Properties of the iliotibial band and their relationships with gait parameters among patients with knee osteoarthritis

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Abstract

This study aimed to determine the thickness and stiffness of the iliotibial band in patients with knee osteoarthritis and to identify the gait parameters that are associated with iliotibial band properties. Eighteen female patients with radiographically diagnosed medial knee osteoarthritis and knee pain (age: 69.7±5.9 years, body mass index: 23.0±3.1 kg/m^2) and 22 age-matched female individuals without knee pain (age: 69.1±7.0 years, body mass index: 21.6±3.6 kg/m^2) were included. Shear wave elastography images were obtained at the height of the proximal pole of the patella with the participants in the supine position, and the iliotibial band thickness and shear wave velocity, which is a surrogate measure of stiffness, were calculated. In patients with knee osteoarthritis, the knee and hip joint angles and moments during walking were calculated using a motion analysis system. The shear wave velocity was significantly higher in patients with knee osteoarthritis than in asymptomatic adults (128.3±22.1 vs. 102.7±36.5 kPa, respectively; p=0.013); however, the thickness did not differ between them (2.1±0.3 vs. 2.1±0.4 mm, respectively; p=0.619). The time-integral value of the knee adduction moment (β=0.512, p=0.03) and maximum value of the hip flexion moment (β=0.509, p=0.031) were associated with the shear wave velocity. Meanwhile, no parameters were associated with the thickness. The iliotibial band was stiffer in patients with knee osteoarthritis than in asymptomatic adults; such a stiffer iliotibial band was associated with greater knee adduction and hip flexion moments during walking. Clinical Significance: Greater mechanical loading was associated with a stiffer ITB in patients with knee osteoarthritis.

Keywords

iliotibial band, knee osteoarthritis, shear wave elastography, ultrasound

1. INTRODUCTION

Knee osteoarthritis (KOA) is a common chronic disease among middle-aged and older adults. [1] Patients with KOA show degenerative and adaptive changes in the knee components and muscles. [2-6] A previous study investigated the prevalence of increased signal intensity around the iliotibial band (ITB) using magnetic resonance imaging. The report was that approximately 75% of patients with KOA had increased signal intensity on the lateral side of the knee joint, indicating inflammation or edema around the ITB.[7] However, what adaptive changes occur in the ITB and what factors are associated with these changes remain unclear.

The mechanical and morphological properties of the ITB could change in patients with KOA. Tateuchi et al. investigated ITB stiffness during one-leg standing in healthy adults using ultrasound shear wave elastography.[8] They reported that the shear elastic modulus of the ITB, which is an index of stiffness, increased during one-leg standing postures with increased external knee adduction moment and angle. As greater knee adduction moment and knee adduction angle are common in patients with KOA during walking,[9,10] greater mechanical loading could also occur in the ITB during walking. Additionally, the ITB is a passive tissue consisting mainly of type I collagen [11] and serial elements of muscle, which can transmit muscle force. [12] These features of the

ITB are structurally and functionally similar to those of the tendons. In addition, the ITB could be subjected to a longitudinal force by the gluteus maximus and tensor fasciae latae and mechanical loads during gait. [8,12] The tendon increases in stiffness and size with repeated mechanical axial loading.[13] Given the structural and functional similarity between the ITB and the tendon, and the similarity in the forces applied to them, the thickness and stiffness of the ITB may be greater in patients with KOA owing to excessive mechanical loading, as seen in tendons.

The lower limb movement, not only of the knee but also the hip movement, changes in patients with KOA [9,10,14], and some of them may cause greater mechanical stress on the ITB. [8,15] For example, greater knee adduction moment and angle characterize the gait in these patients. [9,10] Moreover, many gait features such as greater external hip adduction moment have been observed in patients with KOA.[14] However, the ITB could withstand the increased mechanical stress resulting from the gait characteristics of patients with KOA. For example, the ITB force reduces the compression force in the medial knee compartment,[16] and the ITB is related to hip abduction movements.[12,17] Thus, the knee and/or hip movement observed during gait in patients with KOA could cause a greater mechanical load on the ITB, which could be related to the ITB properties in patients with KOA. However, it is unclear which gait features are associated with the ITB stiffness and thickness.

This study aimed to determine the differences in the ITB thickness and stiffness between patients with KOA and older healthy individuals and clarify the association of gait features with the ITB thickness and stiffness in patients with KOA. We hypothesized that 1) the ITB stiffness and thickness would be greater in patients with KOA compared with those in older healthy individuals and that 2) the ITB stiffness and thickness could be associated with knee adduction and hip adduction moment during walking in patients with KOA.

2. METHODS

Type of study: Cross-sectional study

Level of evidence: III

2.1 Participants

Eighteen female patients with medial KOA and knee pain (KOA group) and 22 older healthy female individuals without knee pain (control group) participated in the study. We chose only female participants because they typically present with a higher prevalence of KOA [1,18,19]. Both groups included individuals who lived independently and were able to walk without a cane. The inclusion criteria for the KOA group were knee pain and diagnosis of KOA with a Kellgren/Lawrence (K/L) grade of 2 or higher by an orthopedic surgeon. When patients with KOA had bilateral KOA, we measured the side with a more severe K/L grade. When the K/L grade was the same on both sides, we considered the side with more severe pain. The inclusion criteria for the control group were no history of knee pain lasting more than 3 months, no present pain while walking or climbing stairs, and a range of knee flexion of >130°.[20-22] The side that met all the inclusion criteria was evaluated in the control group (right side: 16 patients). The exclusion criteria for both groups were rheumatoid arthritis, cardiovascular and neurological diseases, history of lower extremity and back surgeries, and cognitive decline hindering the comprehension of the informed consent procedure. In a previous study, patients with ITB syndrome were assumed to have ITB stiffness that was greater than one standard deviation than the general population. [23] We hypothesized, as in the previous study, that patients with KOA would have ITB stiffness that was greater by more than one standard deviation for the following reasons. A previous study reported that the shear modulus during one-leg standing was greater in conditions with contralateral pelvic drop than in normal conditions. [15] Contralateral side pelvic drop is often observed in patients with KOA during the stance phase of walking. In addition to this increased load on the ITB, a heavier weight and varus knee deformity place a more significant mechanical load on the patient's knee, and thus on the ITB, while walking. [24] Thus, the ITB would be considerably more rigid in patients with KOA. Therefore, we estimated the required sample size to be 17 for a two-sample t-test using α =0.05, 1-b =0.8, and DZ =1.

However, to avoid underpowering owing to dropouts and lack of data, we recruited more than 18 participants in each group. Before the start of the study, the study procedures and goals were explained to all participants, and written informed consent was obtained. The Ethics Committee of Kyoto University Graduate School and Faculty of Medicine approved all procedures (R1647).

2.2 Experimental procedure

The Knee Society Score (KSS) was used to assess knee joint function. The range of knee flexion-extension was measured in increments of 1° in the supine position using a two-arm goniometer (Sakai Medical Co., Ltd., Tokyo, Japan).[25] Subsequently, the ITB properties were evaluated using ultrasound. For patients with KOA, gait analysis at a comfortable speed (Min-Max:0.83-1.40 m/s) was conducted using a three-dimensional motion capture system.

2.3 Measured variables

2.3.1 KSS

Knee joint symptoms and function were evaluated in all participants using the KSS 2011 Japanese Edition.[26] The KSS symptom score consists of pain when walking, pain when climbing stairs, and knee stiffness. The KSS symptom and function scores are rated from 0 to 25 and 100, respectively. A score of 25 for the symptom score indicates no knee joint symptoms, and a score of 100 for the function score indicates the highest knee joint function.

2.4 Ultrasound

The participants rested in the supine position for at least 10 min before the measurement. A 10° knee joint flexion and a neutral hip joint position were maintained using a towel, where the weight of the opposite lower limb was applied to avoid moving the measured limb (Figure 1). This position was determined with reference to a previous study that measured the ITB stiffness at slight knee flexion.[27] Because slight knee flexion can vary depending on the knee status of patients with KOA and this variation can affect the shear wave velocity of the ITB, the knee angle should be consistent between participants. Therefore, we measured ITB properties at 10° knee flexion, where even patients with knee extension limitation could be evaluated. Additionally, the knee angle suited our aim of determining the associations between the ITB shear wave velocity and gait parameters because the mean knee angle was approximately 10-15° during the stance phase.[28,29] The participants were instructed to relax as much as possible. Ultrasound images were captured at the height of the proximal pole of the patella.[8,15]

FIGURE 1

A 4–15-MHz linear transducer and an ultrasound machine (Aixplorer 12.2.0; Knee-mode, SuperSonic Imagine, Axi-en-Provence, France) were used to evaluate the mechanical and morphological properties of the ITB. As a surrogate measure for the mechanical properties, the shear wave velocity of the ITB was calculated via shear wave elastography at the following protocol parameters: penetration mode: 2 Hz, gain: 90%, opacity: 100%, persistence: med, and smoothing: 5, 0–16.3 m/s. Since the machine automatically determines the sampling rate depending on the size and depth of the region of interest (ROI), the size and depth of the ROI were consistent in the preset setting for all participants (size: approximately 2.5×1.0 cm, depth: approximately 0.5–1.5 cm). Before the measurement, on the line perpendicular to the thigh at the height of the superior aspect of the patella, we identified the thickest portion of the ITB in the transverse ultrasonic B-mode image and marked the skin at the site. After the procedure, the probe was placed parallel to the ITB fibers and a color-mapping image was acquired in the elastographic mode. Once a color-mapping image was recorded, the probe was relocated. These procedures were repeated three times to obtain three color-mapping images.

To quantify the shear wave velocity, we manually drew a Q-box on the ITB in the ROI, excluding the adjacent soft tissues (Figure 2). The Axiplorer software can automatically calculate the average Young's modulus in the Q-box using the following equation: Young's modulus=$3\rho V^2$, where ρ is the tissue density, and V is the propagation velocity of the shear wave. The shear wave velocity was calculated the square root of the shear elastic modulus, which was calculated by dividing the value computed automatically by the Axiplorer software by 3.[30]

As a proxy for morphological properties, the thicknesses of the ITB were measured at the center and at both edges of the ROI on the B-mode image, which was captured simultaneously via the elastographic image (Figure 2). This procedure was conducted using Osirix MD (version 9.0; OsiriX Geneva, Switzerland). Although the tissue thickness is usually measured in the transverse image, a previous study has shown that the ITB thickness obtained in the longitudinal image showed high repeatability and was not significantly different from that obtained in the transverse image.[31,32] The mean values of the thickness and shear wave velocity from the three images were used for further analysis.

Intraclass correlation coefficients [ICCs (1,k)], one-way random effects, absolute agreement, and multiple measurements were calculated to confirm the intra-session reproducibility of the ITB thickness and shear wave velocity. [33] The ICC (1,3) values for the shear wave velocity and thickness were 0.991 and 0.926, respectively. In addition, we measured the ITB thickness and shear wave velocity twice on two different days in seven healthy subjects. The ICC (1,1) for shear wave velocity and thickness were 0.761 and 0.864, respectively, which confirmed good inter-session reproducibility.[33]

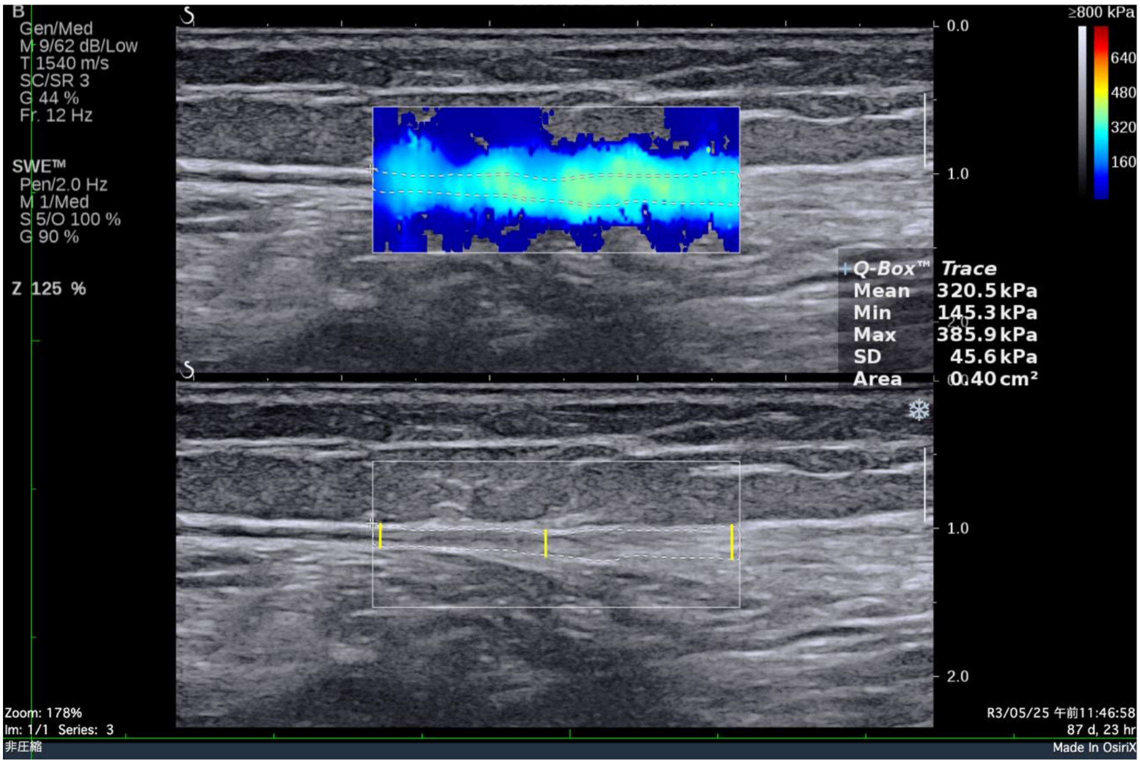

FIGURE 2

2.5 Gait analysis among patients with KOA

In patients with KOA, comfortable walking was captured using a three-dimensional motion analysis system (Vicon Nexus 2.7.1; Vicon Motion Systems Ltd., Oxford, England) consisting of eight cameras with a sampling frequency of 200 Hz and two force plates with a sampling frequency of 1000 Hz (Kistler Japan Co., Ltd., Tokyo, Japan). The marker data were processed with a 6-Hz fourth-order low-pass Butterworth filter, and the ground reaction force data were processed with a 20-Hz fourth-order low-pass Butterworth filter. A Vicon Plug-in-Gait full-body marker set was used. The kinetics and kinematics of the knee and hip joints were calculated from the ground reaction forces and marker position data. The knee angle and external moments of flexion and adduction were calculated (flexion and adduction +, respectively). The knee flexion and adduction moment were bimodal. The peak values of the knee flexion and adduction moment were obtained. In addition, the time integral values of the positive values of the knee flexion and adduction moment during the stance phase were calculated. The maximum knee joint flexion angle and adduction angle during the first half of the stance phase (0–50%) were extracted. The hip angles and external moments of flexion and adduction were calculated (flexion and adduction +, respectively). We also obtained the maximum value of the hip flexion moment, maximum value of the hip extension moment, and peak value of the bimodal hip adduction moment and calculated the time integrals of the positive values of the hip flexion moment and hip adduction moment during the stance phase. In addition, the maximum hip flexion angle in the first half of the stance phase, maximum hip extension angle in the second half of the stance phase, and maximum hip adduction angle were extracted. The average values of the three trials were used for further analyses.

2.6 Statistical analysis

SPSS version 27 (SPSS Japan Inc., Tokyo, Japan) was used. First, the Shapiro–Wilk test was used to check the normality of each index and showed that all indices were normally distributed. Second, homogeneity of variance was assessed in each group using Levene's test for physical characteristics (age, height, weight, body mass index [BMI], range of motion, and KSS), and ITB shear wave velocity, and ITB thickness. A two-sample t-test was performed when homogeneity of variance was observed; otherwise, the Welch's t-test was performed. The effect size (ES) r was estimated for each intergroup difference. Third, a simple regression analysis was performed in the KOA group, with the ITB thickness or shear wave velocity as the dependent variable and each gait parameter as the independent variable. The significance level was set at 5%.

3. RESULTS

3.1 Characteristics of both groups

Table 1 shows the mean values ± standard deviations of the physical characteristics and knee joint function of the two groups. No differences were found in age, height, weight, and BMI between the groups. However, the ranges of flexion and extension were significantly smaller in the KOA group than in the control group. In addition, the KSS symptom and function scores were significantly lower in the KOA group than in the control group.

3.2 Properties of the ITB

Figure 3 shows the shear wave velocity and thickness of the ITB. A two-sample t-test was used to compare these properties. The shear wave velocity in the KOA group was significantly higher than that in the control group (mean value: 11.3±1.0 m/s in the KOA group and 10.0±1.8 m/s in the control group, p=0.010, ES=0.40). Meanwhile, the thickness did not significantly differ between the groups (mean value:2.1±0.3 mm in the KOA group and 2.0±0.3 mm in the control group, p=0.705, ES=0.06).

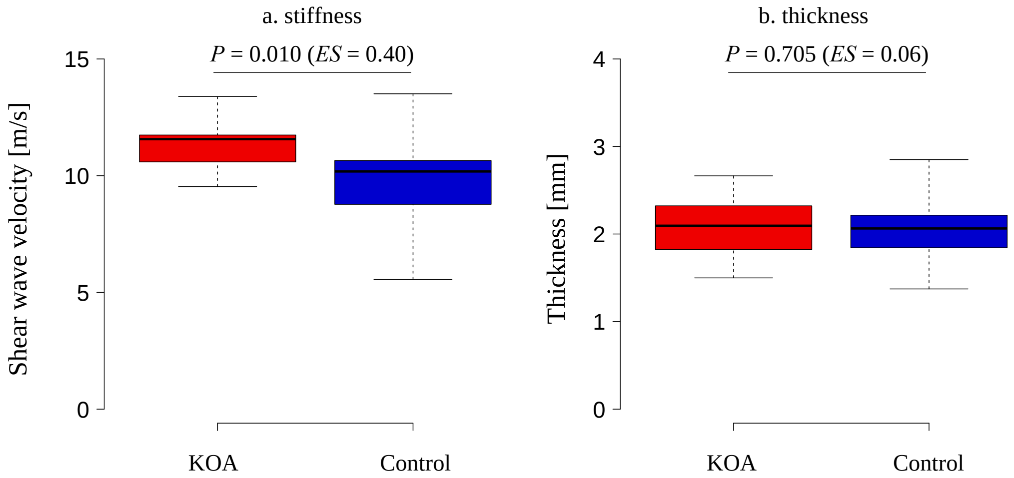

FIGURE 3

3.3 Relationship between the ITB properties and gait parameters in the KOA group

The gait parameters are listed in Table 2. Table 3 shows that the time integral values of knee adduction moment (β=0.507) and the maximum value of the hip flexion moment (β=0.498) were significantly associated with the shear wave velocity of the ITB, but the other parameters were not. Meanwhile, none of the gait parameters were significantly associated with the thickness of the ITB (Table 4). The data pots of each single regression analysis were demonstrated in Figure S-1.

4. DISCUSSION

This study compared the stiffness and thickness of the ITB between patients with KOA and healthy older adults to determine the mechanical and morphological properties of their ITB. In addition, we investigated the gait parameters associated with each ITB property in patients with KOA. To the best of our knowledge, this is the first study to reveal that the ITB in patients with KOA was stiffer than that in healthy adults and that the time integral values of knee adduction moment and the maximum value of the hip flexion moment were associated with ITB stiffness in patients with KOA.

The greater ITB stiffness in patients with KOA partially supports our hypothesis. Since no study has examined the mechanical properties of the ITB in patients with KOA and the mechanism of the greater stiffness, our study could not fully explain why only the mechanical properties of the ITB differed between the groups. However, the ITB alterations are presumed to be similar to the adaptations to mechanical loading in the tendon because the ITB is similar to the tendon. Both are passive tissues that are primarily composed of type I collagen[11] and have the ability to transmit muscle forces. [12] A previous study has reported that tendon stiffness tends to increase more than the cross-sectional area owing to the mechanical loading from training.[13] In particular, the cross-sectional area of the tendon did not increase owing to training in individuals over the age of 60 years.[34,35] Furthermore, previous studies that examined ITB stiffness using elastography have shown that ITB stiffness was enhanced owing to mechanical loading in postures with increased knee adduction angle and moment, which are common in patients with medial KOA.[8,15] Thus, patients with KOA in this study may have had a greater mechanical load on the ITB during motion, such as walking. These factors may have caused the difference only in the shear wave velocity between the two groups.

ITB stiffness was related to hip and knee moments, but not to knee or hip angle during walking. In particular, the time integral values of knee adduction moment and the maximum value of the hip flexion moment were correlated with ITB stiffness, which partially supported our hypothesis that the knee adduction moment and hip adduction moment could be related to ITB stiffness. The knee adduction moment, an index of medial knee contact force, could mainly be the mechanical load on the ITB because the ITB decreased the force in the medial knee compartment.[16,36] Among the knee adduction moment indices, the time integral values of knee adduction moment approximates the total mechanical load applied to the ITB during the stance phase. A previous study considered that the forces of the gluteus muscle and tensor fasciae latae transmitted through the ITB might generate knee abduction force by creating a medially directed force on the lateral aspect of the knee. [12] Since this transmitted force may be greater in patients with KOA who have a greater knee adduction moment, a greater force may be added to the ITB against a greater knee adduction moment. In the first half of the stance phase, the muscle forces of the hip extensors, such as the gluteus maximus muscle, increase to resist an external hip flexion moment.[37,38] Considering that the force tracts the ITB as a tendon of the gluteus maximus muscle, the greater force of the gluteus maximus muscle could induce a mechanical load on the ITB.[12] As mentioned above, the ITB adapts to mechanical loading, similar to tendon tissue. A review article reported that the greater the training load on the tendon tissue, the greater the increase in tendon stiffness.[13] Given these points, we interpreted that patients with KOA with greater time integral values of knee adduction moment and the maximum value of the hip flexion moment had a stiffer ITB. However, we could not define the mechanism of these relationships for the following reasons:1) because we measured the ITB properties in the supine position but not during gait; 2) because the ITB stiffness in the supine position could be influenced by other factors (e.g., muscle stiffness); and 3) because this study had an observational design. Further validation is needed to reveal the causal relationship between ITB stiffness and the knee adduction moment and the hip flexion moment. This may be achieved through longitudinal studies with musculoskeletal simulation that estimates the muscles and ITB forces.

There are limitations in the interpretation of our findings. First, the tissue thickness affects the shear wave velocity when performing shear wave elastography in thin tissues, such as the ITB. Although shear wave elastography is often used to estimate the stiffness of the ITB,[8,15,23,27,32,39] the shear wave velocity may be slower in tissues thinner than 25 mm because of the influence of guided waves, which diffuse and reduce the propagation velocity.[40] As the mean thicknesses of both groups were less than 25mm, the shear wave velocity could have been influenced by guided waves. However, because our analysis showed no significant difference in the ITB thickness between the two groups, the higher shear wave velocity in the KOA group can be interpreted as a greater ITB stiffness. Second, we could not measure ITB stiffness during movement. if we measured ITB stiffness during walking, we could reveal the relationship between the mechanical load and ITB stiffness during walking. However, because the preliminary study confirmed that the shear wave velocity of the ITB exceeded the upper limit of the shear wave elastography measurement in patients with KOA even in the static standing position, we measured the shear wave velocity in the supine position, but not in the standing position or during motion. Third, we measured the ITB properties only at the height of the proximal pole of the patella. Because the thickness and stiffness of the ITB vary by region,[39,41] the results may change if we measure the properties at a different point. Finally, we did not confirm the knee status via radiography, did not measure the gait data, and recruited some participants who had knee pain on the unmeasured side in the control group. Therefore, the control group might have included patients with asymptomatic KOA, and whether the association between ITB stiffness and the gait properties is a characteristic of only female patients with KOA remains unknown.

In summary, our study found that ITB stiffness, but not the ITB thickness, was significantly higher in patients with KOA than in healthy adults. Furthermore, the shear wave velocity of the ITB in patients with KOA was associated with the time integral values of knee adduction moment and the maximum value of the hip flexion moment during gait, suggesting that greater mechanical loading could cause stiffer changes in the ITB in patients with KOA.

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TABLE 1 Demographic data

	KOA (n=18)	Control (n=22)	*P* value	ES
Age (years)	69.7±5.9	69.1±7.0	0.779[a]	0.05
Height (cm)	155.6±6.1	153.8±5.3	0.332[a]	0.16
Weight (kg)	55.9±9.7	51.2±8.8	0.117[a]	0.25
BMI (kg/cm2)	23.0±3.1	21.6±3.6	0.217[a]	0.20
Extension knee ROM（°）	-3.5±3.5	0.5±1.6	**<0.001**[b]	0.68
Flexion knee ROM（°）	141.7±11.6	155.5±7.4	**<0.001**[a]	0.59
KSS Symptom (/25)	15.4±4.6	24.3±0.9	**<0.001**[b]	0.88
KSS Function (/100)	75.6±16.5	97.2±3.9	**<0.001**[b]	0.78
KL Grade (n)	KL2:7, 3:7, 4:4	-	-	-

Bold font indicates statistical significance. [a]Two-sample t-test; [b]Welch’s t-test; KOA: knee osteoarthritis, BMI: body mass index, ROM: range of motion, KSS: Knee Society Score, KL: Kellgren/Lawrence

TABLE 2 Gait parameters in the KOA group

Hip moment						Hip angle [°]		
HFM-Max [Nm]	HEM-Max [Nm]	HFM-Impulse [Nm・s]	HAM-peak1 [Nm]	HAM-peak2 [Nm]	HAM-Impulse [Nm・s]	HFA-Max	HEA-Max	HAA-Max
48.2 ±18.0	-41.1 ± 20.2	9.1 ± 6.0	52.4 ± 16.7	44.3 ± 24.1	41.2 ± 16.1	29.6 ± 6.0	-16.1 ± 4.4	16.2 ± 12.5

Knee moment						Knee angle [°]	
KFM-Peak1 [Nm]	KFM-Peak2 [Nm]	KFM-Impulse [Nm・s]	KAM-peak1 [Nm]	KAM-peak2 [Nm]	KAM-Impulse [Nm・s]	KFA-Max	KAA-Max
21.9 ± 17.7	18.7± 8.8	12.5 ± 10.1	31.9 ± 11.2	26.6 ± 10.7	25.0 ± 10.0	14.9 ± 9.2	7.2 ± 6.6

KOA: knee osteoarthritis, HFM-Max: maximum hip flexion moment, HEM-Max: maximum hip extension moment, HFM-Impulse: time integral of the hip flexion moment, HAM-Peak1: first peak of the hip adduction moment, HAM-Peak2: second peak of the hip adduction moment, HAM-Impulse: time integral of the hip adduction moment, HFA-Max: maximum hip flexion angle in the first half of the stance phase, HEA-Max: maximum hip extension angle in the second half of the stance phase, HAA-Max: maximum hip adduction angle, KFM-Peak1: first peak of the knee flexion moment, KFM-Peak2: second peak of the knee flexion moment, KFM-Impulse: time integral of the knee flexion moment, KAM-Peak1: first peak of the knee adduction moment, KAM-Peak2: second peak of the knee adduction moment, KAM-Impulse: time integral of the knee adduction moment, KFA-Max: maximum knee flexion angle in the first half of the stance phase, KAA-Max: maximum adduction angle in the first half of the stance phase. Positive values of all parameters indicated flexion and adduction (mean ± standard deviation).

Table3. Liner regressions with the ITB shear wave velocity

dependent variables	independent variables				Simple Linear regression			
	joint	moment/angle	direction	variable type	B	95%CI	β	p
Shear wave velocity	Hip	moment	**flexion**	**maximal**	**0.027**	**0.002 ~ 0.052**	**0.498**	**0.036**
			extension	maximal	-0.011	-0.036 ~ 0.014	-0.224	0.373
			flexion	impulse	0.048	-0.124 ~ 0.220	0.146	0.563
			adduction	peak1	0.025	-0.003 ~ 0.053	0.422	0.081
				peak2	0.010	-0.011 ~ 0.031	0.236	0.346
				impulse	0.052	-0.007 ~ 0.111	0.426	0.078
		angle	flexion	maximal	-0.001	-0.088 ~ 0.086	-0.005	0.983
			extension	maximal	0.048	-0.066 ~ 0.162	0.218	0.384
			adduction	maximal	0.021	-0.019 ~ 0.061	0.266	0.286
	Knee	moment	flexion	peak1	-0.003	-0.032 ~ 0.026	-0.057	0.822
				peak2	0.002	-0.056 ~ 0.061	0.022	0.932
				impulse	0.027	-0.075 ~ 0.129	0.137	0.587
			adduction	peak1	0.028	-0.016 ~ 0.072	0.322	0.193
				peak2	0.029	-0.017 ~ 0.075	0.316	0.201
				impulse	**0.100**	**0.010 ~ 0.191**	**0.507**	**0.032**
		angle	flexion	maximal	-0.019	-0.074 ~ 0.037	-0.174	0.489

	adduction	maximal	-0.024	-0.102 ~ 0.053	-0.164	0.516

Bold font indicates a statistically significant regression. B: partial coefficient; CI: confidence interval; β: standardized partial coefficient; p: p-value.

TABLE 4. Liner regressions with the iliotibial band thickness

dependent variables	independent variables				Simple Linear regression			
	joint	moment/angle	direction	variable type	B	95%CI	β	p
Thickness	Hip	moment	flexion	maximal	0.003	-0.007 ~ 0.012	0.144	0.596
			extension	maximal	0.006	-0.002 ~ 0.014	0.351	0.153
			flexion	impulse	0.020	-0.038 ~ 0.079	0.181	0.472
			adduction	peak1	-0.003	-0.013 ~ 0.008	-0.133	0.598
				peak2	-0.002	-0.009 ~ 0.005	-0.135	0.594
				impulse	-0.001	-0.024 ~ 0.021	-0.036	0.888
		angle	flexion	maximal	-0.015	-0.044 ~ 0.013	-0.275	0.269
			extension	maximal	0.010	-0.030 ~ 0.050	0.132	0.601
			adduction	maximal	0.002	-0.012 ~ 0.016	0.083	0.743
	Knee	moment	flexion	peak1	-0.001	-0.011 ~ 0.009	-0.033	0.896
				peak2	-0.006	-0.026 ~ 0.014	-0.165	0.514
				impulse	0.004	-0.031 ~ 0.039	0.057	0.822
			adduction	peak1	-0.001	-0.017 ~ 0.015	-0.027	0.915
				peak2	-0.001	-0.018 ~ 0.015	-0.039	0.877
				impulse	0.005	-0.031 ~ 0.041	0.076	0.766
		angle	flexion	maximal	0.008	-0.010 ~ 0.027	0.229	0.361
			adduction	maximal	0.019	-0.006 ~ 0.044	0.381	0.119

B: partial coefficient; CI: confidence interval; β: standardized partial coefficient; p: p-value.

Figure legends

FIGURE 1 Measurement posture. Before the measurement, we drew a line perpendicular to the thigh at the height of the superior aspect of the patella. After the thickest portion of the ITB on the line was identified in the transverse ultrasonic B-mode image, the probe was placed parallel to the ITB fibers. The middle portion of the probe was maintained in a line. Next, we marked the probe position (square in the left figure) to define the measurement site. The shear wave velocity and thickness were measured at this location. ITB: iliotibial band

FIGURE 2 Representative ultrasound image obtained on shear wave elastography. The top image is a color map of the shear wave velocity calculated on elastography, and the bottom image is a B-mode image obtained simultaneously with the elastographic image. A Q-box was drawn on the ITB to calculate the average Young’s modulus. The length of the yellow line in the B-mode image is measured as the thickness of the ITB. ITB: iliotibial band

FIGURE 3 Comparison of the ITB properties. The shear wave velocity was higher in the KOA group than in the control group by using a two-sample t-test(a); meanwhile, no difference was found in the thickness (b). The upper and lower whiskers represent the maximum and minimum values, respectively. The upper and lower ends of the box represent the upper and lower quartiles, respectively, and the bars in the box represent the median value. ITB: iliotibial band, KOA: knee osteoarthritis, ES: effect size

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