

Incidence, Symptoms and Diagnosis of Jumper's Knee and Knee Contusions in Female College Volleyball Players

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Abstract. [Purpose] There are no recent studies investigating the incidence of jumper's knee and knee contusions in volleyball players. A lack of understanding of knee contusions suffered by players (liberos) receiving the ball has lead doctors to diagnose jumper's knee. There have been no studies distinguishing between jumper's knee and knee contusions, which present similar symptoms. The purpose of this study was to investigate and correlate the two conditions of jumper's knee and knee contusions. [Subjects and Methods] Thirty-one female volleyball players were assessed for their maximum jumping power, body weight, whether they performed broad (slide) spikes, and whether they often hit their knees and so on. [Results] Jumper's knee was found in either or both knees of 12 (57%) of 21 spikers. For knee contusions, symptoms were found in 5 of the 10 liberos and setters, who were confirmed to actually hit their knees by observing videotapes of their practice. [Conclusion] Symptoms resembling jumper's knee were discovered in 4 of 6 liberos. It was difficult to distinguish between jumper's knee and knee contusions in terms of their symptoms, except through observation of the players' actual performance. It is important to discriminate between the two conditions clinically for treatment (including physical therapy) and prevention.

Key words: Jumper's Knee, Knee Contusions, Volleyball

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INTRODUCTION

In recent years, volleyball has seen remarkable technical progress. Particularly in women's volleyball, it is thought that faster performance and evolving techniques have been accompanied by changes in the types and frequencies of injuries. However, there have been no recent studies investigating the incidence of jumper's knee among female volleyball players. Additionally, a lack of understanding of knee contusions suffered by players while receiving the ball has resulted in hospitals making a diagnosis of jumper's knee in those players who receive the ball (the liberos:

generally short, dexterous players who can only receive the ball), where absolutely no jumping is required, and setters (players who toss the ball up into the air). Even if some of them were prohibited to jump, they didn't recover their symptom very much, but there have been no studies conducted to distinguish between the two conditions of jumper's knee and knee contusion, even though these are known to present similar symptoms. The purpose of this study was to clarify the two conditions with regard to prevalence, affected side and symptoms. It is important to discriminate between the two conditions clinically for treatment, including physical therapy, and prevention.

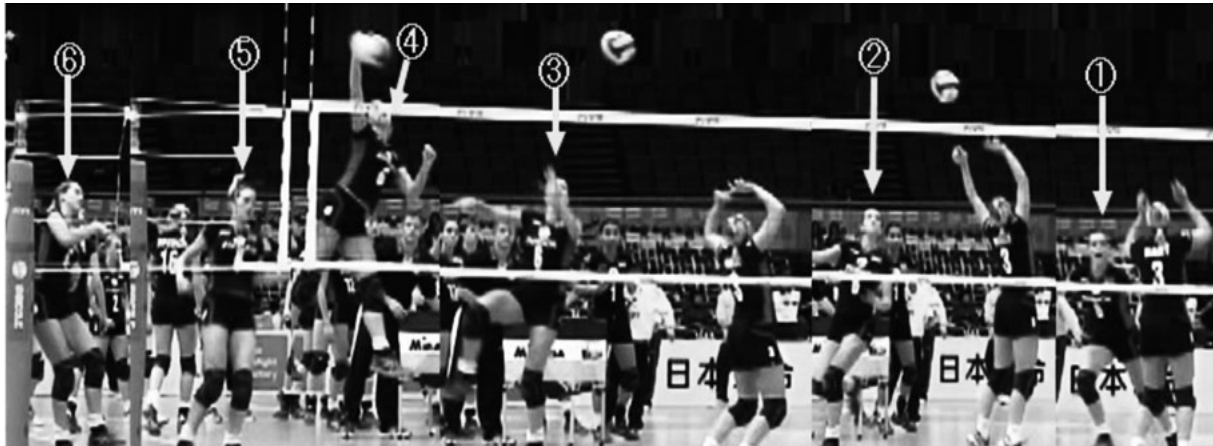


Fig. 1. In a broad spike, the player springs off her left leg to perform a long jump to the right and then lands on both feet. For this reason, it is primarily the right leg that supports the player's weight at landing. Because jumper's knee in players performing broad spikes is more prevalent in the right knee (or when present in both knees, more pronounced in the right knee), it is thought that stress on the knees at landing is greater than at the beginning of the jump.

SUBJECTS AND METHODS

Subjects

Thirty-one players from a women's volleyball team in Kansai's top university league in 2007 were studied (Seniors had retired from the team following the conclusion of the university championship series, so only freshmen, sophomores, and juniors were studied. Of these, 21 were spikers, and 10 were setters and liberos. In terms of position, there were 9 left spikers, 8 center spikers, 4 right spikers, 4 setters, and 6 liberos. Due to the large size of the team, it was extremely unusual for liberos and setters to practice spiking. Spikers had a mean height, weight, and age of 169.5 ± 3.8 cm, 61.4 ± 5.5 kg and 19.9 ± 0.9 years, respectively. In contrast, liberos and setters had a mean height, weight, and age of 159.5 ± 3.9 cm, 57.6 ± 4.3 kg and 19.5 ± 0.9 years, respectively.

Methods

All players were asked a series of medical questions about jumper's knee in the second week after the university championship series, to ascertain their maximum jumping power, body weight, height, whether they performed broad spikes during regular practice, and whether they often hit their knees. Whether they often hit their knees was judged by observing a videotape of their practice on court. Hitting the knees is one proof of knee contusion.

Maximum jumping power was defined as the greatest height recorded over the last two years. This methodology was adopted in order to avoid erroneous results due to pain at the time of the investigation.

Recently, volleyball has seen remarkable technical progress. The broad spike is one of the new techniques. This technique involves the player springing off her left leg to perform a long jump to the right and then landing on the right leg or both feet. So it is primarily the right leg that supports the player's weight at landing. It is possible that broad spikes lead to the development of jumper's knee (Fig. 1).

Next, the author (IKUHIRO MORIKITA) conducted medical examinations alone in order to avoid potential discrepancies arising from the use of multiple examiners. This examination consisted of a buttocks rising test, the results of which are said to be closely related to the severity of jumper's knee. Muscle flexibility, also said to be closely related to the development of jumper's knee¹⁻³⁾, was also investigated. Heel-to-buttock distance and a straight leg raise (SLR) test were used to assess muscle flexibility.

Heel-to-buttock distance was defined as the shortest distance between the buttocks and the heel and was measured in cm. The SLR test was performed by holding the ankle with one hand and gradually flexing the hip joint while pushing down on the player's knee with the other hand to keep it

Table 1a. Twenty-one female volleyball spikers

	Left	Center	Right	Total
Jumper's knee	6	5	1	12
No jumper's knee	3	3	3	9
Total	9	8	4	21

(n=21)

Table 1b. Ten female volleyball athletes

	Libero	Setter	Total
Knee contusion	4	1	5
No knee contusion	2	3	5
Total	6	4	10

(n=10)

extended, and recording the angle of the hip joint when either resistance to this motion rapidly increased or the buttocks rose into the air. During the test, the subjects were instructed not to flex the other knee.

Areas of tenderness were measured by immobilizing the patella between the thumb and forefinger of one hand while checking for tenderness with the tip of the forefinger on the other hand. Physical data (body weight and height) were also collected using a questionnaire, and Roel's stages were used to categorize the degree of severity of jumper's knee and knee contusions⁴.

These measurement results were then investigated for any correlation with the incidence of jumper's knee and knee contusions.

Statistical testing, consisting of the coefficient of correlation, a chi-square test and a t-test, was performed and the chi-square test and t-test were interpreted as indicating significance at a level of $p < 0.05$.

RESULTS

1. Incidence of jumper's knee and knee contusions

Jumper's knee was found in either or both knees of 12 (57%) of the 21 spikers. By position, this included 6 of the 9 left spikers, 5 of the 8 center spikers, and 1 of the 4 right spikers, suggesting the condition was more prevalent among left and center spikers (Table 1a).

For knee contusions, symptoms resembling jumper's knee (that is, soreness where the patellar

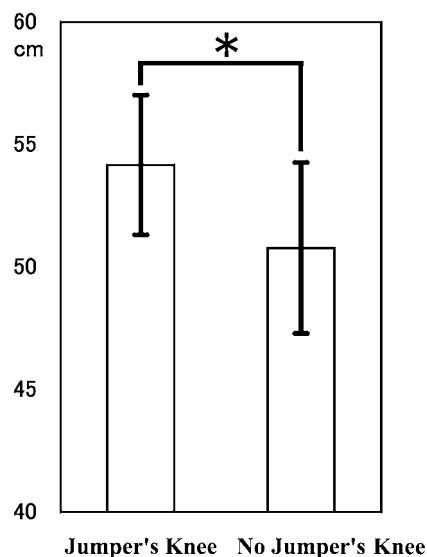


Fig. 2. Correlation of maximum jumping power and jumper's knee. Athletes with jumper's knee have a higher maximum jumping power. $*p < 0.05$

ligament is attached to the lower surface of the patella, tenderness in the same area, and knee pain when jumping) were found in 5 of the 10 liberos and setters, who were confirmed to actually hit their knees by observing a videotape of their practice on court (Table 1b).

2. Maximum jumping power

The mean maximum jumping power for players with jumper's knee was significantly higher, at 54.2 ± 2.9 cm (mean \pm SD), than the 50.8 ± 3.5 cm of players without jumper's knee, suggesting that players with greater maximum jumping power may be more likely to develop jumper's knee (Fig. 2).

3. Performance of broad spikes during regular practice

Ten spikers in 21 performed broad spikes during regular practice. Significantly, symptoms of jumper's knee were found in 8 of the 10 subjects who performed these broad spikes (80%). Of these, four subjects had the condition in both knees (in 1, symptoms were more pronounced in the right knee), and four had jumper's knee in the right knee only (Table 2). In other words, of these players with jumper's knee who perform broad spikes, the

Table 2. Knees affected by jumper's knee

Both	Right	Left
4*	4	0

*Of subjects with the condition in both knees, one had more pronounced symptoms in the right knee.

Table 3. Roels stage breakdown

	Phase 1	Phase 2	Phase 3
Spikers	6	4	2
Liberos and setters	2	2	1

(No. of cases)

condition was present in the right knees of all 8 subjects: 5 of the 8 (63%) had stronger pain in the right knee, while 3 had equivalent levels of pain in both knees. None of the spikers experienced more severe pain in the left knee.

4. Frequency of hitting knees

Upon questioning, all subjects did not think that they had hit their knees. But they all put supporters with knee pads on the same side as the affected right knees (four put supporters with knee pads on the right, one put supporters with knee pads on both sides). Five subjects with symptoms like jumper's knee among the 10 liberos and setters, who had actually hit their knees as observed on videotape of their practice on court, were diagnosed with knee contusions (Table 1b).

5. Buttocks rising test and muscle flexibility

The buttock rising sign was absent in all subjects. All players showed 0 cm for heel-to-buttock distance. The mean SLR for players with jumper's knee was lower than the mean SLR for players without jumper's knee ($99.2 \pm 11.9^\circ$ vs 106.7 ± 14.9 ; mean \pm SD).

The mean SLR for players with jumper's knee was lower than the mean SLR for players with knee contusions ($99.2 \pm 11.9^\circ$ vs 105.0 ± 18.2 ; mean \pm SD).

The subjects with low SLR had a tendency to suffer from jumper's knee, but subjects with knee contusions showed high SLR.

6. Areas of tenderness in jumper's knees and knee contusions

Of the subjects with jumper's knee, all experienced

tenderness in the center, and 3 experienced tenderness on the inside of the knee as well. Of the subjects with knee contusions, all experienced tenderness in the center, and one experienced tenderness on the inside of the knee as well.

7. Roels stages

In terms of Roels stages for jumper's knee, six subjects had phase 1, four had phase 2, and two had phase 3. For knee contusions, two had phase 1, two had phase 2, and one had phase 3 (Table 3).

DISCUSSION

Although volleyball is the sport with the highest incidence of jumper's knee overseas as well as nationally⁵, most published literature on the subject does not classify cases by factors such as gender or age^{1,2,6-16}.

Generally, male athletes have higher jumping power and lower muscle flexibility. For this reason, they suffer from more cases of jumper's knee, and those cases are also more severe. Due to these differences, statistical analysis that fails to differentiate between the genders yields results that do not provide accurate information regarding the differences between male and female athletes. So subjects were limited by gender and age in this study.

There are two general causes in volleyball of tendinitis of the patellar ligament. One is jumping too much (so-called jumper's knee). Another is hitting the knees too much (knee contusions). It is very important to discriminate between the two conditions, because the treatments for the two conditions are quite different: for example, the use of orthosis for the treatment of jumper's knee. An orthosis used to compress the patellar tendon may make the condition worse in the case of a knee contusion because the tendon is injured when hitting the knee when receiving the ball. The way of preventing of the two conditions is also quite different. Stretching of the knee extensor and flexor is not effective for the prevention of knee contusions.

1. Incidence of jumper's knee and knee contusions

Among 5,286 volleyball players examined by outpatient sports medicine departments, jumper's knee was the second most common diagnosis after fascial lumbago, accounting for 665 cases⁷. Most

studies have ranked it first or second in prevalence among volleyball injuries^{1,6-11}). Visnes described the incidence of jumper's knee 29(57%) as the highest reported among 51 male and female elite university volleyball players¹²). Gisslén reported 17 (14%) cases of jumper's knee in 120 patellar tendons in high school volleyball players¹³) and 8 cases of jumper's knee were diagnosed clinically in 44 patellar tendons in elite junior volleyball players^{14,15}). However, most published literature on the subject does not classify cases by factors such as gender or age. At 57%, occurrence of jumper's knee in this study is higher than the findings in other studies except the one of Visnes¹²). This result reflects that the longer career volleyball players have, the higher the percentage of volleyball players suffering jumper's knee is. Also, the fact that the study was conducted immediately after a university championship series is likely to have influenced the result.

Both Roels stages (six phase 1, four phase 2, and two phase 3) and the fact that all subjects had a heel-to-buttock distance of 0 cm indicate that most were mild cases (Table 3). The findings of Roels stages are thought to be due to the fact that subjects' skeletal growth at this age had stopped because they were several years past their growth period, and their longitudinal muscle growth had had time to catch up with skeletal growth.

With 5 cases in 10 subjects, knee contusions occurred with roughly the same incidence as jumper's knee, and the Roels stages also indicated that these occurred at about the same level of severity (Table 1a, 1b, 3). The symptoms were similar, and we conclude that it is difficult to distinguish between the two conditions based on frequency and symptoms, only observation of the players actual performance allowed the conditions to be distinguished from one another. It is important to discriminate between the two conditions clinically for treatment, including physical therapy, and prevention.

2. Maximum jumping power

The mean maximum jumping power for players with jumper's knee was 54.2 cm, compared with 50.8 cm for players without jumper's knee, suggesting that players with greater maximum jumping power may be more likely to develop jumper's knee. Lian concluded that the greater the speed and power of the knee's extensor, the higher

the incidence of jumper's knee¹⁶), and this study supports those findings. This methodology of maximum jumping power was adopted in order to avoid erroneous results due to pain at the time of the investigation. We could get a significant statistical result even though there were only a small number of subjects, suggesting that maximum jumping power is related to actual ability to jump rather than measurement of jumping power, once at the time of investigation.

3. Performance of broad spikes during regular practice

Ten spikers out of 21 performed broad spikes during regular practice. Eight of the ten spikers suffered from jumper's knee. The findings indicate that a high percentage (80%) of players performing broad spikes develop jumper's knee, suggesting that broad spikes may be a cause of jumper's knee. In a broad spike, the player springs off her left leg to perform a long jump to the right and then lands on both feet. For this reason, it is primarily the right leg that supports the player's weight on landing (Fig. 1). Because jumper's knee in players performing broad spikes is more prevalent in the right knee (or when present in both knees, more pronounced in the right knee), it is postulated that stress on the knees at landing is greater than at the beginning of the jump in broad spikes (Table 2).

4. Frequency of hitting the knees

Because athletes wear supporters with knee pads and are largely unaware of whether they are hitting their knees or not, all subjects answered on the questionnaire that they had not been hitting their knees. However, they wore a supporter with a knee pad on the same side as affected knees. Some coaches let players practice without supporters with a knee pad to make players more aware that they are hitting their knees.

Coaches and trainers on the court have mentioned the existence of knee contusions, but these injuries remain completely unreported in the literature. The discovery of symptoms resembling jumper's knee in 4 of 6 liberos, who never jump, supports the existence of these injuries. More detailed study is required, and we are currently involved in experiments designed to shed more light on the topic.

We tried to prove that these players hit their knees in an experiment using pressure sensor paper on the

knees of volleyball players, but the sensor paper disintegrated because the players perspire a lot when they perform vigorously. Accordingly, in this study, we determined whether they often hit their knees by observing a videotape of player's practice on court.

5. Buttocks rising test and muscle flexibility

No subject showed the buttock rising sign and all showed 0 cm heel-to-buttock distance. These results show that muscle flexibility is high at this age in female athletes generally. This study's finding of high muscle flexibility using the heel-to-buttock and SLR tests among flexible female athletes is thought to be due to the fact that subjects' skeletal growth had stopped, because they were well past their growth period, and their longitudinal muscle growth had had time to catch up with skeletal growth, and also because the subjects were older than these of other studies^{1,2,6}).

Hayashi et al. found that 67.6% of players with an SLR angle of less than 90° had jumper's knee⁶), a relatively high percentage that is likely derived from the fact that the study included a mix of Japanese male, female, junior, and senior players and included a large number of tall players.

The mean SLR of players with jumper's knee was lower than that of players without jumper's knee ($99.2 \pm 11.9^\circ$ vs 106.7 ± 14.9 ; mean \pm SD). The subjects with low SLR had a tendency to suffer from jumper's knee, but the subjects without jumper's knee showed high SLR. It is thought that low SLR shows tightness of hamstrings which causes overload of quadriceps, implying that tightness of hamstrings is related to the development of jumper's knee, but not related to knee contusions. This result suggests that the two conditions have different origins.

6. Areas of tenderness in jumper's knee and knee contusions

Although there have been some presentations on areas of tenderness in jumper's knee, we were unable to find any that had been published in manuscript form. This study found tenderness at the center of the knee in all subjects and on the inside of the knee in 3 subjects. Similarly, all subjects suffering from knee contusions experienced tenderness in the center, and one experienced tenderness on the inside of the knee as well. In other words, both jumper's knee and knee

contusions result in tenderness in roughly the same areas, and it is difficult to distinguish between the two conditions on this basis.

7. Roels stages

In terms of Roels stages for jumper's knee, six subjects had phase 1, four had phase 2, and two had phase 3. For knee contusions, two had phase 1, two had phase 2, and one had phase 3. In other words, both jumper's knee and knee contusions result in roughly the same Roels stages, and it is difficult to distinguish between the two conditions on this basis (Table 3).

Although the Japan Volleyball Association has been conducting educational and guidance programs to prevent injuries¹⁷), it is thought, that in future, players performing broad spikes need to be instructed to take special care to stretch and ice their knees before and after match play in order to prevent jumper's knee, especially players who have high maximum jumping power. The Japan Volleyball Association needs to let coaches, trainers and doctors know about the existence of knee contusions.

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