

# Low Back Pain and Lumbar Degeneration in Japanese Professional Baseball Players

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**Background:** Baseball is one of the most popular sports in Asia. It is known that baseball can easily lead to back pain. However, there has been no survey of low back pain (LBP) and lumbar disc degeneration in Japanese professional baseball players to date.

**Purpose:** To investigate the cause of LBP and lumbar degeneration in professional Japanese baseball players.

**Study Design:** Cross-sectional study; Level of evidence, 3.

**Methods:** We retrospectively reviewed the medical records of Japanese professional baseball players with LBP who visited our hospital. Data were collected from July 2018 to April 2021. We also investigated whether the results differed between players in their 20s and 30s or between pitchers and fielders. Data analysis was performed using the chi-square test.

**Results:** We surveyed 32 professional baseball players. The most frequent causes of LBP among players in their 20s ( $n = 21$ ) were lumbar disc herniation (LDH; 57%) and spondylolysis (24%). Of the players with spondylolysis, 50% had adult-onset spondylolysis. Players in their 30s ( $n = 11$ ) most commonly had discogenic pain (55%) as well as LDH and facet joint arthritis (each 18%). The incidence of lumbar intervertebral disc degeneration was significantly higher in players in their 30s (91%) than those in their 20s (14%), as was the incidence of Schmorl nodes and Modic type 1 changes. There was no significant difference in the cause of LBP or the incidence of lumbar intervertebral disc degeneration between pitchers and fielders ( $P = .59$ ).

**Conclusion:** Among professional baseball players in their 20s, lumbar degeneration was less common, and they most frequently developed diseases less related to degeneration, such as LDH. However, among players in their 30s, lumbar degeneration was more advanced, and degenerative diseases such as discogenic pain occurred more frequently. Research on training methods could lead to the prevention of LBP. Our data may be applicable to other professional athletes and will contribute to diagnosis and treatment.

**Keywords:** baseball; low back pain; lumbar disc herniation; discogenic pain; Pfirrmann grade

Low back pain (LBP) is a common and often disabling disorder that imposes a large burden on patients and society and results in decreased work productivity and increased medical costs.<sup>2,39,40</sup> It has a point incidence of 6% to 33% and a 1-year incidence of 22% to 65%.<sup>6,19,41</sup> In the general population, 70% to 85% of adults are expected to experience at least 1 episode of LBP during their lifetime.<sup>1</sup>

In particular, athletes experience LBP more often than nonathletes.<sup>15,16,29,34</sup> Up to 9 in every 10 Olympic athletes experience LBP in their lifetime, and at any single point in time, up to 2 in every 3 athletes might be experiencing LBP.<sup>38</sup> Moreover, the incidence of LBP is 86% among professional beach volleyball players, 95.8% among Japanese volleyball players, and 76.9% among competitive swimmers, and the incidence of back pain is extremely high among

athletes at high levels of competition.<sup>15,16</sup> There are also reports that lumbar degeneration progresses further among athletes compared with nonathletes.<sup>9,15,42</sup> In surveys of swimmers and gymnasts, lumbar disc degeneration was found to progress further with increasing competition level.<sup>9,15</sup>

Hangai et al<sup>13</sup> examined the incidence of LBP among university students who played 1 of 8 sports. The incidence was highest among those who played volleyball, followed by baseball.<sup>13</sup> However, even though baseball places a heavy burden on the lumbar spine, few studies have investigated lumbar spine disease or lumbar spine degeneration among professional baseball players. The studies to date are limited to Major League Baseball (MLB) players in the United States.<sup>4,10,18,26</sup> Moreover, they were all epidemiological studies of players on the disabled list and did not investigate individual computed tomography (CT) or magnetic resonance imaging (MRI) examinations. Furthermore, to our knowledge, there has been no survey of Japanese

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professional baseball players to date. Given that racial differences and genetic factors influence the occurrence of lumbar disc degeneration and spondylolysis, we believe that it is important to investigate the specific characteristics of Japanese professional baseball players.<sup>27</sup>

We expected that professional baseball players would have excessive lumbar degeneration if they had played for a long time. However, it is not known how degeneration of the lumbar spine progresses in professional baseball players and whether it is dependent on player position. Furthermore, the conditions that cause LBP have yet to be determined. Therefore, the purpose of this study was to evaluate the clinical and MRI findings among competitive Japanese professional baseball players with LBP to investigate the cause of LBP and the incidence of lumbar spine degeneration. Also, we investigated whether the results differed between players in their 20s and those in their 30s or between pitchers and fielders. Our hypothesis was that baseball players who have been competing for longer periods of time would be more likely to develop LBP originating from degenerative disease than those who have been competing for shorter periods of time.

## METHODS

### Study Participants

After receiving ethics committee approval for our study protocol, we retrospectively reviewed the medical records of Japanese professional baseball players with LBP who visited our hospital from July 2018 to April 2021. Informed consent was obtained from all participants. There were 32 professional baseball players (all men) (Table 1). The mean age was 27.4 years (range, 20-40 years); 21 players were in their 20s, and 11 were in their 30s. By position, there were 14 pitchers and 18 fielders. We investigated the causes of LBP and the incidence of lumbar spine degeneration on MRI scans.

### Diagnosis

A definitive diagnosis of LBP caused by discogenic pain, facet joint arthritis, spondylolysis, lumbar disc herniation (LDH), or lumbar discal cyst was made in all participants through a selective nerve root, intervertebral disc, or facet joint block injection with 1 mL of 1% lidocaine to avoid the placebo effect. If nonoperative treatment was not effective and LBP or leg pain hindered a return to competition, the patients then underwent surgery.

To evaluate the factors that contributed to LBP in the players, we performed neurological and physical

TABLE 1  
Age and Position of Participants (N = 32)

	No.
Age, y	
20s	21
30s	11
Position	
Pitcher	14
Fielder	18

examinations using plain radiography, CT, and MRI. In accordance with previously reported criteria, we defined early spondylolysis as a fissure-like hairline fracture, progressive spondylolysis as an obvious fracture, and terminal spondylolysis as pseudoarthrosis.<sup>22</sup> Terminal spondylolysis was excluded from the analysis because we could not determine whether it was adult-onset spondylolysis. Adult-onset spondylolysis was defined as early or progressive spondylolysis with a high signal intensity area on short tau inversion recovery MRI scans.

LDH was defined as the presence of herniated nucleus pulposus with radicular leg pain or numbness (Figure 1A). Discogenic pain was defined as the presence of LBP without leg pain. We administered an intervertebral disc block using lidocaine and noted whether the pain was alleviated (Figure 1B). When a clear cause of LBP could not be identified, nonspecific LBP was diagnosed.

### MRI Assessment

We examined abnormal MRI findings (disc degeneration, signal intensity changes in vertebral body endplates and subchondral bone, Schmorl nodes) at each lumbar level to evaluate lumbar degeneration. The degree of disc degeneration was classified into 5 grades according to the Pfirrmann classification (Figure 2).<sup>25</sup> In this study, Pfirrmann grade  $\geq 3$  was considered to indicate degeneration. Degenerative changes in the vertebral body endplate were classified according to the Modic classification.<sup>20,21</sup> Vertebral bone marrow lesions were visualized as Modic changes on MRI scans. Overall, 3 types of Modic changes have been described based on their appearance on T1- and T2-weighted images, as shown in Figure 3. Schmorl nodes were defined as clear, nonmarginal defects in the vertebral body endplate on MRI scans.<sup>24</sup>

All assessments were performed by the same observer, a certified spinal surgeon with 15 years of experience (M.M.). To evaluate intraobserver reliability, the assessments were performed twice within a 1-month interval. In addition, the assessments were performed on all 32 participants, and

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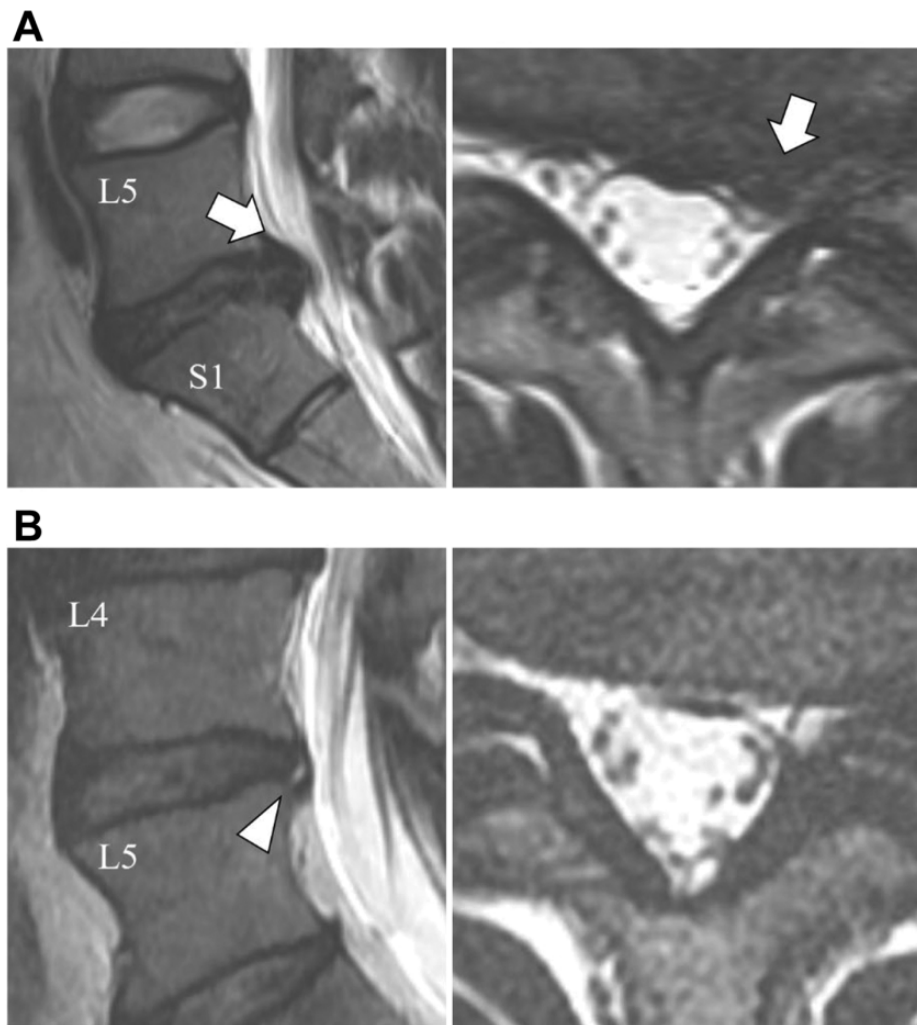
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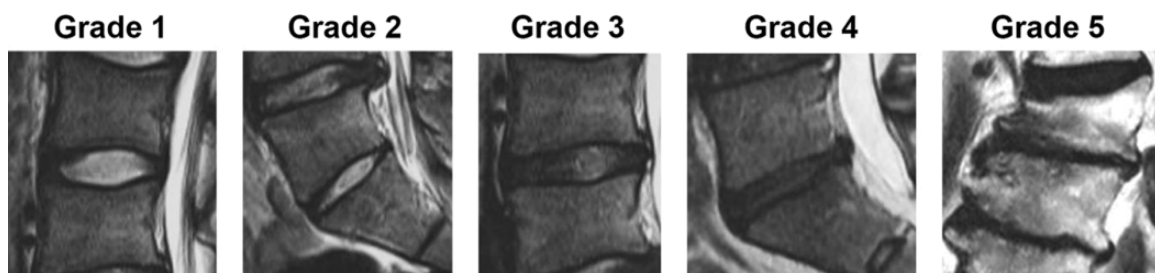
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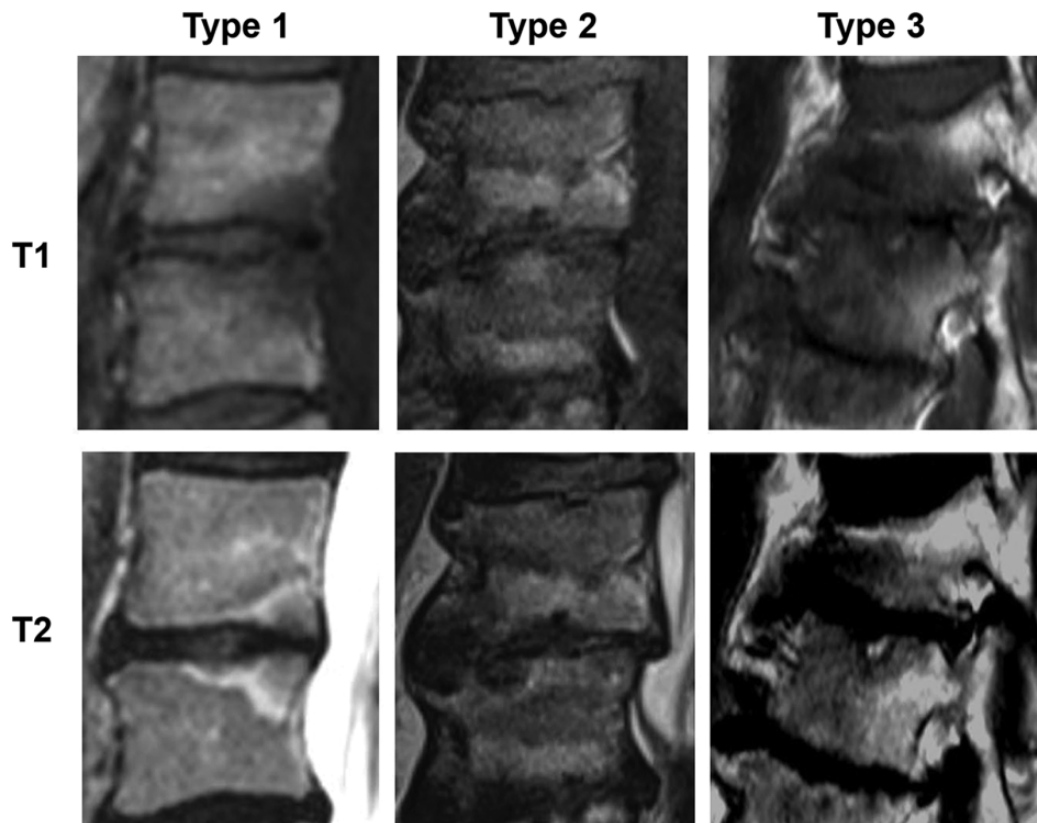
Ethical approval for this study was obtained from Tokushima University Hospital (No. 3060-2).



**Figure 1.** (A) Lumbar disc herniation. T2-weighted magnetic resonance imaging (MRI) scans of the lumbar spine revealed lumbar disc herniation at L4/5, resulting in nerve root compression (arrows). (B) Discogenic pain. Although T2-weighted MRI scans of the lumbar spine revealed a high-intensity zone (arrowhead), spinal stenosis and nerve root compression were not observed.



**Figure 2.** Pfirrmann classification of the severity of disc degeneration. Grade 1 is characterized by a homogeneous disc with high bright white signal intensity and a normal disc height. Grade 2 indicates an inhomogeneous disc structure with high white signal intensity; the distinction between the nucleus and annulus is clear. Grade 3 is characterized by an inhomogeneous disc structure with intermediate gray signal intensity; the distinction between the nucleus and annulus is unclear, and the disc height is normal or moderately decreased. Grade 4 indicates an inhomogeneous disc with low dark gray signal intensity and a disc height that is slightly or moderately low. Grade 5 is characterized by an inhomogeneous disc structure with low black signal intensity; there is no difference between the nucleus and annulus, and the disc space is collapsed.



**Figure 3.** The 3 types of Modic changes as shown on T1- and T2-weighted magnetic resonance imaging scans. A Modic type 1 change is a hypointense signal on T1-weighted images and a hyperintense signal on T2-weighted images. A Modic type 2 change is a hyperintense signal on T1-weighted images and a hyperintense or isointense signal on T2-weighted images. A Modic type 3 change is a hypointense signal on both T1- and T2-weighted images.

interobserver reliability was analyzed between 2 orthopaedic surgeons (a spinal surgeon [M.M.] and a general orthopaedic surgeon with 4 years of experience [R.O.]) and between an orthopaedic surgeon (M.M.) and a musculoskeletal radiologist with more than 16 years of experience (S.T.).

### Statistical Analysis

Categorical variables were examined using the Pearson chi-square test. Simple kappa coefficients ( $\kappa$ ) were calculated to describe interobserver and intraobserver agreement on the MRI assessments, with  $\kappa$  values interpreted as poor ( $\leq 0.2$ ), mild (0.2-0.4), moderate (0.4-0.6), good (0.6-0.8), or excellent (0.8-1.0). Correlation analysis was performed using the Pearson method. Statistical analysis was performed using SPSS Version 21.0 software (IBM). A  $P$  value  $< .05$  was considered statistically significant.

## RESULTS

### Reliability of MRI Assessments

The intraobserver agreement of the spinal surgeon was  $\kappa = 0.90$ . The interobserver agreement between the spinal surgeon and general orthopaedic surgeon and between the

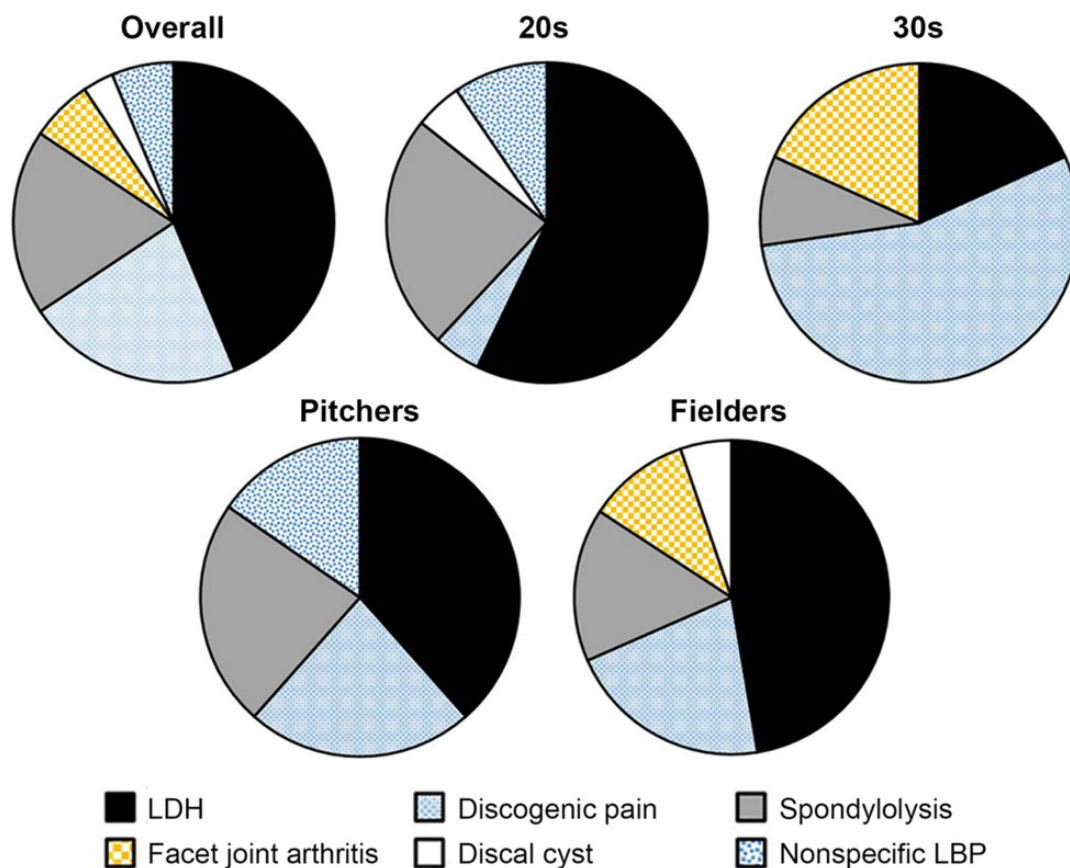
spinal surgeon and musculoskeletal radiologist was  $\kappa = 0.81$  and  $0.82$ , respectively. Both interobserver and intraobserver agreement were considered excellent.

### Surgical Treatment

Of the 32 patients, 12 underwent surgery: full-endoscopic lumbar discectomy in 6 patients with LDH and 1 patient with a lumbar discal cyst, micro-endoscopic lumbar discectomy in 1 patient with LDH, and full-endoscopic spine surgery in 4 patients with discogenic pain.

### Causes of LBP

The cause of LBP was LDH ( $n = 14$  [44%]), discogenic pain ( $n = 7$  [22%]), spondylolysis ( $n = 6$  [19%]), facet joint arthritis ( $n = 2$  [6%]), lumbar discal cyst ( $n = 1$  [3%]), or nonspecific LBP ( $n = 2$  [6%]) (Figure 4). Of the 6 patients with spondylolysis, 3 had adult-onset spondylolysis. In terms of age, the most frequent cause among players in their 20s was LDH ( $n = 12$  [57%]), followed by spondylolysis ( $n = 5$  [24%]). On the other hand, the most frequent cause among players in their 30s was discogenic pain ( $n = 6$  [55%]), followed by LDH and facet joint arthritis (each  $n = 2$  [18%]). These differences were significant between the 2 age



**Figure 4.** Causes of low back pain (LBP). (A) Overall. (B, C) Comparison by age group: (B) 20s and (C) 30s. (D, E) Comparison by position: (D) pitchers and (E) fielders. LDH, lumbar disc herniation.

groups. In terms of position, the most frequent cause of LBP among pitchers was LDH ( $n = 5$  [36%]), followed by discogenic pain and spondylolysis (each  $n = 3$  [21%]). On the other hand, the most frequent cause among fielders was LDH ( $n = 9$  [50%]), followed by discogenic pain ( $n = 4$  [22%]). The incidence of LBP was almost the same between pitchers and fielders.

#### Evaluation of Lumbar Degeneration Based on MRI Findings

The distribution of Pfirrmann grades of the lumbar discs was investigated by age group and player position (Figure 5). In all age and position groups, degeneration was mild in the upper lumbar discs and progressive in the lower lumbar discs.

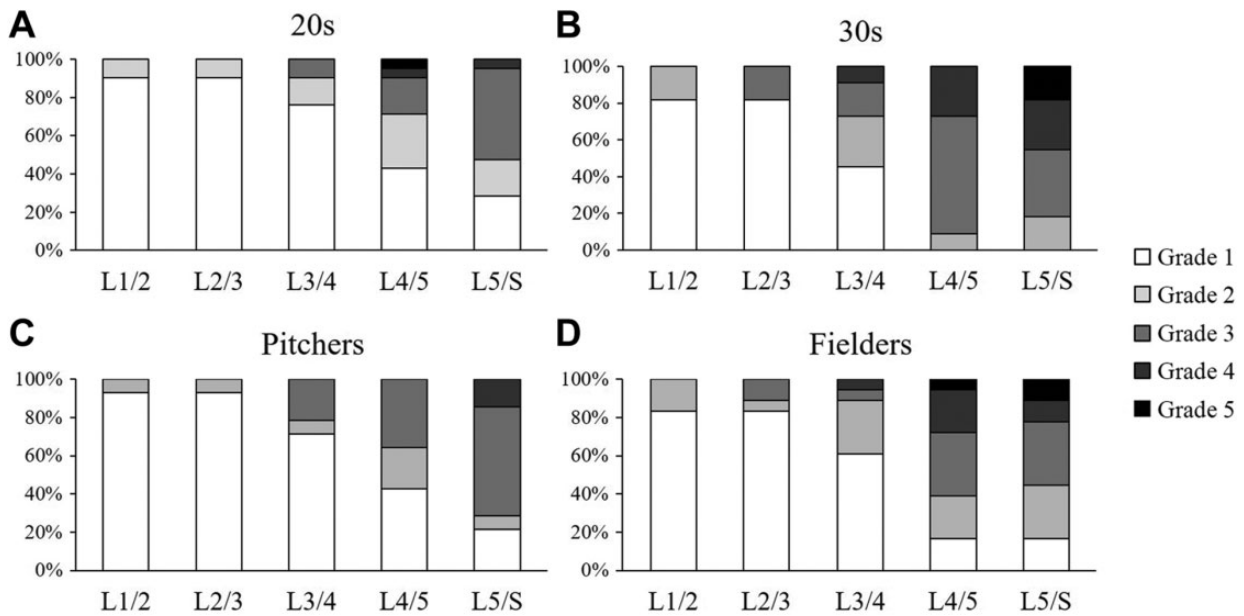
We investigated the incidence of professional baseball players with  $\geq 2$  degenerated intervertebral discs (Pfirrmann grade  $\geq 3$ ) (Figure 6). The incidence among players in their 30s ( $n = 10$  [91%]) was significantly higher than that among players in their 20s ( $n = 3$  [14%]). On the other hand, there was no significant difference between pitchers ( $n = 5$  [36%]) and fielders ( $n = 8$  [44%]). The incidence of Schmorl nodes and Modic type 1 changes was also significantly higher among players in their 30s than among players in their 20s (Table 2).

#### DISCUSSION

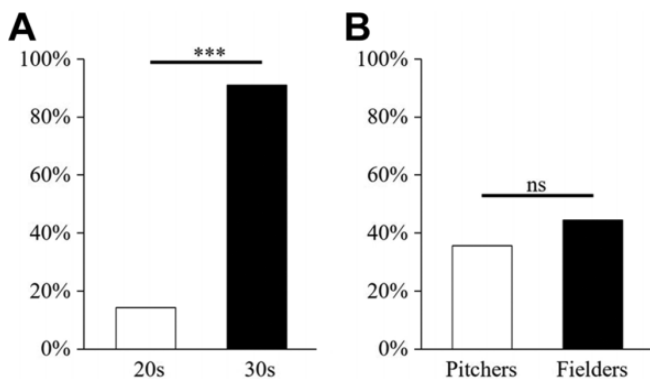
There were 4 main findings of this study as follows: First, the most frequent causes of LBP among players in their 20s were LDH (57%) and spondylolysis (24%). Of the players with spondylolysis, 50% had adult-onset spondylolysis. Second, the most frequent causes of LBP among players in their 30s were discogenic pain (55%), LDH (18%), and facet joint arthritis (18%). Third, the incidence of lumbar intervertebral disc degeneration was significantly higher in players in their 30s (91%) than in those in their 20s (14%) ( $P < .001$ ), as was the incidence of Schmorl nodes (36% vs 5%, respectively;  $P = .019$ ) and Modic type 1 changes (45% vs 5%, respectively;  $P = .005$ ). Fourth, there was no significant difference in the cause of LBP or the incidence of lumbar intervertebral disc degeneration between pitchers and fielders.

LBP is common in the general and athletic populations and is a leading cause of disability globally.<sup>38</sup> Because LBP can interfere with athletic performance and in some cases prevent athletes from playing their sport altogether,<sup>35</sup> understanding the factors related to the occurrence of LBP is important for effective prevention and treatment. There are reports that its incidence is higher among highly competitive athletes than among nonathletes or recreational athletes.<sup>13,15</sup> Even among retired athletes, as shown by Granhed and Morelli<sup>11</sup> in a study with retired wrestlers,





**Figure 5.** Distribution of Pfirrmann grades (% of participants) by age group of (A) 20s and (B) 30s and by position of (C) pitchers and (D) fielders.



**Figure 6.** Distribution of lumbar intervertebral disc degeneration (% of participants) by (A) age group and (B) player position. \*\*\* $P < .001$ . NS, not significant.

**TABLE 2**

Incidence of Schmorl Nodes and Modic Type 1 Changes<sup>a</sup>

	n (%)	P Value
Schmorl node		<b>.019</b>
20s	1 (5)	
30s	4 (36)	
Modic type 1 change		<b>.005</b>
20s	1 (5)	
30s	5 (45)	

<sup>a</sup>Boldface  $P$  values indicate a statistically significant difference between age groups ( $P < .05$ ).

the incidence of LBP was still significantly higher compared with age-matched controls (59% vs 31%, respectively). Hangai et al<sup>13</sup> examined the relationship between

LBP and types of competitive sports (volleyball, baseball, track and field, basketball, swimming, kendo, tennis, and soccer) in university students. They found that the incidence of LBP was significantly higher in all 8 sports groups than a group that had not participated in any competitive sports in childhood, and baseball players were found to have the second highest incidence of LBP after volleyball players.<sup>13</sup> Selhorst et al<sup>29</sup> investigated the incidence of spondylolysis in 1025 adolescent athletes with LBP in 11 sports. The highest incidences were in gymnastics among girls (34%) and in baseball among boys (54%). This suggests that baseball players experience loads on the spine comparable with those in gymnastics, which involves excessive spinal movement.

These findings suggest that continuing to play baseball is a likely cause of LBP and lumbar degeneration. In another study, Posner et al<sup>26</sup> analyzed data from the MLB disabled list from 2002 through 2008. During that period, the incidence of back injuries ranked sixth highest (7.6% of all injuries) of 17 body regions. Up to now, no study has investigated LBP among Japanese professional baseball players. In this study, we found that the most common cause of LBP among players in their 20s was LDH and that the second was spondylolysis. On the other hand, the most frequent cause among players in their 30s was discogenic pain, and the second was LDH or facet joint arthritis.

Given the abovementioned results, baseball players in their 30s were more susceptible to LBP caused by degenerative lumbar disease such as discogenic pain. On the other hand, a large proportion of baseball players in their 20s in this study had LBP caused by LDH and spondylolysis, which are not closely related to degeneration. These results are different from reported results in the general population. LDH more likely develops from ages 20 to 40 years,

peaking from the ages of 30 to 40 years.<sup>7,8,31</sup> In 1972, Spangfort<sup>31</sup> reported that the incidence of LDH among adults aged 30 to 39 years was 33.3% and among adults aged 20 to 29 years was 11.7% based on an analysis of 2504 operative procedures. In 1998, Donceel and Du Bois<sup>7</sup> analyzed 3956 patients with LDH and found that most were aged 30 to 40 years (36.1%), followed by 40 to 50 years (32.8%). The percentage of those younger than 30 years was 15.3%.<sup>7</sup> In a 2019 survey of 34,639 patients, the incidence of LDH was 27.0% among those aged 30 to 39 years and 9.6% among those aged 18 to 29 years.<sup>8</sup> Thus, according to both past and recent reports, the incidence of LDH is highest among those in their 30s. However, among the baseball players in the present study, the incidence of LDH was highest among those in their 20s.

One of the possible reasons for the difference in the age of susceptibility to LDH between the general population and professional baseball players is that professional baseball players are more likely to develop lumbar degeneration. In the present study, the incidence of  $\geq 2$  degenerated intervertebral discs among players in their 30s (91%) was significantly higher than that among players in their 20s (14%). Moreover, age-related degeneration was seen not only in the intervertebral discs but also in the lumbar vertebrae. The incidence of Schmorl nodes and Modic type 1 changes was also significantly higher among players in their 30s than among players in their 20s.

In comparisons of disc degeneration between athletes and nonathletes in the literature, degeneration clearly occurs more frequently in athletes. Kaneoka et al<sup>15</sup> retrospectively analyzed 56 elite swimmers and a control group of 38 university recreational-level swimmers. They found that the incidence of lumbar intervertebral disc degeneration was 29% in the control group and 68% in elite swimmers.<sup>15</sup> In another study, Goldstein et al<sup>9</sup> reported the incidence of lumbar intervertebral disc degeneration among female gymnasts, irrespective of back pain or injuries, finding that spine abnormalities were present in 9% of pre-elite gymnasts, 43% of elite gymnasts, and 63% of Olympic-level gymnasts. The incidence of lumbar disc degeneration has been reported as 89.6% among national team volleyball players, 80% among beach volleyball players, and 75% among elite gymnasts.<sup>14,16,33</sup> Although it is well known that lumbar disc degeneration progresses with age,<sup>5,36</sup> it degenerates even further with continued short-term participation in sports. In a follow-up study by Burnett et al,<sup>3</sup> the occurrence of disc degeneration increased within 4 years among young cricket players.

Hangai et al<sup>12</sup> investigated which athletes showed the most advanced disc degeneration. They analyzed 308 well-trained university athletes (volleyball players, baseball players, runners, basketball players, swimmers, kendo competitors, tennis players, and soccer players) and 71 university nonathletes to find the association between types of competitive sports and disc degeneration.<sup>12</sup> They found that the incidence of degenerative intervertebral discs was highest among baseball players at 59.3% and next highest among swimmers at 57.5%. Because degeneration of the lumbar spine is more advanced in these athletes than among athletes in other sports among university students,

it can be expected that advancing to competition at the professional level will significantly promote degeneration of the lumbar spine.

We found no significant difference in the cause of LBP and the incidence of lumbar degeneration between pitchers and fielders in the present study ( $P = .59$ ). Posner et al<sup>26</sup> examined differences in the patterns of injury between pitchers and nonpitchers in MLB. They found that upper extremity injuries were more common among pitchers and that lower extremity injuries were more common among fielders, but the rate of back injuries compared with all injuries did not differ between pitchers (7.8%) and fielders (7.4%).<sup>26</sup> Yabe et al<sup>43</sup> also reported that the incidence of LBP was similar between pitchers (8.5%) and fielders (8.3%) among young baseball players (aged 6-15 years). These reports are consistent with our results.

During baseball motions such as throwing, hitting, and running, the spine dynamically flexes, extends, rotates, and laterally bends, keeping the head, shoulders, and upper extremities in the proper positions.<sup>4</sup> During batting, initial movement is started according to the pitcher's motion.<sup>17,23</sup> Then, while shifting the center of gravity forward, the batter performs the backswing. Finally, the player executes the forward swing and tries to hit the ball with the bat. On the other hand, the pitching motion is divided into the wind-up, early cocking, late cocking, acceleration, deceleration, and follow-through phases from the preparation of pitching to ball release.<sup>30</sup> After the trunk twists toward the pitching side once, the trunk twists back to the nonpitching side to release the ball. Therefore, during these series of hitting and pitching movements, the lumbar spine twists both anteriorly and posteriorly, and it is considered that a similar load is placed on the lumbar spine in both hitting and pitching movements.

Surprisingly, we diagnosed adult-onset spondylolysis in 3 cases in the present study. Generally, spondylolysis is regarded as a disease of childhood or adolescence,<sup>22</sup> which is supported by the finding of Sakai et al<sup>28</sup> that there was no new spondylolysis observed among 2000 CT scans of adults in the general population. However, Sutton et al<sup>32</sup> published a recent case series describing 8 intercollegiate athletes with acute spondylolysis. Furthermore, Tezuka et al<sup>37</sup> reported 11 cases of spondylolysis among high-level athletes. Although nonoperative treatment is usually sufficient to treat spondylolysis and aims to facilitate healing processes in childhood or adolescence, bone union is difficult to achieve in adult patients. Sutton et al<sup>32</sup> reported that nonoperative treatment failed in 5 of the 8 patients, with 1 patient lost to follow-up. In the study by Tezuka et al,<sup>37</sup> bone union was achieved in only 2 of the 11 patients. In the present study, nonoperative treatment was provided in all 3 cases of adult-onset spondylolysis, and bone union was not achieved in any of these patients. However, LBP was reduced, and all 3 patients returned to professional baseball.

## Limitations

The present study has several limitations. First, this study targeted professional baseball players with LBP. Therefore,

we do not know how degeneration of the lumbar spine progressed in patients without LBP. Second, we did not compare the results between the professional baseball players in this study and the general patient population at our institution. There may have been selection bias because we only investigated patients with LBP referred to our facility. Third, lumbar degeneration is affected by various factors, such as genetics, underlying disease, smoking, body weight, and amount of exercise. However, we did not investigate these factors, and we investigated only pitcher and fielder positions. Fourth, sports career before becoming a professional baseball player was not investigated. Fifth, we are not the team doctor for any baseball team. All patients in this study were referred to us by an orthopaedic doctor for the diagnosis or treatment of LBP. Therefore, the study population may have bias because easily diagnosed causes of LBP might have been excluded. Finally, this study involved 32 baseball players, which is a small sample. Thus, this study was a preliminary study, and further investigations with a larger group of participants are needed in the future. However, our data showing that lumbar degeneration is more likely to progress with years of competition may apply to athletes in other sports who continue to compete at the professional level. In the case of professional baseball players in particular, we expect that this same tendency will be seen even in different countries or leagues.

## CONCLUSION

Among professional baseball players in their 20s, lumbar degeneration occurred less frequently than among players in their 30s, and those in their 20s often developed diseases that were less related to degeneration, such as LDH. On the other hand, among players in their 30s, lumbar degeneration was more advanced, and degenerative diseases such as discogenic pain occurred more frequently. We believe that further research on training methods can lead to preventive measures against LBP. These data may also be applicable to other professional athletes and will contribute to diagnosis and treatment.

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