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Height, Push-Off Angle, Explosive Power: Do they Correlate with Volleyball Athlete Jumping Performance?

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ABSTRACT

Background and Study Aim: Jump performance is the main asset in attacking volleyball. Jump performance is influenced by various factors that affect this indicator, such as body balance, upper and lower body coordination, as well as explosive power. The purpose of this study was to investigate the relationship between height, push-off angle, explosive power, and jumping performance in volleyball student athletes.

Material and Methods: The method used was a correlational, 7 male volleyball student athletes as samples (age = 21.00 ± 1.732 years, height = 167.86 ± 1.864 cm). Sampling technique used is purposive sampling, Shapiro-Wilk and Levene's test to determine normality and homogeneity. Data calculations were processed using the help of IBM SPSS version 26.0., with decision making $p < 0.05$.

Results: Variable Push-Off Angle and Explosive Power show significant results ($p < 0.05$). The Pearson correlation value for Push-Off Angle is -0.781, while the correlation value for Explosive Power is 0.908. Conversely, the variable Height does not show significant results ($p > 0.05$), with a Pearson Correlation value of -0.334. The findings indicate that the aspect of Explosive Power provides a significant contribution with a positive relationship. This is followed by the aspect of Push-Off Angle, but the results show that this aspect provides a moderate contribution with a negative relationship. Additionally, the aspect of Height shows a negative relationship and a low contribution value.

Conclusions: The Study's findings conclude that Push-Off Angle and Explosive Power have a significant correlation and play a crucial role in enhancing Jump Performance. However, Body Height does not exhibit a significant correlation with Jump Performance. These findings also conclude that the aspect that plays a crucial role in jump performance is explosive power.

KEYWORDS: Volleyball Athlete; Jumping Performance; Correlational Study

I. INTRODUCTION

Characteristics of the volleyball game is with a high vertical jump[1], this vertical jump is related to the lower body muscles [2], which leg power plays a role in this case[3]. The characteristic of this vertical jump is related to one of the techniques in volleyball[4], that is, smashes [5] which is a heavy punch, with the attack dipping sharply towards the opponent's court[6]. This is one of the most popular techniques used by athletes to collect point coffers [7]. Thus, subconsciously a high vertical jump is the most important indicator in executing a smash [3], which is supported by various variables that affect these indicators, such as body balance [8], coordination of the upper and lower body[9], and explosive power[10].

Volleyball is a complex and dynamic movement [11], meaning that the game requires more of a good physical component[12], in order to support the appearance of a more optimal performance[13], what is meant by these important components are coordination, balance, agility, speed, strength, explosive power, flexibility, and reaction speed[14]. Limb explosive power is the key to high jumps[15], there is no leg explosive power so there is no jump[16]. This is explained by Saç, that the explosive power of the limbs plays an important role in terms of jumping [17], to produce a high jump it requires a large explosive power of the limbs[18], to get it, the athlete must carry out continuous training[19].

However, other factors also potentially have a significant impact on vertical jumping and maximal explosive power, such as knee flexion angle[20], knee joint range of motion[21], and ankle dorsiflexion [22]. This because by reducing the knee and upper body inclination angles, the center of mass (CoM) can be lowered, and as a result, the acceleration path before take-off can be enhanced[7]. This theory has been explained by previous research[20], [22] wich indicates that increasing the angular velocity of hip and knee joints, combined with the efficient use of arm swings, can enhance vertical jumping during the take-off phase [4], [23].

The concept of vertical jumping is closely related to the height of the athlete as well. Typically, volleyball players have tall body postures and are capable of quick movements in all directions[24]. The average height form female volleyball players is approximately 1.80 ± 0.06 meter meters [25], while for males, the average height is around 193.6 ± 8.4 cm[26]. One theory explains that when a volleyball player performs a spike, jump serve, and block, it is important for them to have an above-average height so that they can combine the power and strength of their lower exermities during vertical jumps[27]. Other studies also indicate that body composition, including height, has a significant correlation with jumping ability[28].

Several findings indicate that lower extremities, such as explosive power, push-off angle, and height, make positive contributions to the performance of volleyball athletes in jumping. [29] This research demonstrates a significant correlation between the results of the Countermovement jump (CMJ) test and jump height. Other findings also reveal a stronger correlation between explosive strength and jump height [30]. Furthermore, this study confirms the curcial role of knee angle in the take-off phase to achieve maximum vertical height[23]. Other findings provide insights that increasing the acceleration of knee extension angle correlates with jump height[22].

Based on the findings of previous studies that indicate a positive correlation between height, push-off angle, and explosive power with jump height, researchers are interested in further exploring these variables. This is due to the lack of research that combines these three variables in a single study. Therefore, the researchers aim to combine the variables of height, push-off angle, and explosive power in one study to provide new contributions to this research field. Furthermore, this study will be conducted in a different location with a different sample. In this research, the goal is to determine the extent to wich height, push-off angle, and explosive power variables contribute to vertical jump performance in volleyball athletes.

II. MATERIALS AND METHODS

A. Participants

The research protocol was approved by the Department of Sports Science, Sports Coaching Education Program, Faculty of Education at Tanjungpura University, Pontianak, Indonesia, on September 14, 2020. The sampling technique used porposive sampling, and the sample selection criteria included: 1) members of the core volleyball team at a university, 2) Male gender, and 3) experience participating in championships in accordance with rules of the Indonesian Volleyball Association (PBVSI). A total seven male volleyball players from the core team of the Sports Coaching Education Program volunteered to participate in this study. The average age was 21.00 ± 1.732 years, and their average height was 167.86 ± 1.864 cm. To ensure the athletes' eligibility for this study, brief health information was collected from each athlete. No pain complaints were reported during the testing process.

B. Research Design

In this study, we analyzed the variables of push-off angle in the skill of a volleyball spike performed bya participants. The analysis was conducted usin the Kinovea software (Version 0.9.4). Volleyball spike skill videos were recorded using a single camera (Canon EOS 400d) with a 170° field of view, MOV video format, 720 fps, and a screen resolution of 1280*720 in a 16:9 aspect ratio. The camera was aimed at the subject and the court shown in Figure 1. To measure explosive power of the volunteers, the researchers used a simple modified vertical jump testing device. To measure height, a height measuring tool was employed. Meanwhile, jump performance was assessed using a vertical jump test.

Each athlete was instructed to wear fitted clothing, such as shorts and sleeveless shirts. Furthermore, all athletes were asked to warm up according to their normal routine to ensure optimal performance. After warming up, the athletes prepared to perform the volleyball spike skill, including the initial stage, jump, contact, and landing. Each athlete was given three attempts to perform the spike skill to obtain information about the push-off angle and jump height from our sample, wich consisted of the main volleyball players from the Sports Coaching Education Program. Data collection took place on the volleyball court of the Department of Sports Science, Sports Coaching Education Program, Faculty of Education at Tanjungpura University, Pontianak.

C. Statistical Analysis

The data analysis procedure in this study includes calculating the mean, standard deviation (SD), and variance as descriptive statistical indicators. Additionally, the Pearson correlation test is used assess the correlations between all identified variables

based on similar research. Furthermore, we conducted the Shapiro-Wilk test to assess the normality of the data and the Levene test to determine data homogeneity. Statistical significance was analyzed at a significance level of 0.05 ($p < 0.05$). The data obtained were analyzed using SPSS statistical software (SPSS for Windows, version 26.0, SPSS Inc., Chicago, Illinois, USA).

III. RESULTS

Table 1 presents the results of the desription of the independent variables, providing information about the mean values ± SD, and variance of the varibles observed in the study.

Table 1. The Results of the Description Obesrved Variables

	N	Variances	Means	SD
Age	7	3.000	21.00	1.732
Height	7	3.476	167.86	1.864
Push-off Angle	7	204.143	153.86	14.288
Explosive power	7	12.238	34.29	3.498
Jumping Performance	7	42.286	53.43	6.503

Table 2. Analysis Results of Push-Off and Jumping Performance

Initial Name	Push-Off Angle (°)	Jumping Performance, (cm)
B	153	53
D	183	46
DW	136	62
F	154	58
H	153	50
R	151	48
U	147	57

Note: °- angle, cm-centimeter

Table 2 presents the results of the analysis of the push-off angle and jump performance, with the push-off angle aspect analyzed using the Kinovea software. Meanwhile, jump performance was assessed using the vertical jump test. Based on the analysis measuring the push-off angle using the Kinovea software, among the seven samples, the maximum value of the push-off angle was 183°. Meanwhile, the minimum value of the push-off angle was 136°. This was followed by an analysis of jump performance using the vertical jump test, where the maximum jump performance value was 62 cm and the minimum jump performance value was 46 cm.

Table 3 shows the results of the Shapiro-Wilk test, indicating that all examined variables have a normal distribution, with values of $p > 0.05$.

Table 3. Results of the Normality Tets of Research Data

Shapiro-Wilk				
		Statistic	df	Sig.
Variables	Height, (cm)	0.898	7	0.319
	Push-off Angle, (°)	0.820	7	0.064
	Explosive Power, (kg)	0.941	7	0.644
	Jumping Performance, (cm)	0.969	7	0.888

Table 4. Results of the Homogeneity Test of Research Data

Levene statistics	Based on Mean	df1	df2	Sig.
	1.909	3	24	0.115

Table 5 displays tha correlation results between height, push-off angle, and explosive power with volleyball jump performance. Significant correlations are observed at the 0.05 level (2-tailed). A significant positive correlation is found between

explosive power and jump performance ($p < 0.05$). Conversely, a significant negative correlation is observed between height and jump performance ($p > 0.05$), and between push-off angle and jump performance ($p < 0.05$).

Table 5. The Relationship or Connection Between Independent Variables and Dependent Variables

Correlations				
Variables		**Height**	**Push-off Angle**	**Explosive Power**
Jumping Performance	Pearson Correlation	-0.334	-0.781	0.908
	Sig. (2-tailed)	0.464	0.038	0.005

IV. DISCUSSIONS

This research aims to test whether height, push-off angle, and explosive power are related to jump efficiency in a group of male univeristy-level volleyball athletes. The data analysis results show varying correlations between these variables, reflected in the range of Pearson Correlation values from -0.334 to 0.908. However, these findings indicate a significant relationship between the independent and dependent variables ($p < 0.05$). Nevertheless, in the case of height, this relationship cannot be considered significant ($p > 0.05$).

One crucial aspect of physical ability in volleyball is the capacity to perform vertical jump [31]. Players are expected to demonstrate optimal performance in vertical jumps, wich directly relates to their attacking abilities during matches [32]. This invovles various indicators, including body balance, lower body muscle strength, coordination between the upper and lower body, and explosive strength [2,8–10].

In the context of our study, the correlation results between height and jump performance reinforce previous findings that jumping ability and height play a central role in volleyball [24]. With an average height reaching 193.6 ± 8.4 cm, players can easily perform spikes, blocks, and jump serves by combining the explosive power of their lower extremities during vertical jumps [26,27]. However, other results suggest a different direction, indicating a negative correlation between height and jump performance [33]. This is in line with the Pearson correlation results showing a figure of -0.334 and significant non-significance ($p > 0.05$). Therefore, it can be concluded that height does not significantly contribute to jump performance in volleyball, and height is not a primary factor in determining jump performance.

Height and arm length play a primary role in determining the maximum height that can be achieved, while the ability to jump most efficiently involves utilizing motor skills, particularly explosive muscle strength [27]. Silva et al., [34] argues that explosive power affects vertical jump performance. Then, reinforced by Thattarauthodiyil & Shenoy [35] which states that an important element for successful athlete performance, especially in vertical jump performance, is leg muscle strength. Findings made by Slovák et al., [36] provides evidence that about 56% explosive strength works on jump height.

A characteristic of volleyball is intense anaerobic endurance that combines explosive movement (that is, in both vertical and horizontal directions) with short recovery durations [34]. Therefore, explosive power is an important component of vertical jump performance[35]. In addition, explosive power is considered as an important element in a competitive event[37]. The data indicates that the explosive power of the leg muscles has a significant influence and plays a crucial role in enhancing jump performance when performing a spike in volleyball. These findings are consistent with the correlation analysis results in our study, which show a positive relationship between explosive power and jump performance.

However, explosive power is not the only important component of jump height, but hip, ankle, and knee strength are also correlated with jump height.[1,38], arm swing contributed to this section[39]. Not only that, muscle flexibility, body coordination, and good jumping technique are also correlated [35-37]. And the angle of repulsion of the legs can also affect the height of the jump. Optimal leg kick angle optimizes energy transfer and maximizes jumping potential. This can be seen in the findings Putra et al., [43] his findings provide information that the repulsion angle affects the jump height, at a leg repulsion angle of 136˚ can produce a jump height of 61 cm, while the repulsion angle of 183˚ can produce a jump height of around 45 cm. These findings confirm that knee flexion angle, knee joint range of motion, and ankle dorsiflexion have the potential to significantly affect jump performance [20–22]. This is because by recuding the angle of knee inclination and upper body, the center of mass (CoM) can be lowered, allowing for increased acceleration before take-off [7]. Some of these results align with the findings of our study, which also emphasizes the significant relationship between these variables and jump performance. However, it's important to note that in the correlation analysis, a negative relationship was found between the push-off angle and jump performance, with a Pearson Correlation value of -0.781. That is, the smaller the angle of repulsion produced by

student volleyball athletes, the higher the jump performance given with the help of leg muscle explosive power and support from height.

Ultimately, the results of this study can provide valuable contributions coaches in considering vertical jump performance. The key to success in executing a spike involves the speed of movement, explosive strength during jumps, and other factors [1,3,7,27]. However, it's important to note that height has less influence on jump performance in volleyball. This data can be analyzed togheter with coaches and fitness trainers to design effective training modules, especially in the context of plyometric training aimed at improving lower extremity strength and explosive power from the floor surface [44].

V. CONCLUSIONS

The findings of this investigation in this study conclude that the push-off angle and explosive power are important factor positively associated with significant jump performance. However, height does not exhibit a significant positive relationship with jump performance. In addition to the variables investigated in this study, there are many other indicators that play a crucial role but were not measured in this research. For future research, it is recommended to include other variables related to jump performance, involving a broader population. It is hoped that this study can serve as a reference foundation for further research or updated studies in the future.

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