

## Effect of lumbar lordosis angle in adolescent baseball players on the development of lumbar spondylolysis

### 1. Background

Lumbar spondylolysis is a stress fracture of the lumbar vertebral arch<sup>1)</sup>. The pathogenesis of lumbar spondylolysis has been investigated by finite element analysis, and it is reported that stress concentrates on the lumbar vertebral arch during lumbar extension and rotation,<sup>2)</sup> resulting in fracture of the lumbar vertebral arch from the ventral caudal side.<sup>3)</sup> The stages of the disease can be classified as very early, early, progressive, and terminal<sup>4)</sup>. In the very early, early, and progressive stages, bracing and exercise therapy are used to achieve bone union. The bone union rate is reported to be 100% in the very early stage, 93.8% in the early stage, and 80% in the progressive stage.<sup>5)</sup> However, it is reported that bone union cannot be expected in the terminal stage.<sup>5)</sup> In addition, it takes 2.5 months for bone union in the very early stage, 2.6 months in the early stage, and 3.6 months in the progressive stage<sup>5)</sup>, and restriction of sports activities until the bone union is achieved is unavoidable. Therefore, prevention of the development of lumbar spondylolysis is necessary, and it is necessary to elucidate the risk factors that influence the development of the disease.

Risk factors for lumbar spondylolysis include genetic factors such as gender<sup>6)</sup> (male: female = 2:1), race<sup>7)</sup>, family history<sup>8)</sup>, and possession of spina bifida occulta<sup>8)</sup>, as well as age<sup>9)</sup> (adolescence: 13-17 years old) and specific athletic events<sup>10)</sup>. Since genetic factors are difficult to modify about the prevention of the development of lumbar spondylolysis, it is considered necessary to elucidate the physical characteristics of athletes with lumbar spondylolysis in adolescents. The prevalence of lumbar spondylolysis has been reported to be 7% to 21% in athletes, compared to 3% to 7% in children<sup>11)</sup>. Baseball/softball (26.91%), rugby (22.22%), weightlifting (19.49%), table tennis (15.63%), gymnastics (13.80%), and soccer (13.35%) are the sports with the highest prevalence.<sup>10)12)</sup> Selhorst reported a prevalence of 53.8% in adolescent baseball players with low back pain<sup>13)</sup>, and baseball was the only sport that showed an increased risk<sup>13)</sup>. The physical characteristics of patients with lumbar spondylolysis have been reported to include decreased flexibility of the hip flexors and hamstrings, muscle weakness of the abdominal and gluteus maximus muscle groups, and lumbar hyperlordosis posture<sup>14)</sup>. In particular, about lumbar spondylolysis and lumbar hyperlordosis posture, it has been reported that patients with lumbar spondylolysis have segmental hyperlordosis of the lumbar spine according to the height of separation<sup>15)</sup>, and in a study of adolescent athletes aged 11-18 years, it was reported that patients with lumbar spondylolysis had a significantly greater lumbar

lordosis angle compared to patients with low back pain without neurological findings or symptoms<sup>16)</sup>. In addition, a study of 700 patients under 18 years of age with low back pain reported that the prevalence of lumbar spondylolysis was 3.5 times higher with an increased lumbar lordosis angle compared to a normal one<sup>17)</sup>. Since lumbar hyperlordosis is thought to increase compressive stress on the vertebral arch<sup>18)</sup>, an increased lumbar lordosis angle may influence the development of lumbar spondylolysis and may be a risk factor for the development of lumbar spondylolysis.

However, there are no reports on lumbar hyperlordosis angle and its effect on the development of lumbar spondylolysis in adolescent baseball players.

## 2. Purpose

The purpose of this study was to determine the effect of lumbar lordosis angle on the development of lumbar spondylolysis in adolescent baseball players.

## 3. Patient

Patients who visited an orthopedic clinic (Hanamizuki Orthopedic Sports Clinic, hereafter referred to as "the clinic") in Aichi Prefecture during the period from January 1, 2018, to October 31, 2021, and who met all of the following selection criteria and did not meet any of the exclusion criteria were considered eligible cases for enrollment.

## 4. Eligibility criteria

### 4.1 Inclusion criteria

- 1) Males aged 11 to 18 years who visited the clinic
- 2) Patients who play baseball as a competitive sport
- 3) Patients who underwent MRI with a chief complaint of lumbar pain lasting more than 2 weeks

### 4.2. Exclusion criteria

- 1) Patients whose superior endplate of L1 and superior endplate of S1 could not be identified in the MRI images

## 5. Methods

### 5.1 Type and design of the study

Retrospective cohort study

### 5.2 Outline of the study

The lumbar lordosis angle, age, and pitching experience of the above patients will be evaluated from their electronic medical records and imaging findings. In addition, the existence of lumbar spondylolysis will be evaluated from imaging findings. Statistical analysis was performed using logistic regression analysis, with the response variable being the existence of the development of lumbar spondylolysis and the explanatory variables being the lumbar lordosis angle, age, and pitching experience.

#### 6. observation items

- 1) Lumbar lordosis angle (the angle between the superior endplate of L1 and the line parallel to the superior endplate of S1) will be assessed using MRI by someone other than the research planner to prevent information bias. The average of three measurements of lumbar lordosis angle will be used.
- 2) Age will be assessed from the electronic medical record.
- 3) The pitching experience will be assessed from the electronic medical record.
- 4) The existence of lumbar spondylolysis will be assessed using MRI.

#### 7. Discontinuation or suspension of the research

The principal investigator will consider whether or not to continue the research in the following cases

- 1) When the purpose of the research is achieved before the expected number of cases or expected duration is reached.
- 2) When it is judged difficult to continue the research appropriately due to deviation from the ethical guidelines and research protocol or violation of the contract.

#### 8. Number of patients

The target patients were all those who fell into the above categories between January 1, 2018, and October 31, 2021. The target number of patients was set at 100.

##### 【Basis for setting the target number of patients】

Of the cases that met the eligibility criteria from the preliminary survey, about 30% were in the non-spondylolysis group. In the case of logistic regression analysis, the number of samples with fewer events should be 10 times the number of covariates (3 in this study), so  $30/0.3 = 100$ , and we set 100 as the target number of patients.

#### 9. Study period

The data collection period will be until October 31, 2022, after the approval of the Ethics Committee and the permission of the head of the research institution.

The research and analysis period will be until November 31, 2022, after the approval of the Ethics Committee and the permission of the head of the research institution.

## 10. Analysis and analysis methods

Statistical analysis was conducted using logistic regression analysis, with the objective variable being the existence of lumbar spondylolysis, and the explanatory variables being lumbar lordosis angle (continuous variable), age (continuous variable), and pitching experience (nominal variable).

For missing data, the multiple substitution method will be used in the main analysis, and a complete case analysis will be conducted as a sensitivity analysis if necessary to examine the robustness of the model.

## 11. Ethical Matters

### 11.1 Regulations to be followed

All researchers involved in this study will conduct this research by the Declaration of Helsinki (Fortaleza Revision, 2013) and the Ethical Guidelines for Life Science and Medical Research Involving Human Subjects.

### 11.2 Informed consent

This research does not necessarily require individual consent from the subjects by "Procedures for Obtaining Informed Consent, etc., Chapter 4, Section 8 of the Ethical Guidelines for Life Science and Medical Research Involving Human Subjects.

However, written information about the implementation of this research will be posted in the waiting room and rehabilitation room of the clinic where the research participants can check the information, and the research participants will be guaranteed the opportunity to refuse the implementation of the research.

If the research participants refuse to participate in the study based on public information, they will not be included in the study and will be excluded.

### 11.3 Handling of personal information

When handling information related to the implementation of the research, a correspondence table will be created with numbers unrelated to the personal information of the subjects, and the information will be anonymized to sufficiently protect the confidentiality of the subjects. The correspondence table will be strictly managed and will

not be provided to outside parties. When publishing the results of the research, information that can identify the participants should not be included. In addition, we will not use the information on participants obtained in the research for any purpose other than the purpose of the research.

## 12. Research Funding and Conflict of Interest

This study does not require any research funding.

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