provide a more comprehensive analysis. Fourth, the study did not consider the potential impact of spastic gait caused by spinal cord disorders. However, all participants with degenerative cervical myelopathy in this study were independently ambulatory. The potential effects of spastic gait on the development of osteoarthritis of the lumbar facet joint at the L5–S level should be explored in future studies.

To the best of our knowledge, this is the first study to examine the association between leg dominance and osteoarthritis of the lumbar facet joint. Our findings suggest that osteoarthritis of the lumbar facet joint at the L5–S level could potentially be delayed or mitigated by altering the leg used to initiate movement in daily life, particularly in individuals in their 40s. This study provides valuable insights into the prevention of spinal deformities among middle-aged and older adults.

CONCLUSION

Our findings indicate that osteoarthritis of the lumbar facet joint develops earlier at the L5–S level on the dominant-leg side compared with the nondominant-leg side. Recognizing the role of leg dominance in spinal health may inform preventive strategies to reduce the risk of spinal deformities.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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