

Evaluation of Volleyball Players' Ability to Jump High and Fast: Targeting Female University Volleyball Players

Ken Nemoto¹, Yuki Mori², Sayuri Umezaki³, Noriyuki Kida⁴

¹Faculty of Sport Science, Nippon Sport Science University, Setagaya, Japan

²Department of Pre-School Education Studies, Sonoda Women's University, Amagasaki, Japan

³Faculty of Physical Education, Tenri University, Tenri, Japan

⁴Faculty of Arts and Sciences, Kyoto Institute of Technology, Kyoto, Japan

Email: nemoto@nittai.ac.jp

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Abstract

This study aimed to investigate the relationship between RSI_{mod} and RSI in various jumping movements in 60 female university volleyball players and to evaluate the validity of these indices in performance evaluation. Spike jumps, block jumps, counter movement jumps, and rebound jumps were measured as jumping movements, and RSI_{mod} and RSI were calculated using an Enode device. As a result, a moderate correlation was found between spike jumps and counter movement jump RSI_{mod} ($r = 0.497$; $p < 0.001$), and between block jumps and counter movement jump RSI_{mod} ($r = 0.433$; $p < 0.05$). However, compared with previous studies targeting male players, it was revealed that the correlation coefficients were lower in female players.

Keywords

Volleyball, RSI_{mod}, RSI, Enode, Approach Jump

1. Introduction

Volleyball is a sport in which players compete to reach a set number of points before their opponent by taking multiple jumps during rallies. In recent years, there has been remarkable development in measuring equipment in the field of sports science, and devices such as VERT (VERT Wearable Jump Monitor) have been developed to evaluate the number of jumps and jump heights of volleyball players during a match in real-time. As a result, the number of jumps per set has been reported to be 12.7 - 16.3 for outside hitters (OH) and opposites (OP), 15.5

- 23.0 for middle blockers (MB), and 19.0 - 32.0 for setters (S) (Esper, 2003; Sheppard, & Gabbett, 2009; Okano, & Tanigawa, 2016; Lima et al., 2019; Mori et al., 2022). The jump height of male athletes during a match is 77% - 90% of the maximum, and this value changes during the match (Wnorowski et al., 2013). Furthermore, a study of top Argentine female athletes revealed that maximum jump height did not decrease before and after a match (Esper, 2003). Jumping ability is an important factor that determines victory or defeat as it is related to technical and tactical elements (Fukuda et al., 1987; Kurokawa, 2000). In other words, jumping ability has been established as an index for measuring the ability of individual athletes.

Jumping movements are broadly divided into two types: vertical jumps (countermovement jumps) and rebound jumps. The vertical jump type is a jumping movement represented by a vertical jump that uses large flexion and extension movements of the three joints of the lower limbs to ensure a relatively long ground contact time, resulting in a large impulse and a high jump height (Kumano et al., 2023). The rebound jump is a jumping movement similar to takeoff in track and field jumping events that mainly use flexion and extension movements of the ankle joint without much flexion of the hip and knee joints (Kumano et al., 2023). Yardsticks, mat sensors, and force plates have been used to measure and evaluate jumping abilities (Endo et al., 2007; Okano et al., 2016; Zushi et al., 2017; Okano et al., 2017; Kumano et al., 2023). Among the measurement items implemented in previous studies, it has been reported that the Drop Jump (DJ) and Rebound Jump (RJ) can clearly measure lower-limb muscle strength and power output characteristics (Zushi et al., 1993).

In net-type ball games, such as volleyball, where players compete for points by repeating rallies across a net, one important aspect of jumping ability evaluation at the field level is the speed at which a player can jump. There are two types of evaluation indices for the ability to jump fast and high: RSImod, which is the vertical jump height divided by movement time, and RSI, which is the RJ jump height divided by ground contact time (Pleša et al., 2022). With advances in measurement technology, cheaper and more convenient methods are required for sports coaching. Therefore, an ultra-compact jump measurement device called Enode (Blaumann & Meyer, Sports Technology UG) can measure RSImod and RSI. Enodes are less expensive than mat sensors and force plates, and can be owned and used by teams at a wide range of competitive levels. Regarding the reliability of the Enode as a jump measurement device, it has been reported that it was not valid when the measurement was performed on the ankle (Lamberto et al., 2023), but was valid when the measurement was performed on the lower back (Jimenez-Olmedo et al., 2023). Therefore, it is appropriate to wear the node on the lower back when using the device.

Pleša et al. (2022) investigated the relationship between RSI and RSImod and the performance of CMJ and DJ on both legs and one leg in 40 male volleyball players. The results showed that the correlation between RSI of DJ and approach

jump was moderately strong ($r = 0.42 - 0.73$), and RSImod of CMJ had the highest correlation ($r = 0.676 - 0.727$). They also reported that RSImod is a useful evaluation index in volleyball competitions (Pleša et al., 2022). However, the authors mentioned the need for further investigation. Points to be investigated in the future include the fact that in previous studies, only spike jumps (SPJs) were evaluated as approach jumps specific to volleyball, but block jumps (BJs) should also be investigated. In addition, it is necessary to consider RSI as an evaluation index for volleyball competitions. We hypothesized that higher values of RSImod and RSI would lead to higher values of various jumping movements, and verified this in this study.

This study aims to investigate the relationship between RSImod and RSI in various jumping exercises in female volleyball players and assess the effectiveness of these metrics for performance evaluation.

2. Methods

2.1. Subjects

The subjects were 60 players (height: 168.4 ± 7.6 cm, weight: 60.9 ± 5.2 cm) from the Kansai University Volleyball Federation Women's Division 1 League. The positions of the participants were outside the hitter (OH, $n = 33$), opposite (OP, $n = 8$), and middle blocker (MB, $n = 19$). In this study, OH, OP, and MB were the subjects, whereas setters, liberos, and receivers were excluded. Before the experiment began, the subjects were verbally informed of the purpose and intent of the study, as well as the possibility of injury associated with the experiment. Consent to participate in the experiment and the use of the survey data were obtained. The Kyoto Institute of Technology University Ethics Committee approved this study (approval number: 2023-14).

2.2. Measurement Items and Methods

1) Morphological measurements

Morphological measurements included height and weight. Reach height was measured using a vertical jump measurement scale (Yardstick, Swift) with the dominant arm extending straight upward in an upright position, and the height from the fingertip to the floor was measured. Weights were measured using a digital weighing scale (DC-430A; TANITA).

2) Experimental exercise

We referred to the experimental exercise methods used in previous studies (Endo et al., 2007; Okano et al., 2017). Therefore, we focused on the time required to perform the movement and used two types of jumping exercises: a short jumping exercise, called a rebound jump (RJ), in which five consecutive jumps are performed in place from a standing position, and a counter movement jump (CMJ), in which a jump is performed using a rebound movement from a standing position, as a jumping exercise with a relatively long movement execution time. BJ and SPJ were used to evaluate typical jumping movements in volleyball. The

participants were given sufficient time to warm up before the measurements were conducted. Furthermore, they were verbally instructed to jump as fast and as high as possible with a short takeoff (ground contact) time.

3) Measurement items and measurement methods

To evaluate the ability to perform jumping movements, RSI_{mod}, RSI, and jump height were used for approach jumps BJ and SPJ. RSI_{mod} was calculated as the ratio of CMJ height to movement time during the jump. RSI was calculated by dividing the jump height during an RJ by the ground contact time.

The Enode, an ultra-compact jump measurement device, was used to measure the experimental movements. With a special jump belt attached to the waist in advance and the Enode placed in a special pocket, the four types of jumps mentioned above, CMJ, RJ, BJ, and SPJ, were measured. For each type of jump, RJ was performed five times in a row, and the other jumps were performed three times.

4) Statistical Processing

The average and standard deviations of each measurement parameter were calculated. To examine the relationship between each measurement item, Pearson's correlation coefficient was calculated. The statistical significance level was set at less than 5%.

3. Results

Table 1 shows the average values and standard deviations for BJ, SPJ, CMJ, CMJ RSI_{mod}, and RJ RSI. **Figure 1** shows the relationship between the BJ and CMJ RSI_{mod}, **Figure 2** shows the relationship between the SPJ and CMJ RSI_{mod}, **Figure 3** shows the relationship between the BJ and RJ RSI, and **Figure 4** shows the relationship between the SPJ and RJ RSI. Moderate correlations were observed between the BJ and CMJ RSI_{mod} ($r = 0.433$; $p < 0.05$), and between the SPJ and CMJ RSI_{mod} ($r = 0.497$; $p < 0.001$). A weak correlation was observed between the BJ and RJ RSI ($r = 0.395$; $p < 0.05$), and a moderate correlation was observed between the SPJ and RJ RSI ($r = 0.476$; $p < 0.001$).

4. Discussion

4.1. Relationship between CMJ RSI_{mod} and BJ and SPJ

In this study, a moderate correlation was found between the SPJ and CMJ RSI_{mod}

Table 1. Mean values and standard deviations for each jumping movement.

	M ± SD
BJ (cm)	49.93 ± 6.81
SPJ (cm)	55.35 ± 7.82
CMJ (cm)	37.88 ± 4.93
CMJ RSI _{mod} (m/s)	0.54 ± 0.12
RJRSI (m/s)	2.20 ± 0.39

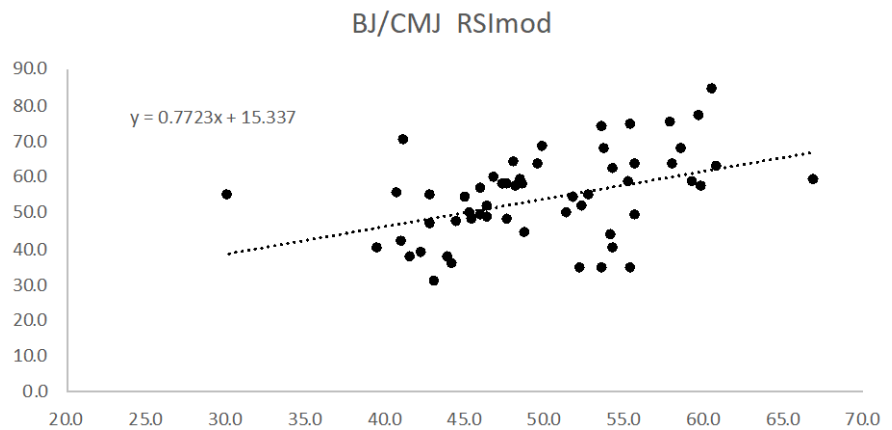


Figure 1. Relationship between BJ and CMJ RSI mod.

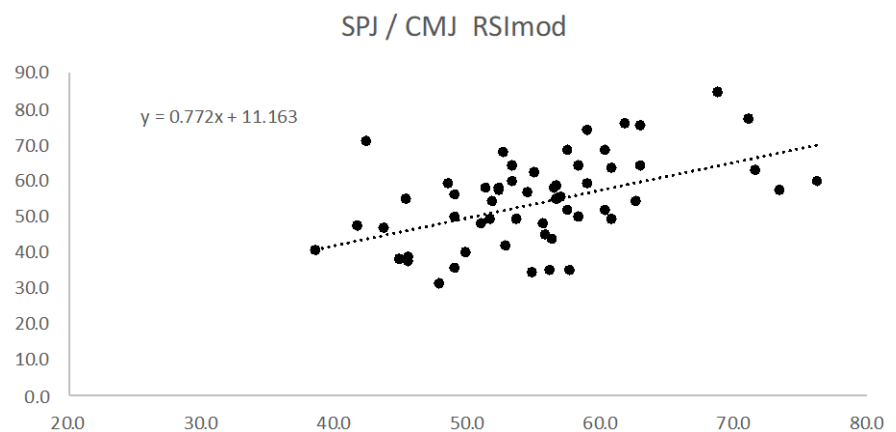


Figure 2. Relationship between SPJ and CMJ RSI mod.

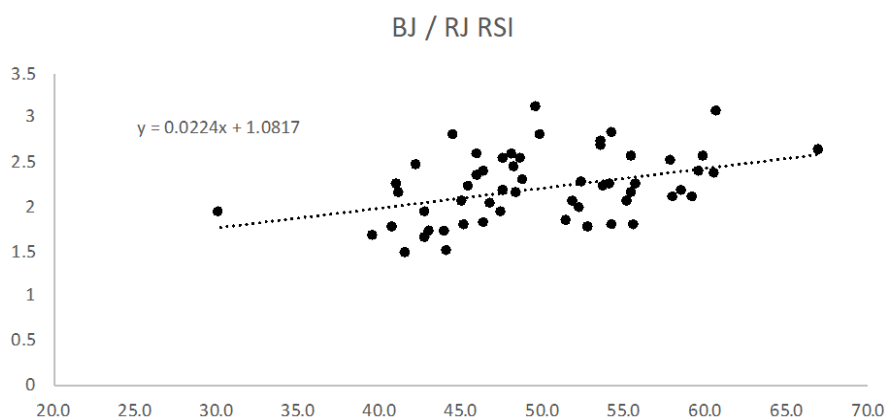


Figure 3. Relationship between BJ and RJ RSI.

($r = 0.497$; $p < 0.001$) (**Figure 1** and **Figure 2**). The results of a survey conducted by Pleša et al. (2022) on male volleyball players showed a high correlation between SPJ and CMJ RSI mod ($r = 0.676$; $p < 0.001$). In this survey, a significant positive correlation was found, like the results of the survey by Pleša et al. (2022); however, the correlation coefficient was lower in female players than in male players. In

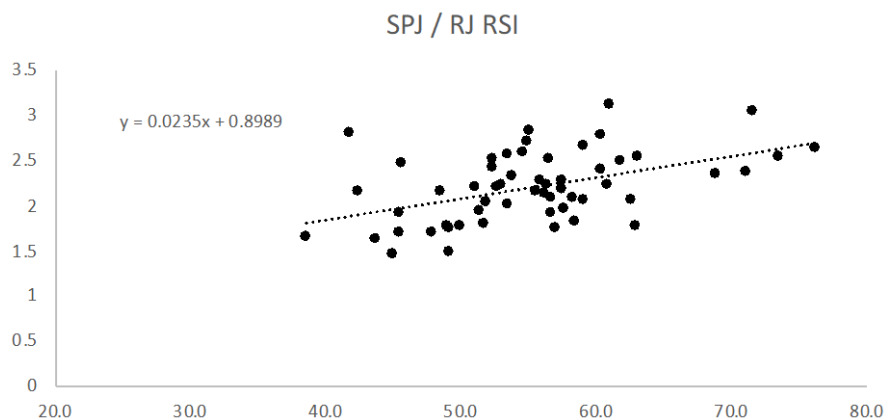


Figure 4. Relationship between SPJ and RJ RSI.

other words, male players with high SPJ jump heights also have high RSI_{mod}, but female players with high SPJ jump heights do not necessarily have high RSI_{mod}. Kumano et al. (2023) suggested that men and women may exhibit different jumping characteristics. In terms of jumping ability, it has been reported that women exert force slower than men, and it takes twice as long as men to exert 70% of their maximum leg strength (Karlsson & Jacobs, 1981). Pleša et al. (2022) investigated the relationship between RSI and RSI_{mod} and approach jump performance, but did not examine BJ. Therefore, the BJ was adopted in addition to the SPJ. A moderate correlation was found between the BJ and CMJ RSI_{mod} ($r = 0.433$, $p < 0.05$). Therefore, although the degree of correlation differs depending on sex, this study confirmed a correlation between SPJ and BJ, which are jumping movements specific to volleyball, and RSI_{mod}.

4.2. Relationship between RJ RSI and BJ and SPJ

In the present study, a weak correlation was found between BJ and RJ RSI ($r = 0.395$; $p < 0.05$), and a moderate correlation was found between SPJ and RJ RSI ($r = 0.476$; $p < 0.001$). Pleša et al. (2022) reported a moderate correlation ($r = 0.44$; $p < 0.05$) between SPJ and DJ RSI, which is equivalent to the results of this study. However, in the present study, RJ was used for RSI measurements, whereas Pleša et al. (2022) used a drop jump (DJ). In addition, differences in the implementation of the study included the sex of the subjects and the fact that in RJ, there was a recoil of the arm swing during jumping, whereas in DJ, the arms were placed on the waist, and the measurement was performed without recoil. As a result, the DJ RSI was 1.82 ± 0.44 (m/s) and the RJ RSI was 2.20 ± 0.39 (m/s), which was higher for women. On the other hand, in a previous study, the RJ RSI for male high school students with arm swing recoil during jumping, as in this study, was 1.35 ± 0.23 (m/s) (Muhammed & Zakiye, 2023), and the DJ RSI for male university students was 1.73 ± 0.14 (m/s) and for females was 0.90 ± 0.19 (m/s) (Addie et al., 2019). It has been reported that RSI values are generally higher in men than in women (Addie et al., 2019; Talin et al., 2023). Many previous RSI measurements have used DJ without arm recoil, and there are few RJs using arm recoil, as in this study. It

is presumed that the arm swing reaction has a significant effect on RSI, and further investigation is necessary in the future. In addition, it is presumed that the difference in jumping motion is related to why the correlation between the BJ and RJ RSI was lower than that of the SPJ in this study. The results of this study also show that higher jump height than SPJ, where the player takes a forward approach toward the net and jumps, and BJ, where the player moves to the side with the net facing forward and jumps (see **Table 1**). To increase the jump height of the SPJ, it is necessary to improve the CMJ and RJ (Okano et al., 2016), which is especially important for high-level volleyball players (Okano et al., 2017). However, the results of this study showed that although players with high jump heights in BJ and SPJ tended to have high RJ RSI, the correlation between BJ and RJ RSI was not as strong as that in SPJ.

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Note

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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