

The influence of jumping performance and coordination on the spike ability of young volleyball athletes

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Abstract

Background and Study Aim Spike is the most important techniques to be mastered due to its big impacts to volleyball match. There is still lack of study to evaluate and discusses how the role of jumping performance and coordination in volleyball could affect spike ability. The purpose of this study was to determine the influence of these variables on spike ability.

Material and Methods This study used a quantitative descriptive method, involved 42 participants (20 men and 22 women). The jump performance was measured using MyJump 2 application which can measure flight time, force, jump height, jumping power and speed based on free-arm jumping method. Then, the measurement of coordination was done using an alternative hand wall test. Spike ability is shown by the results of the hit and spike performance. Spike performance was based on The Volleyball Test Skills for Smasher. For spike performance, data collection is based on observations from five phases of spike movement; i) Initial posture; ii) Initial Motion; iii) Motion of Appeal; iv) Advanced Motion; v) Placement of the ball, using the scoring points 1-4. All the data was analyzed using descriptive statistics and Pearson Correlation.

Results The results of the study show that in the perspective of gender differences, almost all variables had significant difference between men and women on flight time ($0.028 < 0.05$), force ($0.001 < 0.01$), jump height ($0.040 < 0.05$), strength ($0.001 < 0.01$), and speed ($0.028 < 0.05$), coupled with coordination ($0.003 < 0.01$), hit results ($0.181 > 0.05$), and spike performance ($0.216 > 0.05$). Meanwhile, the relationship between variables were found to be significant ($p\text{-value} < 0.01$) on the five jumping performance variables. Another significant correlation obtained from the results of calculations between coordination and jump height ($0.033 < 0.05$), coordination with strength ($0.044 < 0.05$), coordination with spike hitting results was significant ($0.003 < 0.01$). Instead of them, relationship between one and another was not found significant relationship ($p\text{-value} > 0.05$).

Conclusions Coaches can use the information in this study as a guideline to develop training program to improve their athletes effectiveness in spiking.

Keywords: spike, volleyball, jumping, performance, coordination

Introduction

Volleyball consists of a variety of sprints, jumps (blocking and spiking), and high-intensity field movements that occur repeatedly during matches [1]. In volleyball, the spike technique has a significant impact on attack and match results [2]. Volleyball spike requires special skills with high coordination demands through several stages including running, countermovement jumps, a set of explosive overhead movements in the air, and landing phase [3]. The resulting stroke will be determined by the spike phases. It requires sharp analysis from coaches and sports analysts data so that the analysis evaluation is on target and has the potential to improve and improve the spike ability of young volleyball athletes based on their individual needs.

Elementary errors can occur during jumping movements and arm-leg coordination. Due to a variety of factors, this is what causes the ball to slide out or touch the net during the attack. As a result, eye, arm, and leg coordination combine to produce a capable spike ability. The most important secret to teaching a beginner volleyball player to love the game is to stop teaching the underarm pass. Experts hope that no coaches or teachers repeat the statement that 'if you can't pass, you can't hit the ball'. When a new volleyball player is instructed to pass with their arms, they will go home and ask how to get rid of the pain in their arms after practicing, and the next day they will reconsider whether it is necessary to continue practicing because the training they do makes them sick. The first thing that needs to be altered is the method of teaching or training [4] when coaches and teachers intend to help new volleyball players develop their skills. In the process to develop the game, it should be started

with ball hitting and over passing, then move on to the serve (which is controlled by the player and has arm action that allows even young players to send the ball over the net).

Other common mistakes during spikes include running to the ball then smash (Run Up) and jumping (Take Off) too quickly even though the ball has not been released by the feeder, causing the timing with the ball to be off [5]. The ball is then out of reach and has already made a punching motion, preventing hand contact with the ball [2]. Furthermore, there is no wrist flick when hitting the ball, so the ball does not dive into the field area. Finally, when landing, using the tip of the foot should be avoided as this increase vulnerability to injury [3]. Because all of the spike stages have not been solved one by one, there are still errors in the way of learning and the athlete's grasping power to apply physical work and techniques in the field, and many people are unaware of the significant role of jumps and spike coordination on performance and shot results.

Spike applies work in two ways: running while jumping spikes with one leg and two legs [6]. As a result, physical abilities must be supported during the volleyball match. According to one previous study, elite and non-elite volleyball athletes differ in muscle strength, arm muscle strength, and aerobic endurance [7]. In one study of female athletes, the key aspects for spike jump height were; i) optimization of exposure and energy conversion, ii) wide swing arm range allows for strong counter movements, with thus increased range of motion in the lower leg, and iii) large angular velocity in the ankle and knee, particularly on the dominant side [8]. Furthermore, elite volleyball athletes require pre-match training to improve and improve physical condition, which is supported by volleyball game techniques and strategies. Muscle strength and endurance, particularly in the upper and lower extremities, are essential for serving, passing, spiking, and blocking [7]. Over the last decade, the complexity of spike analysis has steadily increased, with practical implications for both coaches and athletes. Spike success is determined by physical [9] and psychological [10] characteristics that can be captured by a variety of kinematic variables of movement [2, 11] and ball speed after momentum of the hand hitting the ball [2].

The purpose of this study is to investigate the effects of jumping performance and eye-arm coordination on spike ability, which includes spike performance and hitting results. The findings of this study are hoped to assist coaches and athletes in evaluating their spike ability and correcting deficiencies so that each stage of the spike movement has a positive effect on the results of a shot that slides hard, is directed, and enters the opponent's area.

Materials and Methods

Participants.

Female and male adolescent athletes totalled 42 subjects in this study, with 20 males and 22 females were recruited based on voluntary basis. Table 1 showed the anthropometric characteristics of the participants. This study was approved by the Human Ethics Committee of Universitas Negeri Yogyakarta.

Table 1. Data of anthropometric characteristics of the participants

Anthropometric	Average SD
Height (cm)	170.83 9.23
Weight (kg)	62.31 10.22
BMI	21.285 2.59
Height when sitting(cm)	86.15 4.44
Lower Limb (cm)	40.76 2.68
Upper Limb (cm)	47.85 3.91
Leg (cm)	22.38 2.49
Length of the leg (cm)	111 6.51
Lower Arm (cm)	25.13 2.83
Upper Arm (cm)	29.88 3.51

Research Design.

To determine the relationship between the independent and dependent variables in the data analysis, this study employs a quantitative descriptive method with the use of correlation. The components of jumping performance and coordination to spike ability are the key data variables in this study (consisting of performance and hitting results).

Data Collection.

Jumping Performance. Data retrieval for jumping performance was performed using the MyJump 2 application [12], where the instrument is valid and reliable [13], and which can measure flight time, force, jump height, power, and velocity using the free arm jump method.

Coordination. Measurement of coordination data was performed using the alternate hand wall test.

Spike Ability. This study's spike ability is the result of spike blows. The Volleyball Test Skills for Smasher was used to collect data on spike performance. The assessment in previous studies was used to determine the target area of the hit result [14]. Participants were given the opportunity to hit five times in the IV position while performing spike movements. The ball is directed by the participants to a predetermined and desired target. Balls that enter target areas A, B, C, D, or go out of bounds are scored according to the scoring system in Table 2. If a player touches the net while spiking,

the score is not recorded and the spike is repeated. The total score is the sum of the points earned from the five spike opportunities. Table 2 shows the measurement scoring of The Volleyball Test Skills for Smasher. Figure 1 also shows the assessment description when viewed from the perspective of the field image.

Table 2. Scoring system for Spike Skills Test

Target Area	Point
A	4
B	3
C	2
D	1
Beyond the area	0

Statistical Analysis

The data was processed using an independent t-test to determine gender differences in ability and a multi-correlation analysis to determine the magnitude of the relationship between jumping performance and coordination elements and spike ability. The data analysis results are expected to reveal which variables have the most powerful influence on the ability to spike between jumping performance and coordination, as well as the relationship between the four existing variables.

Results

Data analysis begins with a gender perspective, male and female, obtaining data on each component, where there are eight different components: Flight time, Force, jump height, power, velocity, coordination, spike results, and spike performance

in Table 3. Except for results ($p = 0.181, p > 0.05$), almost all variables indicated a significant difference between men and women in the measurement variables of flight time ($p = 0.028, p < 0.05$), force ($p = 0.001, p < 0.01$), jump height ($p = 0.040, p < 0.05$), power ($p = 0.001, p < 0.01$), velocity ($p = 0.028, p < 0.05$), and coordination ($p = 0.003, p < 0.01$).

Table 3. Comparison of measurement component between men and women

Measurement Component	Sig.
Flight time	0.028*
Force	0.001**
Jump height	0.040*
Power	0.001**
Velocity	0.028*
Coordination	0.003**
Spike Ability	0.181

* significant correlation ($p\text{-value} < 0.05$); ** significant correlation ($p\text{-value} < 0.01$)

Table 4 showed that the relationship between variables appears to be significant ($p\text{-value} > 0.01$) on all five jumping performance variables. Another statistically significant correlation was found between coordination and jump height ($p = 0.033, p < 0.05$), coordination and power ($p = 0.044, p < 0.05$), and coordination with a significant spike shot ($p = 0.003, p < 0.01$). The remaining data on the relationship between one component and another was not found to be statistically significant ($p\text{-value} > 0.05$).

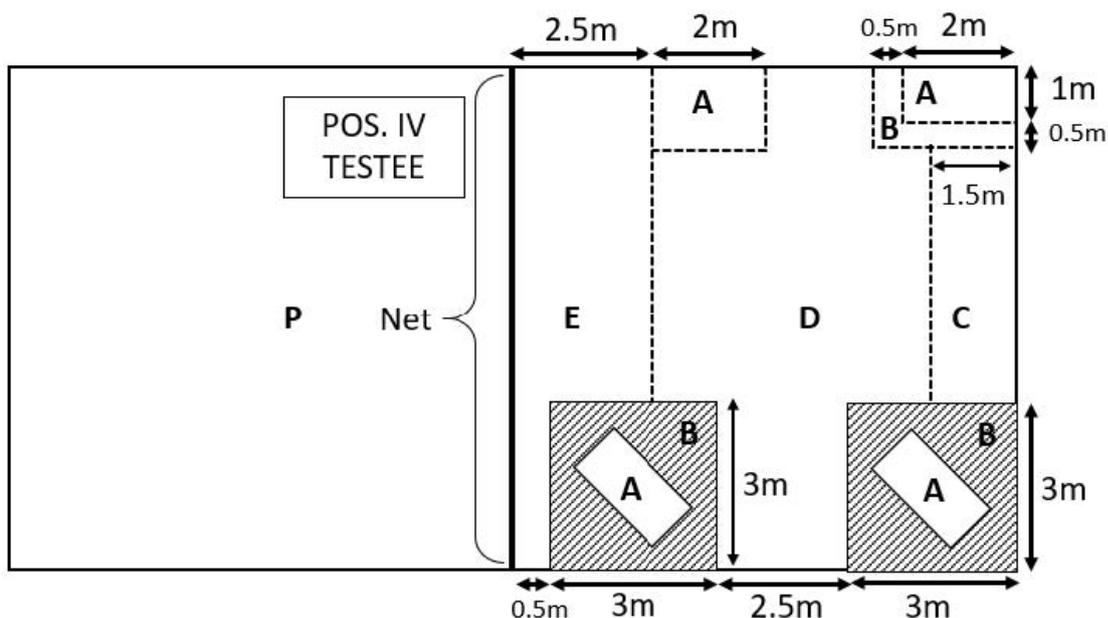


Figure 1. Upper view of scoring area of spikes [14]

Table 4. Comparison of measurement component between men and women

Components	Flight time	Force	Jump Height	Power	Velocity	Coordination	Spike Ability
Flight time	1	0.000**	0.000**	0.000**	0.000**	0.246	0.917
Force			0.000**	0.000**	0.000**	0.033*	0.502
Jump height				0.000**	0.000**	0.249	0.913
Power					0.000**	0.044*	0.576
Velocity						0.246	0.917
Coordination							0.003**
Spike Ability							1

* significant relationship (p-value < 0.05)ж ** significant relationship (p-value < 0.01)

Discussion

The topic of spikes is very interesting to learn about, and various innovations are made in terms of how to train and practice the skill. The discussion in this study is very related when viewed from the technical training program, because it refers to the primary reference in terms of the volleyball training program, i.e. the approach's footwork [15]. This study examines the components of the spike movement, demonstrating the ability of young male athletes to outperform young female athletes. In line with previous research, both male and female athletes have the same ability during the spike approach stage because they only rely on footsteps before jumping take-off. Female athletes' vertical jump ability is not significantly different [16], with an average of 3-4 feet to the jump [5]. However, what distinguishes males from females is the jump results, where the experience of the competition level is higher, thus distinguishing the ability and higher jump results [16]. Male volleyball players initiate different lower limb mechanisms than men when landing. It has been discovered that male and female college volleyball players have different landing strategies after spiking because it provides a very detailed perspective on the distribution of load on the lower extremity joints, which may influence the increased incidence of anterior cruciate ligament injury in women [17]. In one match, male athletes landed on the left (31.5 percent) or right (8.5 percent) foot more than female athletes (23.7 percent and 1.6 percent). The study looked at spike landings that showed unilateral landings (mostly left foot first for right-handed players) in both men and women, but men more frequently [18].

Every volleyball player wants to spike, but these days, being an all-rounder is the norm. When learning to spike, a player must understand the connection between all skills, movement patterns, and situations. A single examination of a complex skill can be misleading. Coaches must understand that open skills necessitate less control and parameters

when teaching volleyball. Closed skills, on the other hand, necessitate a series of work tasks in order to progress toward the outcomes of the given practice material. In the case of spiking, coaches frequently design an exercise with too much information for the nervous system, making it too difficult for newcomers. When beginners see an image of a spike movement, they frequently remember it. However, in order to learn proper movement patterns, they needed to consider the entire skill. When teaching complex skills, it is strongly advised that trainers use video clips rather than still images. This step is a powerful tool for teaching beginners and intermediate level players technique. As players advance in skill, the use of e-tutorials (video clips) and videos becomes more appropriate. Because of advancements in video technology, coaches can now use e-tutorials to provide better models for athletes who want to learn [19].

In volleyball, a spike or attack is a strategy used to send the ball over the net to the opponent in such a way that the ball cannot be returned [20]. Spike is traditionally performed by jumping with both feet. In attack, a spiker usually takes a series of steps towards the ball. The volleyball approach refers to these steps. The goal of the volleyball approach is to get into the best attacking position. So far, jumping exercises performed in conjunction with attacks (countermovement) have proven to be more effective than jumping exercises performed alone [21]. When teaching a player how to approach and hit a volleyball, the two steps before the spike are a good way to start. After mastering the 2-step training method, the athlete can progress to the 3-step or 4-step volleyball approach [5].

According to a previous study, men have a better ability to jump when swinging their arms than female athletes [16], and the conclusion of this previous study is consistent with the findings of this study, that there is indeed a significant effect, particularly on the jumping performance variable, and the five indicators in this study were all significantly related

and demonstrated male athletes' dominance over female athletes. Spike technique can be studied in greater depth for various spike movements (bow-and-arrow high and low, snap, and circular). The previous study attempted to investigate the analysis of the technique of turning the arm when spiked in beach volleyball, which has the same technical characteristics as indoor volleyball. This study included 96 elite beach volleyball athletes who used video recordings from the beach volleyball world championships. According to the findings, the two most common techniques were a low bow and arrow low (51.6 %) and a high bow and arrow high (51.6 %) (37.4 %). However, 11% of players used other strategies (circle: 6.6 %; snap: 4.4 %). Although the observed technique did not appear to affect performance, there was no significant difference in the performance of each player who mostly used variations of the arm swing technique [22]. Most importantly, when jumping, the approach or preparation step becomes the focal point, followed by hitting the ball. One female athlete study described important aspects of jump height as; i) optimized approach and energy conversion, ii) wider arm swings allowed for strong strike motion and, as a result, increased range of motion in the lower limbs, and iii) large angular velocity at the ankle and knee, particularly on the dominant side [8]. The support role of a specific joint may be affected by variations in attack technique.

Jumping is one of the issues that arises during the spike movement. The center of gravity of the body increases in spike with increasing jump distance compared to normal spiking, causing some postural changes in initial contact and ultimately increasing the ground reaction force values, peak ground reaction and average load rate. On initial contact, raised torso with elongated hips and slight knee flexion, followed by extensive joint space at the knees and ankles before moving to the heels. This is a critical component of a safer landing method [3, 23].

Spike technique is also linked to aspects of nutrition and injury risk. There are several types of fluid intake that, if consumed regularly and in the recommended amount, can provide additional energy that is positively correlated with increased physical performance leading to increased accuracy during actual volleyball matches [24], such as taking creatine supplements for four weeks and drinking caffeine-containing energy drinks [24]. It is also difficult to understand nutritional intake, what benefits can be provided when our food and beverage intake is balanced, and up-to-date knowledge of the development of nutritional science [25, 26]. Spike is performed by moving the arm with a wide arm span (the angle formed by the arm) to direct the ball to the opposing side of the field [11, 27]. Spike movement injuries are common and have the greatest impact

on the shoulder [11]. A group of fourteen female college volleyball players completed five successful trials of four different skill types: two-directional spikes, off-speed rolls, and float serve. Volleyball players with symptoms of overuse of shoulder work will be able to reduce repetition performance during training if it is related to shoulder work function during spike work. Similarly, limiting the number of jumps while serving reduces the risk of impaired shoulder function caused by excessive repetition of the movement [9].

Based on just one technique of spike, it is possible to conclude that there are numerous supporting and inhibiting factors. Supporting factors include learning spike exercise material [4], using technology to record spike movements [19], and increasing nutritional intake [24, 28]. On the other hand, motion errors such as when the spike approaches [5], the importance of jumping ability [29], the angle made from the tool analysis during the spike motion [8, 9, 27] will affect whether or not the ball enters the opponent's the landing phase's importance [3, 30] and can even result in injury. The majority of which occur in the shoulder [11, 31, 32] demonstrates how the complexity of one move that significantly contributes to the outcome of a match is the spike technique [2]. Overall, it can be concluded, in accordance with previous research, that the jumping performance component is required by volleyball athletes, particularly at the beginning of talent identification. However, for young athletes, motor coordination is an important factor in determining spike ability that is considered worthy of entering the elite level of volleyball [33]. In light of the findings of this and previous studies, it is worth emphasizing that the maturity of mastery of jumping performance and coordination of motion during spikes is a slick combination that has the potential to be a mainstay weapon for lethal attacks on the opponent's points.

Conclusions

Coaches can use the information in this study as a guideline to develop training program to improve their athletes effectiveness in spiking. It is hope for the future study to be conducted on many more factors that can contribute to enhanced performance in volleyball, as a way to improve the quality of the game specifically among elite and beginner athletes for both men and women.

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Conflict of interest

Authors declare no conflict of interest exist in this study.

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