Research of Factors for Reducing Sports Injuries in Basketball

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Abstract: Prevention of sports injuries is one of the most important issues in sports. Recently, many efforts to detect risk factors and take precautions in advance to reduce the incidence rate of sports injuries have been made. However, the criteria for determining the priority of preventive factors are unclear. The purpose of this paper is twofold. One is to reveal the onset and preventive factors of sports injuries in basketball by logistic regression analysis and Poisson regression analysis using recorded actual practice log data of a high school basketball team. The other is to suggest precautions for sports injuries in basketball based on obtained onset and preventive factors for basketball players or coaches in high school. In this paper, onset and preventive factors of sports injuries in basketball are led by logistic regression analysis and Poisson regression analysis, which are typical analysis methods for quantitative data. From the results of these analyses, we propose precautions to decrease the incidence rate of sports injuries in basketball.

Key Words: Sports injuries, Logistic regression analysis, Poisson regression analysis, Data mining

1. Introduction

There are two main types of injuries in sports?athletic injuries and sports disorders. Athletic injuries are caused by unexpected dynamic forces (e.g., fracture, dislocation, or ligament injury). Sports disorders are caused by overuse (e.g., backache, stress fracture, or jumper’s knee). Sports injury is a generic name for athletic injuries and sports disorders. Prevention of sports injuries is one of the most important issues in sports. Recently, many efforts have been made to detect the risk factors and take precautions in advance to reduce the incidence rate of sports injuries. According to Emery et al.[1], to establish an injury-preventive strategy, risk factors of injury in high school basketball are estimated by the logistic regression model and Poisson regression analysis using a valid injury surveillance system. To identify the available research regarding the risk factors and prevention of injuries in high school athletes, McGuine[2] identified the risk factors for injuries to the ankle, head, and knee by logistic regression analysis and Poisson regression analysis. Thus, risk factors and prevention for injury are studied by applying statistical analysis in foreign countries. In Japan, however, these studies are not active. Therefore, the criteria of preventing risk factors for injuries is unclear. As causes, the following two matters are considered: (1) although there are some reports of sports injuries by the Japan Sport Council[3] and Sports Safety Association[4], there is insufficient research on preventive intervention with sports injuries; (2) many coaches have insufficient knowledge on the prevention of sports injuries. From these causes, many players return to competition with great physical and psychological anxiety[5]. Therefore, it is necessary to set the above criteria by revealing clear onset factors and specific precautions. In this paper, sports injuries in basketball are addressed. The purpose of this paper is twofold. One is to reveal onset and preventive factors of sports injuries in basketball by logistic regression analysis and Poisson regression analysis using recorded actual practice log data of high school basketball teams. The other is to suggest precautions for sports injuries in basketball based on the obtained onset and preventive factors for basketball players or coaches in high school.

Incidentally, according to basketball rules, physical contact is prohibited. However, fairly strong contact occurs and leads to the onset of sports injuries. From the characteristics of the competition, many sports injuries to the lower extremities occur by repeated dashing or jumping[6][7]. With regard to the region of injury, in the upper body, injuries to the hand (including wrist and finger) and forearm are frequent; in the lower body, injuries to the ankle are common. At the top level, injuries to the foot, ankle, knee joint, back, and lumbar region are common[6].

2. Precautions for sports injuries in basketball from previous research

Chapter 1 provides a generalization of sports injuries in basketball. However, onset and preventive factors of sports injuries in basketball depend on a player’s age, gender, and competition level. Therefore, it is necessary to reveal onset and preventive factors in basketball by analysis of actual practice log data. In this chapter, previous research is described. Matsumoto et al.[8] estimated factors of sports injuries in basketball by logistic regression analysis and Poisson regression analysis. These analyses lead to precautions for sports injuries in basketball with regard to muscles (femur and cruris) and joints (knee and ankle). The precautions for sports injuries are determined as follows.

Onset and preventive factors of sports injuries in basketball...
to muscles (femur and cruris): Only the length of exercise time influences the onset of sports injuries in basketball to muscles. The influence of other factors such as temperature is small.

Precaution for sports injuries in basketball to muscles: Refrain from excessive training. Onset and preventive factors of sports injuries in basketball to joints (knee and ankle): Run training (without the use of the ball) is effective in the prevention of sports injuries in basketball to joints. However, it could become an onset factor of sports injuries in basketball to joints.

Precaution for sports injuries in basketball to joints: run training (without the ball) only, and no-run training (without the ball) along with training for different purposes such as practicing game mechanics. The previous research is examined by focusing on factors related to practice methods. However, this examination has not included weather factors (temperature, atmospheric pressure, and humidity), which are related to sports injuries in basketball. Therefore, in this paper, weather factors are examined.

Moreover, in previous research, the causes of sports injuries is unclear. Therefore, the following issues arise: (1) it is difficult to judge whether sports injuries are athletic injuries or sports disorders; (2) if a player has injuries in a plurality of regions on the same day, it is difficult to judge whether they occurred at the same time or one by one; (3) since the process of healing subsequent to an injury cannot be observed, it is difficult to judge when the injuries have healed. In this paper, onset and preventive factors of sports injuries in basketball are estimated using new data in the form of daily practice logs.

3. Preliminary analysis
This chapter analyzes recorded actual practice logs.

3.1 Investigation subject
The investigation subject is a men’s high school basketball club in in Shizuoka, Japan. There are 23 players in this club. The daily practice log data were obtained by managers of this club from June 2013 to May 2014 (a period of 12 months). Categories of daily log data are date, player name, method of treatment (e.g., icing, taping), region of onset for the injury, practice items, practice time, temperature, atmospheric pressure, humidity, and situation in which the injury occurred (e.g., a player sprained his ankle at the time of landing). The outline of daily data is shown in Table 1.

3.2 Practice items
(RT-c), and skill drills (SD). Common training is classified into four types: run training (RT-t), performance training (PT), and core training (CT). In addition, the level of practice intensity is set by the sports trainer. If the practice intensity is strong, the practice methods are difficult. Furthermore, in a high school, practice methods are greatly varied according to the time relative to a tournament. A summary is described as follows.

Immediately after a tournament (June, September, and early February): The purpose of practice is to build up the players’ physical strength. Because there is a relatively long period of time until the next tournament, the practice intensity is increased. Specifically, the intensity of PT and RT-t is increased. Some days, player do not touch the ball. In this period, if sports injuries occur, there is no help provided.

Interphase (July, early August, October, December, January, and early March): The purpose of practice is to build up the players’ basketball skill. Specifically, the practice intensity of SD and RT-c is increased.

Just before a tournament (late August, November, late March, April, and May): The purposes of practice are to build up the players’ sense of the game and take special care with regard to sports injuries. The overall practice intensity is decreased. However, the practice intensity of GF is increased.

3.3 Characteristics of sports injuries
The number of sports injuries is shown in Figure 1. As the figure indicates, the trending incidence of sports disorders is much larger than that of athletic injuries. Currently, sports disorders occupy approximately 72% of total injuries. Therefore, the incidence of sports disorders is investigated.

In addition, as mentioned in chapter 1, sports disorders are caused by overexertion. Thus, accumulation of stress is considered to be a cause for the onset of sports disorders. Accordingly, it is necessary to consider whether the intensity of practice on the previous day was light or hard. The intensity of the previous day’s practice is then paired with that of the current day. The incidence of sports disorders paired with the intensity of practice on the previous day and that of the current day is shown in Figure 2. In this paper, if the intensity of practice on a given day is high, then the practice is harder than the average of that week. Similarly, if the intensity of practice on a given day is low, then the practice is lighter than the average of that week.

In this paper, the following words are defined. A practice method involving the ball is called a competition characteristic. A practice without the ball is called common training. Competition characteristics are classified into three types: game format (GF), run training week. Therefore, the paired intensities of practices are classified into four types: “light × light,” “light × hard,” “hard × light,” and “hard × hard.” For example, “light × light” means that a light practice on the previous day is paired with a light practice on the current day. “hard × light” means that a hard practice on the previous day is paired with a light practice on the current day. The other two types are paired in the same way. As shown in Figure 2, the incidence of “light × hard” is approximately twice the number of the others.

As mentioned in chapter 2, in this paper, we discuss factors related to weather information. Thus, the number of sports disorders per day for each weather condition is shown in Figure 3. In addition, the intensity of practice per day for each weather condition is shown in Figure 4, in which the number of sports disorders per day for each weather condition is calculated by dividing the summed values of practice intensity for each weather condition by the number of days featuring each weather condition. As shown in Figure 3, there is a more significant correlation between the incidence of sports disorders on rainy days

| Investigation subject | Men’s basketball club in high school A in Shizuoka, Japan. (23 players) |
|-----------------------|--------------------------------------------------------------------------------|
| Investigation period  | From June 2013 to May 2014 (12 Months)                                        |
| Description of daily data | Date, Player’s name, Method of treatment, Injury region, Practice content, Practice time, Temperature, Humidity, Atmospheric pressure, Situation caused by Sports Injuries |
than that for other weather conditions by analysis of variance. In addition, as shown in Figure 4, there is no significant correlation between the incidence of sports disorders for any practice method and any weather condition by analysis of variance.

4. Methods of regression analysis

This chapter describes the methods of regression analysis. In section 4.1, the method of logistic regression analysis is described; in section 4.2, that of Poisson regression analysis is described. In these analyses, IBM SPSS ver. 21.0 is used.

4.1 Method of logistic regression analysis

In this method, to indicate the results of logistic regression analysis simply, the method proposed by Takada[9] is applied. In the logistic regression model, the independent variable is incidence rate $P$ and the relationship between incidence rate $P$ and the explanatory variables is represented by formula (1).

$$P(x_1, x_2, \cdots, x_n) = \frac{1}{1 + exp[-(\alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n)]}$$  (1)

where $\alpha$ and $\beta_i (i = 1, 2, \cdots, n)$ are regression coefficients.

In logistic regression analysis, the odds ratio can be expressed as $P/(1 - P)$ from its definition. By formula (1), it can be expressed as

$$Odds\, ratio = \exp(\beta_i)$$  (2)

Generally, consideration of logistic regression analysis is given from the value of the odds ratio[10]. However, it is difficult to read the variation in the incidence rate from the odds ratio. To solve this problem, formula (1) is transformed into formula (3). Formula (3) corresponds to the equation by Taylor expansion in the neighborhood of $z = 0$ and takes the first-order approximation.

$$P(z) = P(x_1, x_2, \cdots, x_n) = \frac{1}{1 + exp[-(\alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n)]}$$

In addition, from

$P(0) = \frac{1}{2}$

Therefore,

$$P(z) \approx P(0) + \frac{dP}{dz}|_{z=0} \times Z$$

where $Z = \alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n$, $(x_1, x_2, \cdots, x_n)|z = 0$ and $\alpha$ and $\beta_i (i = 1, 2, \cdots, n)$ are regression coefficients.

If explanatory variables increase by 1 unit, the probability $P(z)$ is changed by the value of one-quarter of the regression coefficients. This value is used for discussion.

A radar chart is drawn to show the result of the logistic regression analysis not only numerically but also visually. The procedure for creating the radar chart is shown as follows. First, formula (3) is transformed into formula (4).

$$P(z) = P(x_1, x_2, \cdots, x_n)$$

Fig. 1 Incidence of sports injuries

Fig. 2 Incidence of sports disorders paired with intensity of practice on the previous day and the current day

Fig. 3 Number of sports disorders per day for each weather condition

Fig. 4 Intensity of practice methods per day for each weather condition
In Tables 3, 4, 5, and 6, results of regression coefficients, odds ratio and radar charts are shown. In section 5.2, the result of regression analysis are shown. In section 5.1, the result of logistic regression analysis and poisson regression analysis are shown. In this chapter, results of logistic regression analysis and poisson regression analysis are shown. In this method, the incidence of sports disorders is subjected to Poisson regression analysis. In addition, as with the logistic regression analysis, the degree of practice, temperature×weather, temperature difference between the current day and the previous day×weather, atmospheric pressure×weather, humidity×weather, practice time, and dummy variable term are set. Climate factors (temperature, temperature difference between the current day and the previous day, atmospheric pressure, and humidity)×weather represent interaction terms of climate factors and weather. As mentioned in chapter 2, in this paper, factors related to weather conditions are discussed. Therefore, these interaction terms are set as candidates for explanatory variables. The explanatory variables are selected by a backward elimination method, and the regression equation is derived. In addition, because practice methods are greatly changing according to the time relative to a tournament in school A, it is set as a candidate for explanatory variables.

4.2 Method of Poisson regression analysis

In this method, the incidence of sports disorders is subjected to Poisson regression analysis. In addition, as with the logistic regression analysis, the degree of practice, temperature×weather, temperature difference between the current day and the previous day×weather, atmospheric pressure×weather, humidity×weather, practice time, and dummy variable term are set. Climate factors (temperature, temperature difference between the current day and the previous day, atmospheric pressure, and humidity)×weather represent interaction terms of climate factors and weather. As mentioned in chapter 2, in this paper, factors related to weather conditions are discussed. Therefore, these interaction terms are set as candidates for explanatory variables. The explanatory variables are selected by a backward elimination method, and the regression equation is derived. In addition, because practice methods are greatly changing according to the time relative to a tournament in school A, it is set as a candidate for explanatory variables.

5. Results of regression analysis

In this chapter, results of logistic regression analysis and poisson regression analysis are shown. In section 5.1, the result of regression coefficients calculated by logistic regression analysis, odds ratio and radar chart are shown. In section 5.2, the result of regression coefficients calculated by poisson regression analysis are shown.

5.1 Result of logistic regression analysis

In Tables 3, 4, 5, and 6, results of regression coefficients (β) by logistic regression analysis and odds ratio (exp(β)) are shown. The value of β/4 shows the increment for the incidence rate of sports disorders in basketball if explanatory variables increase by 1 unit. For example, in Table 6, the value of β/4 for “temperature×cloudy” is 0.036. This means that if the temperature on a cloudy day increases by 1 °C, the incidence rate of sports disorders in basketball increases by 0.036. In addition, radar charts are shown in Figures 5, 6, 7, and 8. In each radar chart, the larger a value becomes, the more it influences the onset of sports disorders in basketball. Conversely, the smaller a value becomes, the more it influences the prevention of sports disorders in basketball. For example, in Figure 8, “temperature difference between the current day and the previous day×cloudy” is plotted outside. This means that “temperature difference between the current day and the previous day×cloudy” has an influence on the onset of sports disorders in basketball.

As shown in Tables 3 and 4, in the case of a light practice on
the previous day, there is no tendency for a specific climate to have a large influence. However, as shown in Tables 5 and 6, in the case of a hard practice on the previous day, if the weather is cloudy or rainy, the climate factors tend to have a large influence on the onset of sports disorders in basketball according to this analysis. In addition, the values of the odds ratio are small in this analysis. However, if the value of the odds ratio exceeds 1.0, sports disorders tend to occur in actual situations. Moreover, if the value of the odds ratio is less than 1.0, sports disorders tend to prevent in actual situations.

5.2 Result of Poisson regression analysis

In Tables 7, 8, 9, and 10, the result of regression coefficients ($\beta$) by Poisson regression analysis are shown. As shown in Tables 7 and 8, in the case of a hard practice on the previous day, there is no tendency for a specific climate factor to have a large influence in this analysis. However, as shown in Tables 7 and 8, in the case of a hard practice on the previous day, if the weather is cloudy, the climate factors tend to have large influence on the onset of sports disorders in basketball.

As shown in Tables 3 and 4, in the case of a light practice on the previous day, there is no tendency for a specific climate to have a large influence. However, as shown in Tables 5 and 6, in the case of a hard practice on the previous day, if the weather is cloudy or rainy, the climate factors tend to have a large influence on the onset of sports disorders in basketball according to this analysis.

| light x light | $\beta$ | $\text{exp}(\beta)$ |
|---------------|---------|------------------|
| MP | -0.043 | 0.958 |
| temperature | 0.144 | 1.154 |
| temperature difference between the day and the previous day x cloudy | -0.711 | 0.491 |
| atmospheric pressure x sunny | 0.003 | 1.003 |
| just before a tournament | -1.237 | -0.290 |

Table 6 Result of logistic regression analysis by combination of a hard practice on the previous day and a light practice on the current day

Table 7 Result of poisson regression analysis by combination of a light practice on the previous day and a light practice on the current day

Table 8 Result of poisson regression analysis by combination of a light practice on the previous day and a hard practice on the current day

Table 9 Result of poisson regression analysis by combination of a hard practice on the previous day and a light practice on the current day

Table 10 Result of Poisson regression analysis by combination of a hard practice on the previous day and a hard practice on the current day
to this analysis. In addition, the values of the odds ratio are small in this analysis. However, if the value of the odds ratio exceeds 1.0, sports disorders tend to occur in actual situations. Moreover, if the value of the odds ratio is less than 1.0, sports disorders tend to prevent in actual situations.

5.3 Result of Poisson regression analysis
In Tables 7, 8, 9, and 10, the result of regression coefficients (β) by Poisson regression analysis are shown. As shown in Tables 7 and 8, in the case of a hard practice on the previous day, there is no tendency for a specific climate factor to have a large influence in this analysis. However, as shown in Tables 7 and 8, in the case of a hard practice on the previous day, if the weather is cloudy, the climate factors tend to have large influence on the onset of sports disorders in basketball.

6. Examination of onset and preventive factors of sports injuries in basketball
In this chapter, onset and preventive factors of sports disorders in basketball are examined from the results of logistic regression analysis and Poisson regression analysis by the combination of practice intensity on the current day and the previous day. A precaution with regard to sports injuries in basketball from these factors is discussed. Section 6.1 examines the result of logistic regression analysis. Section 6.2 discusses the Poisson regression analysis. Moreover, section 6.3 provides precautions with regard to sports injuries in basketball based on the onset and preventive factors discussed in sections 6.1 and 6.2.

6.1 Examination from logistic regression analysis
As mentioned in section 5.1, in the case of a light practice on the previous day, there is no tendency for a specific climate to have a large influence. However, as shown in Tables 5 and 6, in the case of a hard practice on the previous day, if the weather is cloudy or rainy, climate factors tend to have a large influence on onset of sports disorders in basketball. Accumulated stress from the hard practice of the previous day increases a player’s chances to be affected by the climate factors. Therefore, the combination of practice intensity on the current day and the previous day is discussed.

As shown in Table 3 and Figure 5, in the case of “light×light,” atmospheric pressure has large influence on the onset of sports disorders in basketball. Additionally, the incidence rate increases with decreasing atmospheric pressure. Sato et al.[11] found that physical internal pressure and heart rate increase because of minute atmospheric pressure change. Funakubo et al.[12] found that even a slight change of atmospheric pressure around 5 hPa influences the nervous system of the inner ear, increasing sensitivity to pain (“temperature difference × cloudy” is an abbreviation of temperature difference between the current day and the previous day × cloudy). Therefore, players become tired more easily because their heart rate increases owing to the drop in atmospheric pressure. This additionally increases sensitivity to pain. Thus, these two points cause an increased incidence rate.

As shown in Table 4, in the case of “light × hard,” the influence of RT-c on the onset of sports disorders in basketball is large, and the influence of other factors is small. From this result, because the intensity of practice methods rises remarkably compared to the previous day, a player’s body does not keep up with practice. Therefore, the influence of the factors related to practice content is larger than that of the other three cases. In addition, as shown in Figure 6, atmospheric pressure and humidity of sunny days influence the increase of the incidence rate more than RT-c. Thus, it is considered that in the case of “light × hard,” “lowering intensity of RT-c on days with a hard practice” and “budgeting for practice plans not to execute a hard practice on a fine day” are necessary.

As shown in Table 5 and Figure 7, in the case of “hard × light,” the influence of GF on the onset of sports disorders in basketball is large. It is considered that because a player executes high-intensity GF on a day before practice overall is light, sports disorders in basketball occur when executing GF practice.

As shown in Table 6 and Figure 8, in the case of “hard × hard,” temperature and temperature difference between the current day and the previous day on cloudy days tends to have a large influence on the onset of sports disorders in basketball. In addition, because the sign of the regression coefficients for “temperature × cloudy” is positive, it is considered that the incidence rate increases with a rise in temperature in the summer. In addition, because the sign of the regression coefficients for “temperature difference between the current day and the previous day × cloudy” is negative, it is considered that the incidence rate increases with a fall in temperature in the winter.

6.2 Examination from Poisson regression analysis
As shown in Tables 7 and 8, in the case of a light practice on the previous day, there is no tendency for a specific climate factor to have a large influence. However, as shown in Tables 9 and 10, in the case of a hard practice on the previous day, if the weather is cloudy, climate factors tend to have a large influence on the onset of sports disorders in basketball. This result is similar to the result from logistic regression analysis as mentioned in section 6.1. Obtained onset factors of sports disorders in basketball from these analyses are shown by combination of practice as follows:

1. “light × hard”: incidence rate increases with drop in atmospheric pressure.
2. “light × hard”: incidence rate increases with increased intensity of RT-c.
3. “hard × light”: incidence rate increases with increased intensity of GF.
4. “hard × hard”: incidence rate increases with rise in temperature in the summer. Moreover, the incidence rate increases with the fall in temperature in the winter.

6.2 Precautions for sports injuries in basketball
This section describes precautions derived from the analytical result of this paper. In the case of a light practice on the previous day, the incidence rate increases with increased intensity of RT-c practice. Therefore, the precaution for the next day would be to execute a light practice with reduced intensity of RT-c. In addition, in the case of the next day, the plan would be to execute a light practice, because the heart rate is increased by the fall of atmospheric pressure, and it becomes easy to accumulate stress. Therefore, it is necessary to increase the number
of break and stretch times during practice. In the case of a hard practice on the previous day, the incidence rate increases with increased intensity of GF practice. Therefore, the precaution for the next day would be to execute a hard practice with reduced intensity of GF. In addition, in the summer, the incidence rate increases with the rise in temperature the day after a hard practice; in the winter, the incidence rate increases with the fall in temperature the day after a hard practice. Therefore, in the summer, it is necessary to execute a light practice on a day when the temperature compared to the previous day rises more than usual. In addition, in the winter, it is necessary to execute a light practice on a day when the temperature compared to the previous day falls more than usual.

7. Conclusions

The purposes of this paper are to reveal the onset and preventive factors of sports injuries in basketball by using actual recorded practice logs and to propose precautions with regard to sports injuries in basketball derived from these factors to be executed by basketball players or coaches. The onset and preventive factors of sports injuries in basketball are estimated by logistic regression analysis and Poisson regression analysis.

As a result of these analyses, precautions with regard to sports injuries in basketball are as follows:

- The day after executing a light practice: Lower the intensity of RT-c and increase the number of break and stretch times during practice.
- The day after executing a hard practice: Lower the intensity of RT-c.
- Practice in the summer: Execute a light practice when the temperature compared to the previous day rises.
- Practice in the winter: Execute a light practice when the temperature compared to the previous day falls.

However, these precautions are obtained from analysis results of this paper and are assumed to be executed in a manner that would not cause trouble for an onsite practice plan.

As future subjects of research, analysis of players’ performance level and sports injuries of other competitions are suggested.

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