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[Original article]

Relationship between lumbar disc degeneration on MRI and low back pain : A cross-sectional community study

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Abstract

Purpose : Although an association has been suggested between disc degeneration (DD) and low back pain (LBP), some DD is thought to be an age-related change unrelated to symptoms. Age-inappropriate DD, however, may be associated with LBP. The purpose of this study was to investigate whether there is a difference in LBP and LBP-related quality of life between age-appropriate and age-inappropriate DD, as assessed by magnetic resonance imaging (MRI).

Participants and methods : In this cross-sectional study, degenerative change in the lumbar intervertebral discs of 382 subjects (age range, 27-82 years) was evaluated by MRI. Degenerative Disc Disease (DDD) scores were assigned using the Schneiderman classification, as the sum of grades for all intervertebral levels (0-15). We classified subjects into three groups according to age and DDD score : Low DD (mild DD relative to age), Appropriate (age-appropriate DD), and High DD (severe DD relative to age). We compared the three groups in terms of LBP prevalence, LBP intensity, LBP-specific quality of life (QOL) according to the Roland-Morris Disability Questionnaire (RDQ), and the Short Form-36 Item Health Survey (SF-36).

Results : Of 382 subjects, there were 35% in the Low DD group, 54% in the Appropriate group, and 11% in the High DD group. There were no significant differences among the groups in terms of prevalence of LBP, LBP intensity, RDQ score, or SF-36 score.

Conclusion : No association was found between age-inappropriate DD (Low or High DD group) and age-appropriate DD (Appropriate group) in terms of prevalence of LBP, LBP intensity, RDQ, or SF-36.

Key words : cross-sectional study, disc degeneration, low back pain, age-related

Introduction

Low back pain (LBP) is highly prevalent in developed countries, where two thirds of adults have been affected by back pain[1]. LBP is associated with high health care costs and the loss of productivity, and is considered to have an economic impact[2]. In addition, it is widely known that LBP affects depression[3] and quality of life (QOL). Therefore, it is important to investigate the causes of LBP.

Magnetic resonance imaging (MRI) is a non-invasive and accurate method for morphological evaluation of the lumbar spine[4]. It is appropriate for assessing the association between the morphological findings on imaging and LBP[5], and is commonly performed in current LBP practice. Disc degeneration (DD) can be visualized as an abnormal finding on MRI. Histologically, DD is a state of reduced water content and motility due to reduced proteoglycan content and fibrosis in the nucleus pulposus[4,6]. Such degeneration is apparent as decreased T2 signal intensity in the disc and narrowing of the interverte-

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bral height on MRI. Intervertebral DD is known to involve both age-related changes and tissue damage brought on by combined stresses, including those from mechanical, nutritional, and chemical factors[7,8]. However, the relationship between DD and LBP remains controversial. Numerous previous studies have suggested that DD on MRI is related to the presence of LBP[5,9-13]. DD is commonly observed as age-related change in asymptomatic subjects[14-16], but abnormal DD that is not appropriate for age may be symptomatic. Previous cross-sectional studies in the general population have suggested that DD is an age-related phenomenon[17-20], although a small percentage of young people have multiple DD whereas some older people do not have DD[19]. It has been suggested that some DD is related to factors other than age, such as genetics, nutrition, and trauma[5,21,22]. Several case-control studies in young subjects have suggested a relationship between DD and LBP[5,23,24]. Advanced DD in young people is thought to indicate pathological degeneration that may be associated with symptoms. Several problems can be identified in previous studies of the relationship between DD seen on imaging and LBP. The first is the evaluation of symptomatic and asymptomatic DD as a single category. Age-related DD in the elderly and more rapidly progressive DD in the young may have different pathologies and should be evaluated separately. The lack of assessment of the characteristics of LBP is another problem. Complaints of LBP vary widely and are reported to be associated with psychosocial factors[25]. LBP due to psychosocial factors may not be based on abnormal findings on imaging. In addition to the presence or absence of LBP, it is also important to assess LBP-specific QOL and health-related QOL. The purpose of this study was to investigate the association between LBP and DD in community residents using a detailed assessment of LBP, and to investigate whether there is an association between age-appropriate and age-inappropriate DD and LBP.

Methods

This study was approved by the ethics committee of our university. In all cases, informed consent was documented in writing.

Participants

In 2004, a cross-sectional survey was conducted among community residents of Ina Village, Tateiwa Village, and Tadami Town, all in a mountainous inland area of Fukushima Prefecture, Japan. In conjunction with a general health checkup — part of Japan's system of universal health care — 1862 residents agreed to participate in this study, of whom 459 underwent MRI of the lumbar spine[26]. Those with MRI examinations that were insufficient for assessment due to image artifacts or blurring, or who had not fully completed the questionnaire, were excluded from the study. A final total of 382 subjects were included in the study (Figure 1.), 119 males and 263 females, with mean age of 64.5 years (range, 27-82 years). The largest age group consisted of those in their 70s. Demographic characteristics including age, sex, body mass index (BMI), and smoking status (Brinkman index ; BI)[27] were recorded.

LBP evaluation

In the questionnaire, the participant's current presence or absence of LBP was recorded as LBP (+) or LBP (–), respectively ; the duration of LBP was described as less than 1 week, from 1 week up to 1 month, from 1 month up to 3 months, or 3 months and beyond. Whether LBP mildly or significantly impaired activities of daily living (ADL) was recorded as no, mild, or severe ADL disturbance. Degree of LBP was evaluated by a 1 to 10 numerical rating scale (NRS, with 0 for no pain, and 10 for maximum pain imaginable). Japanese versions of the Roland-Morris Disability Questionnaire (RDQ) for LBP-specific QOL[28,29] and the medical outcomes study Short-Form 36-Item Health Survey (SF-36) for general health-related QOL[30-32] were also evaluated. In this study, norm-based scores standardized by age and sex were used in the RDQ, and eight domains were used in the SF-36 for the reason that norm-based scores are useful for making within-group comparisons in groups of different ages and sex. Norm-based scores are available for people aged 20-79 years in the Japanese population. In norm-based scores, a score of 50 is the national norm, and a score below 50 indicates QOL below the national norm[29,30].

MRI evaluation

MRI was performed using one of two scanners : 0.2T Airis Mate (Hitachi Ltd, Tokyo, Japan) or 1T Excelart with Pianissimo (Toshiba Medical Systems Corporation, Tochigi, Japan). Sagittal T2-weighted images were acquired with 6 mm slice thickness (Airis Mate : turbo spin echo [TSE] ; repetition time [TR] / echo time [TE], 3000 / 125 ; Excelart : TSE ; TR / TE, 3300 / 110).

Degeneration in each of the five intervertebral

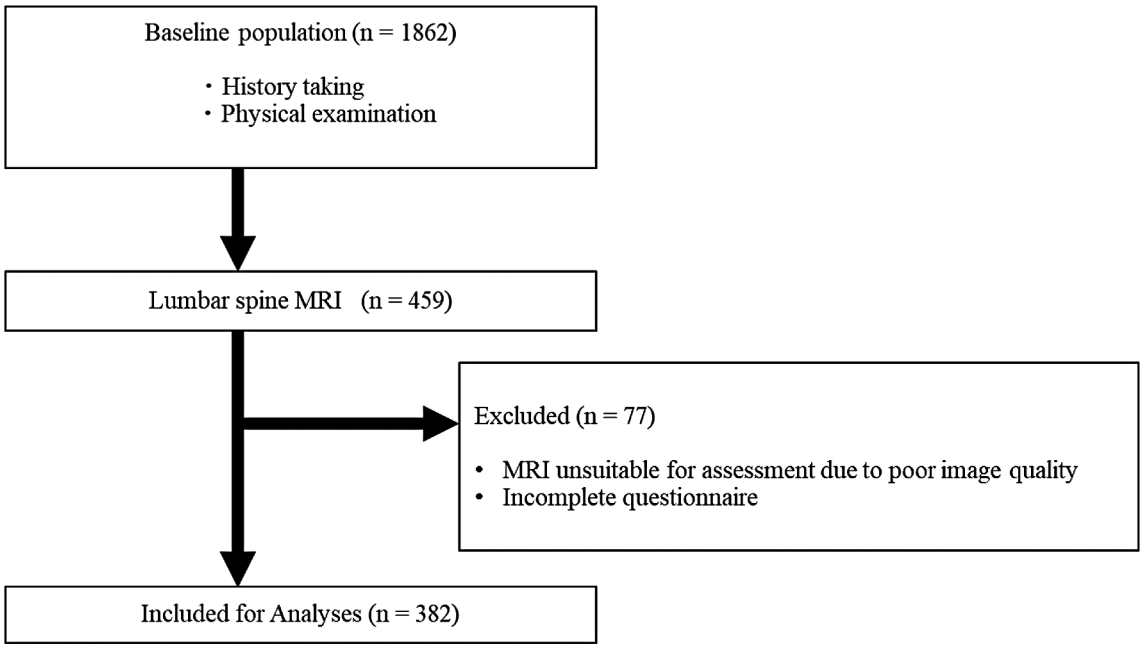

Fig. 1. Participants and exclusion criteria
A questionnaire survey and physical examination were administered to community residents, and lumbar spine MRI imaging was performed. After applying the exclusion criteria, 382 patients were included in the analysis.

discs from L1-2 to L5-S1 was evaluated using the Schneiderman classification[33] (Table 1). Disc degeneration disease (DDD) score was recorded as the sum of the five levels (scored 0-15)[34]. The images were evaluated by one orthopedic surgeon (TW). To measure intra-examiner reliability, 30 images were randomly selected and remeasured at intervals of one month or longer.

Method of group categorization

The participants were classified into three groups (Low DD, Appropriate, or High DD) according to combined age and DDD score. Age was classified as young (< 50 years), moderate (50-64 years), or older (≥ 65 years). DDD score was classified as mild (1-6), moderate (7-10), or severe (11-15), using analysis of variance with the cutoff value showing the highest F value, based on the methods of Serlin[35] and Jensen[36].

The three groups contained subjects with the following characteristics, as shown in Figure 2. Low DD group : moderate age with mild DD, older age with mild or moderate DD. Appropriate group : younger age with mild DD, moderate age with moderate DD, older age with severe DD. High DD group : younger age with mild or severe DD, moderate age with severe DD[37].

We compared the prevalence of LBP, duration of LBP, degree of LBP, LBP-specific QOL, and health-related QOL among the three groups.

Statistical analysis

The Kruskal-Wallis test was used for continuous variables, and the χ^2 test or Fisher's exact test was used for comparison of nominal variables. A logistic regression analysis was conducted to estimate the risk of LBP associated with age-related DD. Sex, BMI, and BI were used as the confound-

Table 1. Schneiderman classification

Definition of MRI Signal Intensity	
Term	*Definition*
Normal	Normal height and signal intensity
Intermediate	Speckled pattern or heterogeneous decreased signal intensity
Marked	Diffuse loss of signal
Absent	Signal void

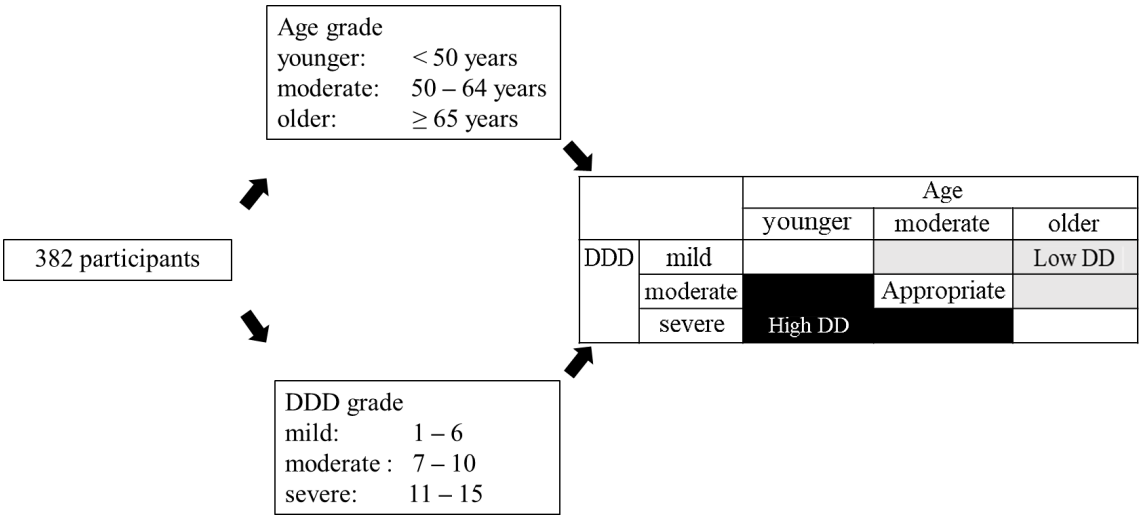

Fig. 2. Classification based on age and disc degeneration
Participants were graded according to age and DDD score (center panels) and then assigned into the following three groups using the table on the right : Low DD, Appropriate, and High DD.

ing variables. P values less than 5% were considered statistically significant. Statistical analyses were performed using IBM SPSS Statistics V25 for Windows (IBV Japan Inc., Tokyo) and R version 3.6.3 (Copyright ©2020 The R Foundation for Statistical Computing Platform : 1386-w64-mingw32 / i386 [32-bit]).

Results

The kappa coefficient for intra-examiner reliability was 0.774, which was judged as substantive and acceptable[38].

Table 2 lists the demographic data. Eighty-five (22%) of the participants had LBP. There were no statistically significant differences between the LBP (+) and LBP (–) groups in terms of age, sex, BMI, or smoking. In the SF-36, bodily pain (BP) (p=0.029) and general health (GH) (p=0.001) were significantly lower in the LBP (+) group than the LBP (–) group. There was no statistically significant difference in the mean value or distribution of DDD score between these groups.

Table 3 summarizes the characteristics of LBP according to sex. Of the 85 subjects in the LBP (+) group, 29 were male and 56 were female. Mean age was significantly higher in females than in males (68.4 vs 62.4 years, p = 0.026). Eighteen males (62%) and 44 females (79%) had LBP for more than 3 months. There was no significant difference in mean NRS of LBP between males and females (5.6 and 5.0, respectively ; p = 0.359) or in mean norm-based RDQ score (48.6 and 47.6, respectively ; p = 0.522). A norm-based RDQ score < 50 points (i.e., lower than the national norm) was higher in females than males (63% vs 45%), but the difference was not significant (p = 0.119). DDD score was significantly more severe in females than in males (p = 0.047).

Table 4 lists the demographic data of the three groups based on age and DD. There were 206 participants (54%) in the Appropriate group, 134 (35%) in the Low DD group, and 42 (11%) in the High DD group. There was no significant difference among the groups in terms of sex, BMI, smoking status, or any of the eight domains of the SF-36.

Table 5 lists the characteristics of LBP according to group. The prevalence of LBP was 34 (25%) in the Low DD group, 44 (21%) in the Appropriate group, and 7 (17%) in the High DD group (no significant difference, p = 0.408). The most common duration of LBP was > 3 months in all three groups (no significant difference). The prevalence of LBP causing mild ADL disturbance was 22 (65%) in the Low DD group, 28 (64%) in the Appropriate group, and 5 (71%) in the High DD group (no significant difference, p = 0.844). The RDQ norm-based score was 48 in the Low DD group, 48 in the Appropriate group, and 47 in the High DD group (no significant difference, p = 0.775). The prevalence of patients with a norm-based RDQ score < 50 was 22 (65%) in the Low DD group, 22 (50%) in the Appropriate group, and 4 (57%) in the High DD group (no significant difference).

Table 6 lists the results of multiple logistic regression analysis of the effect of age-related DD on LBP in the three groups. LBP was examined for

Table 2. Demographic data

(*n*, [%])	**Total** (*n*=382)	**LBP (+)** (*n*=85, [22])	**LBP (–)** (*n*=297, [78])	***p* value**
Age (mean, [95%CI])	64.5 (63.4–65.6)	66.4 (64.4–68.4)	63.9 (62.7–65.2)	0.079
Age (years ; *n*, [%])				
< 50 years	36 (10)	5 (6)	31 (10)	0.139
50–65 years	124 (32)	23 (27)	101 (34)	
≥ 65 years	222 (58)	57 (67)	165 (56)	
Sex (*n*, [%])				
male	121 (32)	29 (34)	92 (31)	0.583
female	261 (68)	56 (66)	205 (69)	
BMI (*n*, [%])				
< 18.5	19 (6)	3 (4)	16 (6)	0.566
18.5–24.5	222 (68)	47 (64)	175 (69)	
25–29.5	79 (24)	22 (30)	57 (23)	
≥ 30	5 (2)	1 (1)	4 (2)	
Smoking (BI >0) (*n*, [%])	91 (24)	19 (22)	72 (24)	0.701
SF-36 norm-based score (mean, [95%CI])				
PF	49.7 (48.2–51.2)	49.7 (47.3–52.1)	49.7 (48.3–51.2)	0.455
RP	47.9 (46.7–49.1)	46.1 (43.2–48.9)	48.4 (47.0–49.7)	0.106
BP	46.8 (45.6–48.0)	44.0 (41.5–46.5)	47.5 (46.2–48.9)	0.029
GH	48.3 (47.3–49.2)	45.4 (43.4–47.4)	49.1 (48.0–50.1)	0.001
VT	50.4 (49.3–51.5)	48.9 (46.1–51.6)	50.7 (49.6–51.9)	0.248
SF	49.9 (48.8–51.1)	48.1 (45.1–51.1)	50.4 (49.2–51.7)	0.314
RE	48.3 (47.0–49.5)	46.1 (43.0–49.2)	48.8 (47.4–50.1)	0.358
MH	49.1 (48.0–50.1)	47.5 (45.1–49.9)	49.5 (48.4–50.7)	0.166
DDD score (mean, [95%CI])	9.2 (8.9–9.5)	9.6 (9.0–10.3)	9.1 (8.7–9.4)	0.197
Distribution of DDD score (*n*, [%])				
mild : 1–6	68 (18)	11 (13)	57 (19)	0.397
moderate : 7–10	178 (46)	43 (51)	135 (46)	
severe : 11–15	136 (36)	31 (36)	105 (35)	

LBP : low back pain, CI : confidence interval, BMI : body mass index, BI : Brinkman index, PF : physical functioning, RP : role physical, BP : bodily pain, GH : general health, VT : vitality, SF : social functioning, RE : role emotional, MH : mental health, DDD : disc degenerative disease.

three categories : Category 1, all LBP versus no LBP ; Category 2, LBP duration less than 3 months versus no LBP ; Category 3, LBP duration of 3 months or more versus no LBP. Any age-related DD had no effect on the prevalence of any of LBP, LBP duration < 3 months, or LBP duration ≥ 3 months.

Discussion

In this study, participants were divided into three groups : Appropriate, High DD (severe DD relative to age), and Low DD (mild DD relative to age). Several previous studies have reported an association between aging and DD, and it is generally believed that most DD is an age-related change[17-20]. Other factors considered to have an association with DD include genetic factors, nutritional factors, trauma, obesity, and smoking[5,21,22]. Most studies that reported an association between severity of DD and LBP were case control studies limited to young adults[5,23,24] or epidemiological studies covering a wide range of ages[19]. Although case control studies in young adults have strongly sug-

Table 3. Characteristics of LBP according to sex

(*n*, [%])	**Total** (*n*=85)	**Males** (*n*=29, [34])	**Females** (*n*=56, [66])	***p* value**
Age (years ; mean, [95%CI])	66.4 (64.4–68.4)	62.4 (58–66.8)	68.4 (66.5–70.4)	0.026
LBP (*n*, [%])				0.024
< 1 week	8 (9)	1 (3)	7 (13)	
1 week up to 1 month	12 (14)	8 (28)	4 (7)	
1 month up to 3 months	3 (4)	2 (6)	1 (2)	
≥ 3 months	62 (73)	18 (62)	44 (79)	
NRS (mean, [95%CI])	5.2 (4.67–5.75)	5.6 (4.74–6.43)	5.0 (4.31–5.72)	0.359
Norm-based RDQ score (mean, [95%CI])	48.0 (45.8–50.1)	48.6 (44.5–52.7)	47.6 (45.1–50.2)	0.522
Norm-based RDQ score (*n*, [%])				0.119
< 50	48 (56)	13 (45)	35 (63)	
≥ 50	37 (44)	16 (55)	21 (37)	
Distribution of DDD score (*n*, [%])				0.047
mild : 1–6	11 (13)	7 (24)	4 (7)	
moderate : 7–10	43 (51)	15 (52)	28 (50)	
severe : 11–15	31 (36)	7 (24)	24 (43)	

Females were significantly older and had a higher prevalence of LBP and severe DD.
CI : confidence interval, LBP : low back pain, NRS : numerical rating scale,
RDQ : Roland–Morris Disability Questionnaire, DDD : disc degenerative disease

Table 4. Demographic data of age-related DD groups

(*n*, [%])	**Low DD group** (*n*=134, [35])	**Appropriate group** (*n*=206, [54])	**High DD group** (*n*=42, [11])	***p* value**
Sex (*n*, [%])				0.088
Male	52 (39)	57 (28)	12 (29)	
Female	82 (61)	149 (72)	30 (71)	
BMI (*n*, [%])				0.768
< 18.5	8 (7)	10 (6)	1 (3)	
18.5–24.5	84 (72)	113 (65)	25 (71)	
25–29.5	24 (21)	47 (27)	8 (23)	
≥ 30	1 (1)	3 (2)	1 (3)	
missing	17	33	7	
Smoking (BI > 0) (*n*, [%])	36 (32)	49 (30)	6 (17)	0.239
missing	21	40	7	
SF-36 norm-based score (mean, [95%CI])				
PF	50.6 (48.4–52.7)	49.2 (47.4–50.9)	49.5 (45.9–53.0)	0.62
RP	48.9 (46.9–50.8)	46.9 (45.1–48.7)	49.4 (46.1–52.8)	0.335
BP	47.7 (45.7–49.6)	45.5 (43.8–47.2)	49.5 (45.9–53.0)	0.091
GH	49.3 (47.7–50.8)	47.7 (46.4–49.0)	48.2 (45.3–51.0)	0.492
VT	51.6 (49.7–53.4)	49.2 (47.7–50.8)	51.3 (48.6–54.1)	0.07
SF	50.1 (48.0–52.1)	49.8 (48.1–51.4)	50.1 (46.8–53.4)	0.35
RE	49.5 (47.5–51.5)	47.0 (45.2–48.8)	49.9 (46.0–53.8)	0.77
MH	50.0 (48.3–51.6)	48.7 (47.2–50.2)	48.6 (45.3–51.8)	0.665

There were no significant differences among the three groups in terms of age, sex, BMI, smoking, or any of the eight domains of SF-36.
DD : disc degeneration, BMI : body mass index, BI : Brinkman index, PF : physical functioning, RP : role physical, BP : bodily pain, GH : general health, VT : vitality, SF : social functioning, RE : role emotional, MH : mental health

Table 5. Characteristics of LBP according to age-related DD group

(*n*, [%])	Low DD group (*n*=134, [35])	Appropriate group (*n*=206, [54])	High DD group (*n*=42, [11])	*p* value
LBP (*n*)	34 (25)	44 (21)	7 (17)	0.408
Duration (*n*, [%])				0.817
< 1 week	4 (12)	4 (9)	0 (0)	
1 week up to 1 month	3 (9)	7 (16)	2 (29)	
1 month up to 3 months	1 (3)	2 (5)	0 (0)	
≥ 3 months	26 (76)	31 (70)	5 (71)	
ADL disturbance (*n*, [%])				0.844
none	2 (6)	5 (11)	1 (14)	
mild	22 (65)	28 (64)	5 (71)	
severe	10 (29)	11 (25)	1 (14)	
Norm-based RDQ score (95%CI)	48.0 (45.1-50.7)	48.3 (44.8-51.7)	46.5 (37.1-56.0)	0.775
Norm-based RDQ score (*n*, [%])				0.43
< 50	22 (65)	22 (50)	4 (57)	
≥ 50	12 (35)	22 (50)	3 (43)	

There were no significant differences among the three groups in terms of prevalence of LBP, ADL disturbance, or Norm-based DRQ score.
LBP : low back pain, DD : disc degeneration, ADL : activities of daily living, RDQ : Roland–Morris Disability Questionnaire

Table 6. Logistic regression analysis of age-related DD and LBP

	Category 1 All LBP			**Category 2 LBP < 3 months**			**Category 3 LBP ≥ 3 months**		
	OR	95%CI	*p* value	OR	95%CI	*p* value	OR	95%CI	*p* value
Age-related DD group									
Appropriate		Reference			Reference			Reference	
High DD	0.69	0.265-1.798	0.448	0.446	0.055-3.636	0.446	0.82	0.29-2.318	0.709
Low DD	1.142	0.644-2.027	0.649	0.879	0.307-2.521	0.879	1.237	0.655-2.337	0.512

Logistic regression analysis was performed to determine whether age-related DD is associated with LBP. LBP was categorized as lasting for the entire period, for < 3 months, or for ≥ 3 months. No association was found for any category. Logistic regression analysis was performed after adjusting for sex, BMI, and BI.
DD : disc degeneration, LBP : low back pain, BMI : body mass index, BI : Brinkman index

gested a relationship between LBP and severity of DD[5,23,24], studies in the general population have shown that the effects of age-related DD cannot be ignored[19]. For these reasons, the present analysis focused on divergence between the degree of DD and age. In other words, we sought to clarify the relationship between age-related DD and LBP by focusing on whether DD was age-appropriate, more advanced than expected for age, or, conversely, less advanced than expected for age.

The results showed that approximately half (54%) of the participants had age-appropriate DD, 11% had severe DD relative to age, and 35% had mild DD relative to age. There was no difference in sex ratio among these three groups. Sex differences in severity of DD have been reported, with males showing more degeneration than females in younger adults[39], significantly more advanced degeneration in older postmenopausal females, and more advanced degeneration in females. Wang *et al.* reported a significantly faster rate of lumbar DD in menopausal females (age 49-50) than that in males of the same age, and that after the 50s, DD was more severe in females than in males of the same age[40]. They also report that relative estrogen deficiency may accelerate DD in older post-

menopausal women. According to these reports, the High DD group would include more young adults and have a higher proportion of males compared with the Low DD group ; however, this was not the case in the present study.

There was no difference in obesity (assessed by BMI), which is considered a risk factor for DD, among the three groups in this study. There is no consensus regarding the relationship between obesity and severity of DD. Dario *et al.* reported a systematic review of twin studies on the association between obesity and LBP, and between obesity and severity of DD. An association between obesity and severity of DD was reported in a study in which genetic factors were not considered[41]. In two studies in which genetic factors were considered, however, there was an association between obesity and severity of DD in some cases but not in others[42,43]. In addition, a longitudinal study reported no association between obesity and severity of DD, regardless of the presence or absence of genetic factors[44].

Previous clinical and basic research has shown that smoking increases the severity of DD. In a study of 20 pairs of twins, Battie *et al.* reported that mean DD score was 18% higher in smokers than in nonsmokers[45]. Animal studies have also shown negative effects of cigarette smoke and nicotine on the intervertebral discs[46,47]. There were no significant differences in smoking status among the three groups in this study. It is possible that factors other than age (e.g., genetic influences, smoking, obesity, trauma, nutrition) may have biased the findings in the DD High and Low groups, but we found no differences in terms of obesity or smoking status in this study. Further investigation of unexamined confounding factors is needed.

We found that BP and GH were lower in LBP (+) than LBP (–) cases ($p = 0.029$, $p = 0.001$), but our cross-sectional study could not establish causality. In general, BP and GH were low in the presence of LBP. There was no association between SF-36 and age-inappropriate DD. Corniola *et al.* reported that in 284 patients undergoing surgery for lumbar DDD, there was no association between severity of DD, LBP, or QOL score on the SF-12[48] (The SF-12 is a simplified version of the SF-36. It consists of 12 questions selected from the SF-36 questionnaire and allows comparison with SF-36 scores). Few studies have focused on severity of DD and QOL. For the hypothesis of an association of more severe degeneration with more severe back pain and/or disability in the present three groups, we would have expected to find worse health-related QOL in subjects with more severe degeneration. In other words, we hypothesized that the High DD group would have a higher prevalence or severity of LBP and lower health-related QOL compared with the Appropriate DD and Low DD groups. However, there were no significant differences in the prevalence or severity of LBP among the three groups based on age and DD. It is noteworthy that not only was prevalence of LBP not significant in the group with severe DD relative to age, but also, there was a 25% prevalence of LBP in the group with mild DD relative to age, and no differences were found between these two groups. There was no association among the three groups in the prevalence of subjects with LBP, nor in terms of duration of LBP, presence of ADL disability, and RDQ, which were not significantly different. The High DD group, which appears to be conventionally associated with LBP, did not necessarily have a large number of cases of LBP, and the Low DD group had the same percentage of LBP as the Appropriate group, indicating that the age-related DD alone may not predict the presence or absence of LBP.

In logistic regression analysis, a more robust statistical method, the presence of age-divergent DD was not associated with the prevalence of LBP, compared with having age-appropriate DD. That is, having high DD relative to age (conventionally considered likely to be symptomatic) or having low DD relative to age (conventionally considered likely to be asymptomatic) also had no direct effect on the presence or absence of LBP. Despite the influence of unadjusted confounders, LBP risk was not increased in the at-risk population with severe DD relative to age, and LBP risk was not decreased with mild DD relative to age, suggesting a low association between LBP and age-related DD.

Whereas a number of previous studies in young subjects have suggested an association between severity of DD and LBP, longitudinal studies have reported no such association on MRI imaging. Jarvik *et al.* found no association between MRI imaging DD and LBP in a 3-year longitudinal study of 148 veterans, but reported that depression was an important predictor of LBP[49]. Shambrook *et al.* analyzed lumbar spine MRI imaging in 354 patients with LBP and reported that High intensity zone, DD, disc herniation, and nerve root compression were not associated with acute LBP. They also noted the importance of psychological risk factors in the absence of a physical pathology[50]. In this study, not only was the prevalence of LBP not high in the High DD group, which would be assumed to have a high prev-

alence of symptoms, but there were several cases of LBP in the DD low group, which would be assumed to have a low prevalence of symptoms. The present results align with previous studies showing that many factors contribute to LBP, but that DD on MR imaging is not necessarily a factor in LBP.

It is a strength of this study that in addition to past methods of investigating the relationship between severity of DD and LBP in community residents of all ages, we also investigated age-related DD. Adding the new focus of age-divergent DD to previous research methods may have allowed us to more clearly reevaluate the association between LBP and age-related DD. However, there are some limitations in this study. First, the presence or absence of LBP was used as an outcome, as in previous studies, but the results may change if the nature of LBP were to be classified in more detail. Second, the overall prevalence of LBP onset was relatively low because study subjects were drawn from routine health examinations that are part of Japan's system of universal health care. Third, the groupings in this study were defined by the age of the subjects and thus the results cannot be directly generalized. How young, old, and severity of DD are defined differ depending on the observed population and methodology of a study. Although the age criterion for the younger age group was somewhat older compared with that used in previous studies, the age criterion for the older age group was in a similar range. Finally, evaluating DD by the DDD score (as the sum of each DD grade) may have reduced the discriminative power of the LBP diagnosis. The same total score can be attained for mild degeneration in several discs or for severe degeneration in a few discs, which are different pathological entities. However, Cheung *et al.* reported that it is possible to assess the relationship between DD and LBP using the DDD score[19)]

Conclusion

When age-related DD was considered for clarifying the association between DD and LBP, no association was found between age-inappropriate DD (High or Low DD group) and age-appropriate DD (Appropriate group) in terms of LBP, RDQ, or SF-36. When examining the relationship between imaging findings of degeneration and symptoms such as LBP, it is necessary to take into account the physiological progression of aging, rather than simply the presence or absence of degeneration.

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Disclosure

The authors declare no conflicts of interest associated with manuscript.

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