Characteristics of Lumbar Spondylolysis in Adolescent Baseball Players: Relationship between the Laterality of Lumbar Spondylolysis and the Throwing or Batting Side

Shotaro Teruyaa, Toru Funayama¹, Masaki Tatsumura¹, Hisanori Gamada¹, Shun Okuwaki¹, Takeo Mammothre, Atsushi Hirano³, Masashi Yamazaki¹

¹Department of Orthopaedic Surgery, Institute of Medicine, University of Tsukuba, Tsukuba, Japan
²Department of Orthopaedic Surgery, Kasumigaura Medical Center, Tsuchiura, Japan
³Department of Orthopaedic Surgery and Sports Medicine, Tsukuba University Hospital Mito Clinical Education and Training Center, Mito Kyodo General Hospital, Mito, Japan

Study Design: A retrospective, cross-sectional study was conducted to analyze the implications of asymmetric baseball movements on the incidence of spondylolysis.

Purpose: This study aimed to evaluate the relationship between asymmetric movements and the laterality of spondylolysis.

Overview of Literature: Baseball, characterized by its asymmetric throwing and batting, may disproportionately stress one side. Lumbar spondylolysis is a frequent cause of lower back pain in young athletes, particularly those involved in activities with consistent unilateral rotations such as baseball. However, whether a link exists between the laterality in spondylolysis and the dominant throwing/batting side or whether disparities exist between pitchers and fielders remains unclear.

Methods: The study included 85 players. Participants were divided into two groups: pitchers and fielders. The association between the laterality of spondylolysis and the throwing/batting side in the overall cohort and between the two groups was evaluated.

Results: Among pitchers, 16 lesions appeared on the throwing side and 32 on the nonthrowing side (p=0.029). For fielders, no notable difference was observed between the two sides (p=0.363). Furthermore, batting preference did not influence the laterality of spondylolysis in either group.

Conclusions: Adolescent baseball players, particularly pitchers, exhibited a higher incidence of lumbar spondylolysis on the side opposite their throwing arm. The findings of this study highlight the significant effect of asymmetrical sporting activities on the development of spondylolysis, to which pitchers are particularly susceptible.

Keywords: Spondylolysis; Baseball; Throwing; Batting; Laterality

Introduction

Lumbar spondylolysis is the most commonly recognized cause of low back pain in adolescent athletes [1]. Several sports are associated with spondylolysis [2]. Soler and Calderón [3] reported a high incidence (27%) of spondylolysis...
dylolysis in throwing sports. Lumbar spondylolysis is commonly reported in adolescent baseball players [4]; approximately 16% of amateur baseball players have a history of lumbar spondylolysis [5]. Lumbar spondylolysis is related to the concentration of stress in the pars interarticularis caused by extension and rotation of the lumbar spine [6,7]. Finite element analysis showed that stress was applied to the pars interarticularis on the side opposite to the direction of rotation [8]. Therefore, unilateral lumbar spondylolysis is common in sports with repetitive unilateral rotation, such as baseball [9]. Of the cases of lumbar spondylolysis diagnosed at our hospital, baseball was the most common causative sport [10]. Baseball involves asymmetric movements in throwing and batting, which are expected to place a greater load on one side. However, whether a correlation exists between the laterality of spondylolysis and the throwing or batting side or whether the characteristics of spondylolysis are different between pitchers and fielders is unclear.

This study aimed to evaluate the relationship between asymmetric movements, such as throwing and batting, and the laterality of spondylolysis and compare spondylolysis by the position played in baseball.

**Materials and Methods**

This retrospective, cross-sectional study was conducted and approved by the Institutional Review Board of Tsukuba University Hospital Mito Clinical Education and Training Center/Mito Kyodo General Hospital under approval number 23-02. Written informed consent was obtained from all patients.

Adolescent male baseball players diagnosed with lumbar spondylolysis who were evaluated by computed tomography (CT) or magnetic resonance imaging at Tsukuba University Hospital Mito Clinical Education and Training Center/Mito Kyodo General Hospital between April 2014 and March 2021 were screened. All players were amateurs and visited the hospital with low back pain as the chief complaint. Initially, 141 cases were included in the study; however, patients with inadequate imaging or unknown throwing/batting side were excluded, leaving 85 players with 146 lesions in the final study (Fig. 1). Of the 85 players, three were found to have grade one spondylolisthesis. Of these, 30 were pitchers and 55 were fielders. The mean age at the initial diagnosis was 14.8 years (range, 11–17 years). Lesions ranged from L2 to L5, with 10 players having lesions at multiple levels. Moreover, 65 lumbar spondylolysis lesions were found on the right side and 81 on the left side (Table 1), ranging from the pre-lysis stage to the terminal stage [11]. Moreover, 30 lesions were in the pre-lysis stage, 51 in the early stage, 21 in the progressive stage, and 44 in the terminal stage, with 43 lesions at L5 in the terminal stage (Table 2).

At the first visit, data on age, throwing/batting side, and playing position were collected. For lumbar spondylolysis, the level of the lesion, unilateral or bilateral nature, side of unilateral lesions, and lesion stage on CT were assessed.
Participants were divided into two groups: pitchers and fielders. The association between the laterality of spondylolysis and the throwing/batting side in the whole cohort and between the two groups was evaluated. A binomial test was used to compare the two groups, and $p<0.05$ was considered statistically significant.

**Results**

1. **Relationship between the laterality of spondylolysis and the throwing side**

On the throwing side, 74 players were right-handed and 11 were left-handed. Among pitchers, 23 were right-handed and seven were left-handed; among fielders, 51 were right-handed and four were left-handed (Table 3). In total, 60 and 86 lesions were found on the throwing and non-throwing sides, respectively ($p=0.038$) (Table 4). Among pitchers, 16 and 32 lesions were found on the throwing and non-throwing sides, respectively ($p=0.029$). No difference was found between the throwing and non-throwing sides among fielders ($p=0.363$).

2. **Relationship between the laterality of spondylolysis and the batting side**

On the batting side, 62 players were right-handed and 23 were left-handed. Among pitchers, 18 batted right-handed and 12 batted left-handed. Among the fielders, 44 were right-handed batters and 11 were left-handed batters (Table 3). In total, 65 and 81 cases of spondylolysis were found on the batting and contralateral sides ($p=0.214$), 18 and 30 for pitchers ($p=0.114$), and 47 and 51 for fielders ($p=0.762$), respectively (Table 5).

**Discussion**

Throwing and batting movements, which are common asymmetric movements in baseball, were analyzed as independent events and showed lateralization in pitchers between the throwing side and the spondylolytic side. No difference was noted in laterality based on the throwing arm for fielders nor for pitchers or fielders based on the batting side.

Lumbar spondylolysis is caused by stress concentrated in the pars interarticulare due to the extension and rotation of the lumbar spine [8]. With rotation, stress is concentrated in the left pars interarticulare during right rotation and right pars interarticulare during left rotation [8]. In a detailed analysis of the throwing motion, the lumbar spine precedes the upper trunk in a rotational movement from the cocking phase to the acceleration phase [12]. A study also reported that pitchers hyperextend their lumbar spine during throwing [13]. In other words, in right-handed pitchers, a right lumbar rotation occurs simultaneously with extension during throwing, which is thought to concentrate stress on the pars interarticulare on the left side. We suspect that this is the mechanism why lumbar spondylolysis is more common on the opposite side of the throwing side.

The association between the throwing side and the laterality of spondylolysis was stronger in pitchers than in fielders. According to reports measuring the angle of rotation during throwing, the angle of rotation of the lumbar spine is greater in pitchers [14]. Thus, lumbar spondylolysis is more common in pitchers than in fielders because of the greater mechanical stress caused by the greater angle of rotation. This may be due to the throwing motion in pitchers, large number of pitches [15], and tendency to rotate and hyperextend.
The lack of association with batting could be that although the load is the highest at the follow-through phase, it is not very high [12]. For a right-handed batter, the stress is concentrated on the right side of the pars interarticularis in the left rotation. Therefore, we expected to find more cases of lumbar spondylolysis on the same side as batting; however, no significant difference was noted. Not only is the stress concentration in batting not as high as that in throwing; however, in right-handed players, stress may have been distributed with a left-sided lesion in throwing and a right-sided lesion in batting.

In this study, lumbar spondylolysis lesions tended to occur more commonly on the side opposite the throwing side and were more common in pitchers. Clinically, lumbar spondylolysis was reported to more likely occur on the side opposite the dominant arm [9], which was confirmed in this study. However, some spondylolysis cases were observed on the same side as the throwing arm. Although baseball is a sport involving various unilateral movements, such as throwing and batting, symmetrical movements include running and fielding, as in other sports. Furthermore, the extension motion during the acceleration phase of pitching may also influence the occurrence of spondylolysis on the same side. This may have led to variations in the location of spondylolysis.

In this study, conservative treatment was fundamental in treating the players. After examination and confirmation of images, the diagnosis of spondylolysis was made, and the disease stage was determined. For the pre-lysis to progressive stages, conservative treatments such as rest, brace wearing, and rehabilitation were performed. For the terminal stage, treatments mainly consisted of rehabilitation aimed at pain control, stretching, and improving core muscle strength. Some cases included surgery for pain relief or early return to competition. When performing surgery, we focused on preserving the mobility of the segment by securing only one vertebra using the smiley face rod method [16]. This series included seven surgical cases, and bone union was achieved in six cases.

This study has some limitations. First, multiple lesions, such as bilateral cases, were counted as distinct lesions. Bilateral cases may occur simultaneously on both sides of the pars, or they may be bilateral because a lesion occurs after a unilateral lesion. Given the lack of evidence of change over time in bilateral cases, they were counted and analyzed equally in this study. Second, this study included only baseball players who visited a hospital; therefore, there is a selection bias, and the results do not apply to all baseball players. In addition, for pitchers, an examination of each pitching form has not been conducted.

**Conclusions**

Lumbar spondylolysis in adolescent baseball players is more likely to occur on the side opposite the throwing side in pitchers. No significant differences for fielders or any significant differences based on the batting side were found.

**Conflict of Interest**

No potential conflict of interest relevant to this article was reported.

**ORCID**

Shotaro Teruya: https://orcid.org/0009-0006-4851-0837; Toru Funayama: https://orcid.org/0000-0002-7325-4357; Masaki Tatsumura: https://orcid.org/0000-0002-3679-9438; Hisanori Gamada: https://orcid.org/0000-0002-7860-7094; Shun Okuwaki: https://orcid.org/0000-0002-9614-5399; Takeo Mammoto: https://orcid.org/0000-0002-9055-0756; Atsushi Hirano: https://orcid.org/0009-0004-3035-8051; Masashi Yamazaki: https://orcid.org/0000-0002-9293-3531

**Author Contributions**

Conception and design: ST; data acquisition: ST, MT, HG, SO, TM, AH; analysis of data: ST; drafting of the manuscript: ST; critical revision: MT, TF, MY; obtaining funding: none; administrative support: MT; supervision: TF; and final approval of the manuscript: all authors.

**References**