Lumbar intervertebral disc degeneration in collegiate rowers

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Abstract The aim of this study was to clarify the prevalence and distribution of disc degeneration in collegiate rowers and investigate the relationship between disc degeneration progression and low back pain (LBP). In this cross-sectional study, 68 collegiate rowers were evaluated for lumbar disc degeneration using the Pfirrmann classification based on T2-weighted magnetic resonance imaging (MRI). After 2 years, 20 participants underwent follow-up MRI. Injury surveillance to check LBP was conducted between the first examination and follow-up study. The relationship between symptoms and disc degeneration was investigated. Thirty-one (45.6%) rowers had disc degeneration: 48.8% of male rowers and 40.0% of female rowers. After 2 years, disc degeneration progression was observed in 5 (25%) rowers. During the 2 years, 6 rowers reported LBP. In the LBP group, disc degeneration progression was observed in 4 (66.7%) rowers. Significantly more participants in the LBP group than in the non-LBP group (7.1%) ($p = 0.014$) showed disc degeneration progression. The prevalence of disc degeneration among collegiate rowers was 45.6%, high at the level of the lower lumbar spine. Progression of lumbar disc degeneration was observed in significantly more LBP than non-LBP rowers during the longitudinal study.

Keywords : rowing, spine abnormalities, low back pain, two-year longitudinal study

Introduction

Low back pain (LBP) is the most common symptom in rowers. Smolijanovic et al.¹⁾ reported that low back injury was predominant in both traumatic and overuse injuries in international elite junior rowers; and another study showed that 32% of former intercollegiate rowers developed back pain during intercollegiate rowing²⁾. There are various factors contributing to rower's LBP, such as less motion of the pelvis by shortening of the hamstrings³⁾ and hyper mobility of the lumbar spine⁴⁾. Previous studies have reported associations between disc degeneration and LBP. Hangai et al.⁵⁾ reported that severe LBP may be a predictor of disc degeneration. Additionally, Luoma et al.⁶⁾ found that LBP is associated with signs of disc degeneration in late middle-aged men. However, these previous studies were cross sectional; thus, it is difficult to show a cause and effect relationship between disc degeneration and LBP.

In addition to LBP, suggested risk factors for lumbar intervertebral disc degeneration are heredity, aging, high body mass index (high BMI), high low-density lipoprotein cholesterol, occupational lifting, and sports activities^{7,8)}. In previous studies, the relationship between competitive sports activities and disc degeneration has been reported. Disc degeneration was significantly more common in collegiate baseball players and swimmers than in the control group⁹⁾. Moreover, Sward et al.⁹⁾ reported that the prevalence of disc degeneration in elite gymnasts was significantly higher than that in non-athletes. Excessive rowing activity may be one of the factors causing disc degeneration, because the relationship between competitive sports activities and disc degeneration has been reported. The prevalence of disc degeneration in asymptomatic adolescent rowers has been reported to be approximately 18%¹⁰⁾. However, that study included only asymptomatic rowers, and it is difficult to determine the exact prevalence of disc degeneration among rowers in general. Therefore, the purpose of the present cross-sectional study was to clarify the prevalence and distribution of disc degeneration in

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collegiate rowers. The second purpose of the longitudinal study was to investigate the relationship between disc degeneration progression and LBP.

Materials and Methods

Participants. Sixty-eight Japanese collegiate rowers (43 men and 25 women) participated in the cross-sectional study. Fig. 1 shows the cross-sectional study profile. Their ages ranged from 18 to 22 years, and the average age was 19.5 years. Fifteen, 49 and 4 participants were at the international, national, and regional competition level, respectively. All participants belonged to the same team and followed training about 11 sessions a week for about 2 hours, which included weight training approximately 2 times a week, regardless of season or weather. Male rowers mainly participated in sweep oar rowing, while female rowers mainly participated in scull oar rowing. Participants whose rowing career duration was less than 3 years at the time of the first magnetic resonance imaging (MRI) examination were excluded from the cross-sectional study. MRI scan of second time or later were also excluded from the cross-sectional study.

Twenty Japanese collegiate rowers (14 men and 6 women) participated in the longitudinal study. Fig. 2 shows the longitudinal study profile. Follow-up MRI evaluation was performed 2 years after the first examination. Nine rowers

were followed up from 2008 to 2010, and 11 rowers were followed up from 2010 to 2012. Although one participant was excluded from the cross-sectional study, this participant underwent first and follow-up MRI evaluations. This participant was included in the longitudinal study because rowing career duration can have a small effect on the result of the longitudinal study. Among the participants who developed LBP during the longitudinal study, none had LBP at the first examination. This study was approved by the Ethical Committee of Waseda University (Notification Number 2010-078). Participants were informed of the study goal and procedures before participation, and written informed consent was obtained.

Assessment of disc degeneration. The lumbar spine was evaluated by MRI in all participants from 2008 to 2012 (except 2009). T2-weighted sagittal MR images (repetition time: 2800 ms/echo times: 90 ms) of the lumbar spine were obtained using a 1.5T MR system (Signa HDxt XV, GE Healthcare, Tokyo, Japan) with a body coil in 2008 and with a 4-channel spine coil in 2010, 2011, and 2012. The slice thickness was 4.0 mm, and field of view was 300 × 300 mm. MR image scanning was performed with the participants in the supine position. On the midsagittal image (Fig. 3), intervertebral discs from L1-L2 to L5-S1 were classified into 5 grades according to the Pfirrmann classification¹¹⁾, with grades 3, 4, and 5 considered de-

Fig. 1 Flow diagram of the participant recruitment in the cross-sectional study.

generated discs (Fig. 4). In addition, the participants who had degenerated discs at 1 or more disc levels were categorized as having disc degeneration. In the longitudinal study, fresh disc degeneration that was found first in the follow-up MRI was defined as disc degeneration pro-

gression. Two orthopedic surgeons assessed the images independently. Finally, a consensus decision was reached in conference. At all times, the same two orthopedic surgeons assessed the images.

First MRI evaluation

2008~2010: 33 participants
2010~2012: 21 participants

Participants who were not able to participate in follow-up MRI

2008~2010: 24 were not able to participate in follow-up MRI
21 graduated from college
1 shifted to manager
1 left the team
1 could not find a suitable time

2010~2012: 10 were not able to participate in follow-up MRI
7 graduated from college
3 shifted to cox or manager

Follow-up MRI evaluation

2008~2010: 9 participants
2010~2012: 11 participants

20 were the participants of longitudinal study

Fig. 2 Flow diagram of the participant recruitment in the longitudinal study.

Fig. 3 A midsagittal T2-weighted image of the lumbar spine.

Fig. 4 Pfirrmann classification.

Injury surveillance. Injury surveillance was conducted on 20 rowers who could participate in the MRI follow-up study. Presence or absence of LBP development from the first examination to the follow-up examination was investigated in the retrospective study. Skilled athletic trainers evaluated the injuries. History, observation, palpation, and special and stress tests were conducted to evaluate injuries. If the actual condition of the injury was not clear, the diagnosis was confirmed by an orthopedic surgeon. Injury was defined as that which caused participants to miss normal practice for more than 1 day. Participants who developed LBP one or more times during the period of this study were categorized as participants with LBP.

Statistical analysis. Age, height, weight, BMI, and career duration were compared between men and women using the unpaired t-test. The prevalence of disc degeneration was compared between men and women by the χ^2 test. The prevalence of disc degeneration progression and symptoms was compared by Fisher's exact probability

test. The statistical significance was set at $p < 0.05$.

Results

Prevalence and distribution of disc degeneration. Subject demographics and clinical characteristics are presented in Table 1. Height, weight, and BMI were significantly higher in men than in women (Height, weight: $p < 0.001$, BMI: $p = 0.002$); however, there were no significant differences in age and rowing duration. MRI revealed that among all the participants, 31 (45.6%) had lumbar intervertebral disc degeneration (Table 2). The prevalence of disc degeneration was 48.8% in male rowers and 40.0% in female rowers, showing no significant difference between genders ($p = 0.481$, Table 2). The prevalence of disc degeneration was high at the levels of L4/5 and L5/S1. Among all degenerative discs, 17 (32.7%) were at the level of L4/5 and 22 (42.3%) were at the level of L5/S1 (Table 3).

Table 1. Subject Characteristics

	Men, mean (SD)	Women, mean (SD)	P Value
Age (years)	19.4 (1.1)	19.7 (1.1)	0.267
Height (cm)	176.4 (5.9)	164.2 (4.3)	<0.001
Weight (kg)	74.3 (8.1)	60.0 (5.4)	<0.001
Body mass index (kg/m ²)	23.9 (2.0)	22.2 (1.8)	0.002
Duration of rowing career (years)	4.8 (1.4)	5.1 (2.0)	0.473

Table 2. Prevalence of Disc Degeneration

	Disc Degeneration	
	Yes	No
All (N=68)	31 (45.6%)	37 (54.4%)
Men (N=43)	21 (48.8%)	22 (51.2%)
Women (N=25)	10 (40.0%)	15 (60.0%)

Table 3. The Distribution of Disc Degeneration

	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Disc Degeneration ^a
L1/2	1 (1.5%)	63 (92.6%)	3 (4.4%)	1 (1.5%)	-	4 (7.7%)
L2/3	1 (1.5%)	63 (92.6%)	4 (5.9%)	-	-	4 (7.7%)
L3/4	1 (1.5%)	62 (91.2%)	3 (4.4%)	2 (2.9%)	-	5 (9.6%)
L4/5	4 (5.9%)	47 (69.1%)	9 (13.2%)	6 (8.8%)	2 (2.9%)	17 (32.7%)
L5/S1	4 (5.9%)	42 (61.8%)	8 (11.8%)	9 (13.2%)	5 (7.4%)	22 (42.3%)

^a There were a total of 52 degenerative discs in 31 subjects.

Progression disc degeneration and LBP (Table 4) (Fig. 5).

During the 2-year follow-up, 5 rowers (7 discs) showed progression of disc degeneration, and 6 rowers experienced LBP. In this LBP group, 4 rowers (66.7%) had progression of disc degeneration. The progression of disc degeneration was observed in significantly more rowers with LBP compared to those without LBP (7.1%) ($p = 0.014$).

Discussion

The aims of this study were to clarify the prevalence and distribution of disc degeneration in collegiate rowers, and investigate the relationship between disc degeneration progression and LBP.

This study found that the prevalence of disc degeneration among collegiate rowers was 45.6%. The results of this study showed a higher prevalence than did those of a previous study¹⁰. The reasons for this difference could be as follows: participant training intensity in the previous

study was much less (training at least 5 times a week for approximately 2 hours per session, and included 2 weight training sessions a week) than that of the present study's participants; and the previous study participants were asymptomatic.

The prevalence of disc degeneration among collegiate rowers was higher than that among coeval non-athletes^{5,12}. In collegiate non-athletes (male and female), 31.4% of them had lumbar disc degeneration at 1 or more disc levels⁵. The prevalence of lumbar disc degeneration among women in their twenties was approximately 30%¹². A repeated load on the lumbar spine may affect disc degeneration in rowers, because the peak compressive force at the lumbar spine during the drive phase is 4.6 times the body weight¹³. A previous study reported the relationship between disc degeneration in cricket players and counter-rotation¹⁴. Maximum exertion trunk rotation using a nonlinear thoracolumbar finite element model generated axial compression and shear force on the intervertebral disc¹⁵. In sweep rowing, unilateral trunk rotation to the oar side occurs in the entry phase. Thus, axial compression and shear force exerted on the lumbar spine, because of trunk rotation, may be one of the risk factors for rower's disc degeneration. Additionally, it has been reported that excessive lumbar flexion during rowing may influence the potential for injury to spinal structures¹⁶. Therefore, repetitive trunk rotation and flexion during rowing may lead to disc degeneration. Furthermore, extensive rowing in the early morning might also affect disc degeneration, because bending stress on the disc in the early morning is about 3 times higher than in the afternoon¹⁷. In addition, in the surveyed team, trunk stabilization exercise was conducted to prevent LBP. Thus, in other teams without an LBP prevention program, the prevalence of disc degeneration may be higher than that of the present study.

During the longitudinal study period, the rate of progression of disc degeneration was significantly higher in the LBP group than in the non-LBP group. A previous study reported that LBP during the preceding 12 months is associated with signs of disc degeneration⁶. In addition, it has been reported that severe LBP may be a predictor of disc degeneration⁵. However, the relationship between disc degeneration progression and LBP has not been reported. In the present study, longitudinal research was conducted and LBP during the study period was found to be associated with disc degeneration progression.

There are some limitations in the present study. First, the sports history of each participant was not considered. In this study, participants whose rowing career duration was less than 3 years at the time of the first MRI examination were excluded from the cross-sectional study. However, if the participants had a history of participating in other sports before they started rowing, their sports history may have affected their disc degeneration. Second, the number of participants in the longitudinal

Table 4. Disc Degeneration and Low Back Pain

	Progressed Disc Degeneration	
	Yes	No
Low Back Pain	4 (66.7%)	2 (33.3%)
Non-Low Back Pain	1 (7.1%)	13 (92.9%)

$p=0.014$ (Fisher's exact probability test)

Rowers with progressed disc degeneration in the low back pain group vs. non-low back pain group

Fig. 5 Midsagittal T2-weighted images before and at 2-year follow-up examination.

a T2-weighted MRI examination in a 19-year-old male rower.

b T2-weighted MRI at 2-year follow-up examination shows moderate disc degeneration and progression at the L4-L5 disc.

study was small, and the pathophysiology of LBP was not diagnosed. Further studies intended for a large number of rowers should be conducted in the future. Third, the relationship between LBP and disc degeneration was not analyzed in the cross-sectional study. In the cross-sectional study, the 31 participants with disc degeneration may have experienced LBP throughout their life; their lifetime experience of LBP may have affected disc degeneration. To confirm the relationship between disc degeneration and LBP, further investigation is needed. Fourth, pain scales such as the Visual Analog Scale (VAS) were not used. Four participants presented both disc degeneration progression and LBP during the longitudinal study. These 4 participants may have experienced severe pain during the longitudinal study. To confirm the relationship between disc degeneration progression and the degree of LBP, a pain scale should be used in the future.

In conclusion, the prevalence of disc degeneration among collegiate rowers was 45.6%, and was high at the level of the lower lumbar spine. Progression of lumbar disc degeneration was observed in significantly more rowers with LBP than without during the longitudinal study.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this article.

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References

- 1) Smoljanovic T, Bojanic I, Hannafin JA, Hren D, Delimar D and Pecina M. 2009. Traumatic and overuse injuries among international elite junior rowers. *Am J Sports Med* 37: 1193-1199.
- 2) Teitz CC, O'Kane J, Lind BK and Hannafin JA. 2002. Back pain in intercollegiate rowers. *Am J Sports Med* 30: 674-679.
- 3) Duncan AR and Peter JM. 2000. Factors contributing to low back pain in rowers. *Br J Sports Med* 34: 321-322.
- 4) Howell DW. 1984. Musculoskeletal profile and incidence of musculoskeletal injuries in lightweight women rowers. *Am J Sports Med* 12: 278-281.
- 5) Hangai M, Kaneoka K, Hinotsu S, Shimizu K, Okubo Y, Miyakawa S, Mukai N, Sakane M and Ochiai N. 2009. Lumbar intervertebral disc degeneration in athletes. *Am J Sports Med* 37: 149-155.
- 6) Luoma K, Riihimäki H, Luukkonen R, Raininko R, Viikari-Juntura E and Lamminen A. 2000. Low back pain in relation to lumbar disc degeneration. *Spine J* 25: 487-492.
- 7) Hangai M, Kaneoka K, Kuno S, Hinotsu S, Sakane M, Mamizuka N, Sakai S and Ochiai N. 2008. Factors associated with lumbar intervertebral disc degeneration in the elderly. *Spine J* 8: 732-740.
- 8) Battié MC, Videman T and Parent E. 2004. Lumbar disc degeneration: epidemiology and genetic influences. *Spine* 29: 2679-2690.
- 9) Sward L, Hellstrom M, Jacobsson B, Nyman R and Peterson L. 1991. Disc degeneration and associated abnormalities of the spine in elite gymnasts: a magnetic resonance imaging study. *Spine* 16: 437-443.
- 10) Maurer M, Soder RB and Baldisserotto M. 2011. Spine abnormalities depicted by magnetic resonance imaging in adolescent rowers. *Am J Sports Med* 39: 392-397.
- 11) Pfirrmann CW, Metzendorf A, Zanetti M, Hodler J and Boos N. 2001. Magnetic resonance classification of lumbar intervertebral disc degeneration. *Spine J* 26: 1873-1878.
- 12) Powell MC, Wilson M, Szypryt P, Symonds EM and Worthington BS. 1986. Prevalence of lumbar disc degeneration observed by magnetic resonance in symptomless women. *Lancet* 2: 1366-1367.
- 13) Morris FL, Smith RM, Payne WR, Galloway MA and Wark JD. 2000. Compressive and shear force generated in the lumbar spine of female rowers. *Int J Sports Med* 21: 518-523.
- 14) Hardcastle P, Annear P, Foster DH, Chakera TM, McCormick C, Khangure M and Burnett A. 1992. Spinal abnormalities in young fast bowlers. *J Bone Joint Surg Br* 74: 421-425.
- 15) Arjmand N, Shirazi-Adl A and Parnianpour M. 2008. Trunk biomechanics during maximum isometric axial torque exertions in upright standing. *Clin Biomech* 23: 969-978.
- 16) Caldwell JS, McNair PJ and Williams M. 2003. The effects of repetitive motion on lumbar flexion and erector spinae muscle activity in rowers. *Clin Biomech* 18: 704-711.
- 17) Adams MA, Dolan P and Hutton WC. 1987. Diurnal variations in the stresses on the lumbar spine. *Spine* 12: 130-137.