The relationship between explosive power, elbow angle, and jump height with smash accuracy in volleyball games: correlational studies

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How to Cite

Abstract

Background and purpose
Background. Smash is synonymous with powerful punches and swift dives. Accuracy stands as the primary factor that holds significant importance. Purpose. The purpose of this study is to investigate the relationship between the independent variables, namely explosive power, elbow angle, and jump height, and the dependent variable, which is smash accuracy.

Material and Methods
Descriptive research design with correlational methods. This research involved a group of 15 male student athletes, whose age (M ± SD = 21.27 ± 1.163 years) and height (M ± SD = 167.67 ± 1.877 cm) were recorded. The sampling technique used purposive sampling, with certain criteria. Prerequisite tests such as normality test and linearity test were conducted, followed by hypothesis testing. The data was analyzed using SPSS 26.0.

Results
The results demonstrate a significant and simultaneous association between the independent variable and the dependent variable, as indicated by the observed significance value of 0.015 <0.05. The data output reveals a simultaneous correlation coefficient of $R = 0.776$, with a determination coefficient of $R^2 = 0.601$, indicating that 60.1% of the variation in the dependent variable can be explained by the independent variables. The remaining 39.9% is attributed to and explained by factors other than the independent variables.

Conclusions
The findings and discussion of the research demonstrate a noteworthy association between explosive power, elbow angle, and jump height, and the accuracy of smashes in volleyball. As a result, this study presents substantial evidence supporting the significant contributions of explosive power, elbow angle, and jump height to smash accuracy.

Keywords: smash accuracy, student athlete, volleyball
Анотація
Мартінес Едісон Путра, Фаузи, Фаїдилла Курніаван, Нові Ресмі Нінгрум, Нугрохо Сусанто. Відносини між вибуховою силою, кутом ліктя та висотою стрибка з ударною точністю у волейболі: кореляційні дослідження

Обґрунтування і мета
Нападаючий удар є синонімом потужних ударів і стрімких стрибків. Точність виступає як основний фактор, який має велике значення. Мета. Метою цього дослідження є дослідження зв’язку між незалежними змінними, а саме вибуховою силою, кутом ліктя та висотою стрибка, та залежною змінною, якою є точність удара.

Матеріал і методи
Описовий дизайн дослідження кореляційними методами. У цьому дослідженні взяла участь група з 15 чоловіків-спортоменів-студентів, чий вік (M ± SD = 21,27 ± 1,163 року) і зріст (M ± SD = 167,67 ± 1,877 см) реєструвалися. Техніка вибірки використовувала цілеспрямовану вибірку за певними критеріями. Були проведені попередні тести, такі як тест на нормальності і тест на лінійність, а потім перевірка гіпотез. Дані були проаналізовані за допомогою SPSS 26.0.

Результати
Результати демонструють значний і одночасний зв’язок між незалежною змінною та залежною змінною, про що свідчить спостережуване значення значущості 0,015 <0,05. Вихідні дані показують одночасний коефіцієнт кореляції R = 0,776 з коефіцієнтом детермінації Rsquare = 0,601, що вказує на те, що 60,1% варіації залежної змінної можна пояснити незалежними змінними. Решта 39,9% приписується та пояснюється факторами, відмінними від незалежних змінних.

Висновки
Висновки та обговорення дослідження демонструють значний зв’язок між силою вибуху, кутом ліктя та висотою стрибка, а також точністю ударів у волейболі. У результаті це дослідження представляє вагомі докази, що підтверджують значний внесок взривної сили, кута ліктя та висоти стрибка на точність розбивки. 

Ключові слова: точність удару, студент-спортсмен, волейбол

Аннотация
Мартинес Эдисон Путра, Фаузи, Фаидилла Курниаван, Новые Ресми Нингрум, Нугрохо Сусанто. Соотношения между взрывной силой, углом локтя и высотой прыжка с ударной точностью в волейболе: корреляционные исследования

Обоснование и цель
Нападающий удар является синонимом мощных ударов и быстрых прыжков. Точность выступает в качестве основного фактора, который имеет большое значение. Цель. Целью данного исследования является изучение взаимосвязи между независимыми переменными, в том числе взрывной силой, углом локтя и высотой прыжка, и зависимой переменной, которая является точностью удара.

Материал и методы
Описательный дизайн исследования с использованием корреляционных методов. В данном исследовании приняли участие 15 студентов-спортсменов мужского пола, у которых регистрировались возраст (M ± SD = 21,27 ± 1,163 года) и рост (M ± SD = 167,67 ± 1,877 см). В методе выборки использовалась целенаправленная выборка по определенным критериям. Были проведены предварительные тесты, такие как тест на нормальность и тест на линейность, с последующей проверкой гипотез. Данные были проанализированы с использованием SPSS 26.0.

Результаты
Результаты демонстрируют значительную и одновременную связь между независимой переменной и зависимой переменной, о чем свидетельствует наблюдаемое значение значимости 0,015 <0,05. Выходные данные показывают одновременный коэффициент корреляции R = 0,776 с коэффициентом детерминации Rsquare = 0,601, что указывает на то, что 60,1% вариаций зависимой переменной можно объяснить независимыми переменными. Остальные 39,9% объясняются факторами, отличными от независимых переменных.

Выводы
Результаты и обсуждение исследования демонстрируют заметную связь между взрывной силой, углом локтя и высотой прыжка, а также точностью ударов в волейболе. В результате в этом исследовании представлены существенные доказательства, подтверждающие значительный вклад взрывной силы, угла локтя и высоты прыжка в точность удара.

Ключевые слова: разбивочная точность, студент-спортсмен, волейбол
Introduction

The smash technique in volleyball is characterized by powerful strikes and precise dives towards the opponent’s area [1], making it a favored technique among athletes for scoring points [2]. The act executing a smash is frequently correlated with a substantial vertical jump [3,4]. Several factors contribute significantly to the effectiveness of the smash technique [5], including lower and upper body muscle strength [5,6], which encompasses explosive power, body coordination, balance, and other factors [6–10].

Volleyball is known for its intricate and dynamic movements [11,12], requiring various physical attributes to enhance performance [13,14]. These essential attributes include coordination, balance, agility, strength, explosive power, flexibility, and reaction speed [3,15,16]. These components are crucial for executing the smash technique [12,17], as it relies not only on physical capabilities but also on precision [12]. The primary aim of implementing the smash technique is to tactically position the ball in a manner that optimizes the chances of scoring [18].

Among these factors, accuracy plays a pivotal role [18,19]. Accuracy refers to an individual’s ability to accurately estimate distances and coordinate body movements swiftly and effectively [12,15]. Achieving optimal accuracy requires precise control over muscle movements, directing them towards a specific target [12]. Volleyball players strive to contribute to their team’s success by executing fundamental skills, such as serves, blocks, and particularly spikes, with great accuracy and precision [15]. Therefore, mastering these skills is essential for excelling in the game [18].

The purpose of the study. Based on the aforementioned characteristics of volleyball and the significance of the smash technique, it becomes crucial to focus on accuracy. However, achieving accurate and precise smash performance relies on various aspects, including balance, control, coordination, explosive power, and more. Therefore, the researcher aims to investigate the variables related to smash accuracy. The objective of this study is to acquire a comprehensive comprehension of the variables that exert the most substantial impact on accuracy in smash techniques. As a result, the researcher intends to establish a correlation between explosive power, elbow angle, jump height, and smash accuracy among volleyball athletes.

Materials and methods

Experimental approach to the problem

The primary aim of this study is to examine the association between the independent variables, namely explosive power, elbow angle, and jump height, and the dependent variable, which is smash accuracy. The research design adopted in this study is a descriptive approach integrating correlational methods.

Participants

Throughout the study, the participants involved in this research were male student athletes in the sport of volleyball (n = 15, M ± SD = age, 21.27 ± 1.163 years, height, 167.67 ± 1.877 cm).

This research has been provided in accordance to ethical principles embodied in the Helsinki Declaration.

Sampling technique

The study employed purposive sampling as the sampling technique, whereby the selection of participants was based on predetermined characteristics. The criteria for sample selection included: firstly, being part of the core team at a university; secondly, being male; and thirdly, having participated in a championship following the guidelines of the Indonesia Volleyball Association (PBVSI).

Statistical Analysis

Descriptive statistics were computed for the entire dataset and presented as the mean and standard deviation (mean±SD). The assess the distribution of the data, both the normality test and linearity test were conducted. The significance level was set at 5%. The data were collected through measurement tests, including a vertical jump test to measure leg power, and the analysis of elbow angle and jump height was performed using Kinovea software. Additionally, a smash accuracy test was administered. All statistical calculations were conducted using SPSS software version 26.0.
**Results**

The data obtained from each of these variables are then grouped and analyzed with statistics as follows:

*Table 1*

Data Description of of Test Result for Explosive Power, Elbow Angle, Jump Height and Smash Accuracy

<table>
<thead>
<tr>
<th>Explosive Power</th>
<th>Elbow Angles</th>
<th>Jump Height</th>
<th>Smash Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samples</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Means</td>
<td>31.07</td>
<td>33.67</td>
<td>39.60</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>4,317</td>
<td>4,353</td>
<td>5,692</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7,518</td>
</tr>
</tbody>
</table>

Based on the provided data description table, the following information can be obtained: For the variable “explosive power”, based on the research conducted on a sample of 15 male student volleyball athletes, the average explosive power was found to be 31.07 with a standard deviation of 4.317. Regarding the variable “elbow angle”, the data description from the research with the same sample revealed an average elbow angle of 33.67 with a standard deviation of 4.353. As for the variable “jump height”, the research findings from the sample of 15 male student volleyball athletes showed an average jump height of 39.60 with a standard deviation of 5.692. Lastly, for the variable “smash accuracy”, the data description based on the research conducted on the same sample indicated an average smash accuracy of 104.67 with a standard deviation of 7.518.

The normal distribution of the data in this study was assessed using the Shapiro-Wilk test. The results of the normality test performed on the data of the explosive power (X1), elbow angle (X2), jump height (X3) and smash accuracy (Y) variables in this study are as follows:

*Table 2*

The Normality of the Data Was Evaluated Using the Shapiro-Wilk Test

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Linearity</th>
<th>Significance (Sig.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smash Accuracy * Explosive Power</td>
<td>Deviations from linearity</td>
<td>0.743</td>
</tr>
<tr>
<td>Smash Accuracy * Elbow Angle</td>
<td>Deviations from linearity</td>
<td>0.625</td>
</tr>
<tr>
<td>Smash Accuracy * Jump Height</td>
<td>Deviations from linearity</td>
<td>0.738</td>
</tr>
</tbody>
</table>

Based on the linearity test results, the linearity between smash accuracy and explosive power was found to be 0.743 > 0.05, the linearity between smash accuracy with elbow angle was 0.625 > 0.05, and the linearity between smash accuracy with jump height was 0.738 > 0.05. These results indicate that there is a linear relationship between the independent variables and the dependent variable. With the completion of the prerequisite test calculations presented in the table above, the next step is to calculate the correlation between the independent variables and the dependent variable.

*Table 4*

Correlation Analysis Results of Each Predictor

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Notes: "" - The correlation is statistically significant at the 0.01 level (two-tailed); "*" - The correlation is statistically significant at the 0.05 level (two-tailed); a – Correlation is calculated using the Pearson method; r – Pearson
correlation coefficient; \( p - \) p-value (two-tailed) 0.05

Pearson’s bivariate correlation test was used to analyze the relationship between explosive power, elbow angle, jump height, and smash accuracy. According to table 4, the correlation analysis reveals the following results: explosive power \((X1)\) and smash accuracy \((Y)\) have a significant correlation with a significance value of 0.028 <0.05, elbow angle \((X2)\) and smash accuracy \((Y)\) have a significant correlation with a significance value of 0.037 <0.05, height jump \((X3)\) with smash accuracy \((Y)\) have a significant correlation with a significance value of 0.022 <0.05. These findings indicate a significant relationship between the independent variables and the dependent variable.

With a sample size \((N)\) of 15 and a significance level of 5%, the critical correlation coefficient \((r_{table})\) is 0.514. The calculated correlation coefficient \(r_{count}\) are as follows: 0.566 > \(r\) table 0.514 for explosive power \((X1)\), 0.542 > \(r\) table 0.514 for elbow angle \((X2)\), and 0.584 > \(r\) table 0.514 for height jump \((X3)\). Since all the calculated correlation coefficients are greater than the critical correlation coefficient, the null hypothesis \((H_0)\) is rejected. This implies that explosive power accounts for 32.1% of the variation in smash accuracy, while 67.9% is influenced by other factors beyond the variable \(X\). Similarly, the correlation between elbow angle \((X2)\) and smash accuracy \((Y)\) yields an \(R\) value of 0.542, with an \(R^2\) of 0.294. Consequently, elbow angle contributes to 29.4% of the variance in smash accuracy, while 70.6% is attributed to other factors unrelated to variable \(X\). Regarding the correlation between height jump \((X3)\) and smash accuracy \((Y)\), the \(R\) value is 0.584, resulting in an \(R^2\) of 0.341. This indicates that height jump explains 34.1% of the variation in smash accuracy, while the remaining 65.9% is influenced by factors outside the variable \(X\).

In summary, these correlation and coefficient of determination values demonstrate the extent to which each independent variable (explosive power, elbow angle, and jump height) affects smash accuracy. The majority of the variation in smash accuracy is influenced by factors beyond these variables.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Correlation ((R))</th>
<th>Coefficient of Determination ((R^2))</th>
<th>(F)</th>
<th>Significance ((Sig.))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explosive Power * Smash Accuracy</td>
<td>0.566</td>
<td>0.321</td>
<td>6.137</td>
<td>0.028</td>
</tr>
<tr>
<td>Elbow angle * Smash Accuracy</td>
<td>0.542</td>
<td>0.294</td>
<td>5.406</td>
<td>0.037</td>
</tr>
<tr>
<td>Height Jump * Smash Accuracy</td>
<td>0.584</td>
<td>0.341</td>
<td>6.735</td>
<td>0.022</td>
</tr>
</tbody>
</table>

The provided table illustrates the correlation coefficient \((R)\), representing the strength of the relationship, and the coefficient of determination \((R^2)\), indicating the percentage of variance in the dependent variable explained by the independent variable. For the correlation between explosive power \((X1)\) and smash accuracy \((Y)\), the \(R\) value is 0.566, and the corresponding \(R^2\) is 0.321. This implies that explosive power accounts for 32.1% of the variation in smash accuracy, while 67.9% is influenced by other factors beyond the variable \(X\). Similarly, the correlation between elbow angle \((X2)\) and smash accuracy \((Y)\) yields an \(R\) value of 0.542, with an \(R^2\) of 0.294. Consequently, elbow angle contributes to 29.4% of the variance in smash accuracy, while 70.6% is attributed to other factors unrelated to variable \(X\). Regarding the correlation between height jump \((X3)\) and smash accuracy \((Y)\), the \(R\) value is 0.584, resulting in an \(R^2\) of 0.341. This indicates that height jump explains 34.1% of the variation in smash accuracy, while the remaining 65.9% is influenced by factors outside the variable \(X\).

In summary, these correlation and coefficient of determination values demonstrate the extent to which each independent variable (explosive power, elbow angle, and jump height) affects smash accuracy. The majority of the variation in smash accuracy is influenced by factors beyond these variables.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Correlation ((R))</th>
<th>Coefficient of Determination ((R^2))</th>
<th>(F)</th>
<th>Significance ((Sig.))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explosive Power, Elbow Angle, Height Jump with Smash Accuracy</td>
<td>0.776</td>
<td>0.601</td>
<td>5,534</td>
<td>0.015</td>
</tr>
</tbody>
</table>

Based on the summarized regression analysis presented in the table above, the correlation calculation between explosive power \((X1)\), elbow angle \((X2)\), height jump \((X3)\) and smash accuracy \((Y)\) yields a significance value of 0.015 <0.05. Therefore, it can be concluded that there is a significant simultaneous relationship between the independent variables and the dependent variable.
The table also provides the simultaneous correlation coefficient, denoted as R, which has a value of 0.776. This value indicates that the relationship between all the independent variables and the dependent variable is nearly perfect. Furthermore, the coefficient of determination, represented by R-square, is calculated to be 0.601. This implies that the combined influence of the independent variables on the dependent variable is 60.1%, while the remaining 39.9% is influenced by other factors beyond the variables X.

In summary, the regression analysis results indicate a significant simultaneous relationship between the independent variables (explosive power, elbow angle, jump height) and the dependent variable (smash accuracy). The correlation between these variables is nearly perfect, and the independent variables collectively explain 60.1% of the variance in the dependent variable. The remaining variance is attributed to other factors not accounted for by the variables X.

**Discussion**

This study aims to investigate the association between explosive power, elbow angle, jump height, and smash accuracy in volleyball. The findings reveal a significant correlation with a significance value of 0.015 < 0.05, rejecting the null hypothesis (Ho). Therefore, this study provides evidence of a substantial link between explosive power, elbow angle, jump height, and smash accuracy in volleyball. Previous studies [20–22] have also reported similar results, further emphasizing the noteworthy relationship between these variables and smash accuracy.

Considering the crucial role of the smash in scoring points, it is essential for players to possess solid physical components. Therefore, the improvement of smash skills can be achieved through various training methods. Individual efforts to enhance smash skill in volleyball can be accomplished through cooperative methods, utilizing multiple cycles to manage progress [23]. Additionally, the hanging balls training method has shown effectiveness in improving smash abilities [24]. Resistance training methods can also be developed to enhance smash skills in volleyball [25]. From the findings of these three studies, it can be concluded that diverse training methods can improve a person’s smash ability.

In the game of volleyball, the strength and capability of the lower and upper leg muscles significantly impact performance [2,26]. Jumping ability is also crucial as it facilitates attacking the opponent’s territory to earn points [17]. Therefore, the improvement of jumping ability in volleyball necessitates employing various training methods such as plyometric training, resistance training, and traditional training [27–30]. Based on the aforementioned research, it is evident that multiple factors must be considered to enhance players’ abilities in the game of volleyball.

Numerous training methods have been applied to enhance smash skills among athletes, and research results have confirmed their success. For example, the application of the part and whole training model has demonstrated improvements in the smash skills of novice players in volleyball game [31]. Therefore, the ability to smash is influenced by factors such as strength, speed, balance and coordination in reading the game situation. Plyometric exercises have proven to be effective in improving jumping ability for executing smashes [32]. Furthermore, research indicates that employing two training methods can enhance jumping ability in volleyball smashes [33].

It is apparent that plyometric exercises can increase jump height in volleyball smashes [29,34]. Moreover, the ability to jump in volleyball smashes is closely linked to speed and strength [28]. Thus, plyometric training is highly efficient due to its capacity to enhance strength, speed, and balance [33].

In volleyball, players aim to score points and win games by accurately executing basic skills such as serves, blocks, and smashes [15]. Consequently, volleyball players must exhibit expertise in performing these skills [18]. Accuracy plays a vital role and is a major contributing factor in executing the smash technique [18]. Estimating distances and coordinating body movements at high speeds during gameplay heavily relies on individual skills, which refer to a person’s level of accuracy [12,15]. Attaining a good level of accuracy necessitates complete control over muscle movements directed towards a specific target [12].

Smash accuracy measures the degree to which a smash reaches the intended target, such as the predicted angle or area that generates points [35]. It is commonly believed that maximum explosive power can result in high volleyball speed, increasing the likelihood of the ball penetrating the opponent’s defense. However, if explosive power is not properly
controlled, smash accuracy may suffer, causing the ball to be too forceful or deviate from the intended target [24]. Previous researchers have indeed affirmed the relationship between explosive power and smash accuracy [25]. Furthermore, the correct elbow angle can significantly impact smash accuracy [20]. Elbow angles that are too acute or wide can result in inaccurate smashes [12]. These findings are supported by research that emphasizes the importance of adjusting the elbow angle appropriately to achieve the desired target [18].

Jump height is another crucial component as it enables players to assume better positions for executing smashes [36,37]. Several studies have demonstrated that sufficient jump height provides players with additional time to select the correct elbow angle and yield optimal explosive data for smashes [22]. Moreover, a good jump height enables players to effectively surpass the opponent’s defense [38]. Collectively, these studies underscore the interrelatedness and influence of various factors in the game of volleyball.

**Conclusion**

The aforementioned research findings demonstrate a robust correlation between explosive power, elbow angle, and jump height with smash accuracy in the context of volleyball games, drawing upon previous research references. The results and discussion of the study substantiate a significant association between explosive power, elbow angle, and jump height with smash accuracy in volleyball. Therefore, this study provides substantial evidence indicating the noteworthy contributions of explosive power, elbow angle, and jump height to smash accuracy.

Nevertheless, it is crucial to acknowledge the limitations of this study. The limitations primarily stem from the observation of activities exclusively involving student athletes, with the sample consisting solely of male student athletes. Consequently, generalizing the findings necessitates cautious consideration.

The outcomes of this study bear significant implications within the realm of volleyball games. The newly established reference concerning the factors influencing smash accuracy in this sport can serve as a valuable resource for sports coaches and educators. By attentively addressing the identified influential factors, they can devise more effective training strategies to enhance players’ smash accuracy.

**Conflict of Interest**

Authors do not have any conflicts of interest to declare.

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