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Original Article

Investigation of the relationship between vertical jump and core performance on competition shooting performance in elite female basketball players

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Abstract
Objective of the Study: The aim of the study is the examination of the relationship between vertical jump and core performances compared to shooting test and shoot accuracy. **Method:** The research group comprise of elite female athletes (n=10) competing in the Turkish Basketball Federation Women's 1st League. In the study vertical jump, plank test (core), and shooting test measurements were included. The vertical jump performances of the athletes were measured by usingthe Smart Speed® brand device; the Smart Jump® measuring mat. the "Sport-Specific Core Muscle Strength and Stabilization" test was used to test the athletes' core performance. The "Aahperd" shooting test was used to determine the athletes' shooting performance. In addition, the average points per game values to shooting accuracy of the athletes were obtained from the official competition data they played in the 2020-2021 season. The relationship between vertical jump and plank test scores compared to shooting test and shooting accuracy was analyzed statistically ($p<0.05$). SPSS package program (IBM, 24.0 v) was used for statistical analysis of the data. **Findings:** According to skewness, and kurtosis coefficients distribution of the datas resulted to be normal (mesocurtical) (±3). Based on the normality of the datas, in order to determine correlations between variables Pearson correlation analysis was used. **Conclusion:** As a result, it was determined that there was a high level of positive correlation between the vertical jump test and the Aahperd shooting test and the average points per a game values of the athletes participating in the study ($p<0.05$). In addition, it was determined that there was no significant relationship between the results of the plank (core) test, the average points per a game values and the results of the Aahperd shooting test ($p>0.05$).
Keywords: Jump, stabilization, plank, shooting performance, game performance, shooting accuracy

Introduction

Basketball is one of the most followed branches among team sports. The fact that basketball is a fast game increases the excitement and attracts the attention of the audience. Basketball is an anaerobic branch, the athletes have to do many short-term and high-intensity movements such as rebounds, shots, blocks during the competition. It can be said that basketball is a complex sport that requires many different motor skills. Such as which is characterized by the repeated sprints, jumps and high-intensity runs (Delextrat et al., 2015), basketball also can be defined as primarily anaerobic sport which players frequently exposed to more than approximately 3000 movements (Matulaitis, Sirtautas, Kreivyte, & Butasutas, 2021), in addition it can be well-defined as an intermittent and multiskilled team sport (Erculj, Blas, & Bracic, 2010) that requires a wide variety of physical characteristics (Mancha-Triguero, García-Rubio, Gamonales, & Ibáñez, 2021). However, transferring the mentioned motor skills to competition performance is as important as the development of these motor skills. This situation is thought to affect the performance, especially the lower extremity strength, as well as the level of core strength for the continuity of movement before and after each jump.

The relationship between force and power has an important place for performance. Thanks to the increased strength and power, the athletes can jump higher and produce the force they will need one after the other, with the development of the nervous conduction system (Rice et al., 2017). It can be said that vertical jump comes to the forefront, which is one of the basic parameters that reveal the power that is dominant especially in the lower extremity strength. The vertical jump is defined as a movement that requires a high level of motor coordination between the upper and lower extremities. The maximum jump height achieved by an individual, which is accepted as an indicator of leg muscle strength, is accepted as one of the basic criteria for performances such as rebound, block and shot in basketball (Rodríguez-Rosell, Mora-Custodio, Franco-Márquez, Yáñez-García, & González-Badillo, 2017). In addition, in basketball, where many anaerobic movements such as vertical jump and sprint are performed, core strength is stated as another prominent element for balance and movement quality. Core Strength ensures the correct basketball-specific stance and the correct start and completion of the movement (Sannicandro & Cofano, 2017). Muscle strength and endurance around the lumbar spine are required to maintain functional stability during both upper and lower extremity movements. This area includes the abdominal muscles anteriorly, the paraspinal and gluteus posteriorly, the diaphragm above, and the pelvic floor and hip girdle muscles below, and is defined as the "core". The purpose of the core

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muscles is to control and stabilize. The core helps distribute the forces generated by the upper and lower limbs by allowing as a connection between the lumbosacral area and the upper and lower parts of the body. In sports, the core becomes particularly important as it provides proximal stability for distal mobility. Core stability turns out to be an important component of biomechanical efficiency as it leads to maximum force generation, thereby reducing loads on peripheral joints (Arora, Singh, & Varghese, 2021). With the development of the biomechanical proficiency level, shooting performance, which is the product of complex skill, gains importance for basketball.

Competition statistics can express as the quantitative data of the developed motor skills associated with performance. When we think of statistically evaluating the transfer of a motor skill to performance, the first thing that comes to mind is probably shooting performance. It can be said that one of the most important statistics that determines the winner and the loser in a basketball competition is the shoot accuracy (Krause & Nelson, 2018). Shooting technique is probably the most well-known basic skill in basketball and athletes performance is directly correlated to this technique (Krause & Nelson, 2018). Also, shooting is the most important skill in basketball (Wissel, 2018).

Considering that the shooting technique is one of the most important skill in basketball and that its's accuracy is decisive for winning or losing the competition, it is interesting to see which motor skills affects shooting accuracy. Vertical Jump performance has been regarded as measure of athleticism in sport (Montalvo et al., 2021). Also, it can be said that one of the basic movement skills applied during shooting in basketball is vertical jump (Hoffman, Stavsky, & Folk, 1995). In addition, it is thought that the effectiveness of the core muscles, which provides balance and staying in the air during this jump, take an important role on athletes performance (Chen et al., 2018; Gillett, 2019). For instance, the side plank movement applied in core strength training is a exercise that improves trunk stability, thus increasing higher jumping and faster running skills. So with this training we can provide development the balance of the upper body which is important during shooting with a strong core strength (Cole & Panariello, 2015). Also, the jump height during the shooting makes it easier for the player to shooting from a smaller angle, thus reducing the need to have a high level of movement speed required for an accurate shoot (Malone, Gervais, & Steadward, 2002; Miller & Bartlett, 1993; Reinschmidt, 1997). Usually, players are asked to release the ball at the highest point they can reach during the shooting (Elliott, 1992; Knudson, 1993).

According to the previous information, the aim of the study is the examination of the relationship between vertical jump, core performances and shoot accuracy.

Methods

Research Model:

This study was carried out using the relational survey model, which is among the quantitative research methods. The relational screening model used in this study is a screening model that aims to determine the existence or degree of co-variance between two or more variables (Karasar, 2005).

Participants:

The research group of the study comprise of 10 elite (A team) female athletes who compete in the TBF Women's 1st League, and play licensed in "Çeşme Basketball Sports Club" (A team)

Procedure:

10 elite level female basketball players aged 20 and over in Çeşme Basketball Sports Club voluntarily participated in the study. The athletes were informed about the risks (even there is no potential risk) and benefits of the activities at the beginning of this activity. The best score of two trials was recorded. The athletes were applied vertical jump test of smart speed brand device using smart jump measuring mat, plank test (core) to measure core stabilization and Aahperd basketball shooting test to determine shoot performance in the study. In addition, the average game point values of the athletes were obtained by using the statistics they reached in the official matches they played in the 2020-2021 season.

Vertical Jump Test; In in order to determine the vertical jump performance of the athletes, the smart jump measuring mat of the smart speed brand device was used. Athletes were asked to jump to the highest point they could jump from a 90° knee angle (Pereira et al., 2020).

Plank Test; It was conducted with the Sport-Specific Core Muscle and Stabilization Plank test battery developed by Mackenzie (2005) (Mackenzie, 2005). The validity and reliability of the test (95%, 0.94-0.99%) was carried out by Tong, Wu, and Nie (2014). The test consists of 8 stages of totally 180 seconds. The position of the back, neck and head should be maintained throughout the test. If the athlete are unable to continue to hold the position, the test is stopped (Mackenzie, 2005). The stage at which the athlete stopped holding position, is noted and recorded with its duration (Tong, Wu, & Nie, 2014).

Aahperd Shooting Test; Before the athletes start the shooting test, the areas where the shooting will be taken were determined at a distance of 4.57 meters from the projection of the circle and were marked with 5 training skittles placed at equal intervals. Athletes continued to shoot or took lay-ups from 5 shooting points during the given 1 minute period in accordance with the rules determined in the protocol. At the end of the given 1 minute period, each successful shooting is evaluated as 2 points, while 1 point is added to the athlete's score after an unsuccessful shoot. If the lay-up is successful with a ball returning from the hoop, it is scored as 2

points. If two successful lay-ups are made in a row, the second one is not scored. No points were awarded for shootings made with violations in dribbling, ball handling and the shooting line (Mülazımoğlu, 2012).

This study was carried out using the relational survey model, which is among the quantitative research methods.

Statistical Analysis:

An obtained data analysis was made by using the SPSS 24 package program. In order to obtain the general information's such as an average (X) and standard deviation (SD) descriptive statistics were used. In order to determine the normality of the datas the skewnees and kurtosis values were carried out. Based on these analyses obtained datas resulted to be normal (mesocurtical) (±3). Kalaycı et al., argued that coefficient values in the range of ±3 might be considered as acceptable (Büyüköztürk, 2007). Pearson's correlation analysis was applied to assess the correlation status of the parameters with a normal distribution of the data. Results of the study were considered statistically significant when the p values were below 0.05 ($p<0.05$).

Results

Table 1. Descriptive Statistics of the Participants

Variables	n	Minimum	Maximum	X±SD
Age (year)	10	20	35	23,60±4,351
Height (cm)	10	163.0	182.0	174.0±6,815
Weight (kg)	10	56.0	115.0	76,92±17,35
BMI (kg/m²)	10	18,98	35,43	25,27±4,627

Table 1 shows that the average age of 12 female athletes was 23.60±4.351, average height was 174.0±6.815 cm, while mean body weight was 76.92±17.35 kg and mean Body Mass Index was 25.27±4.627.

Table 2. Vertical Jump, Plank Test (core), Game Point Averages and Aahperd Shooting Test Values of the Participants

Variables	n	X±SD	Minimum	Maximum
Vertical Jump (cm)	10	42,20±3,881	38.0	50.0
Plank Test (core) (points)	10	7,90±1,595	5	9
Game Point Averages (points)	10	7,86±6,480	0,67	21,47
Aahperd Şhooting Test (points)	10	19,80±2,098	16	22

When Table 2 is examined, the vertical jump test average value of 10 female athletes participating in the study resulted to be 42.20±3.881 cm, the average value of the plank test 7.90±1.595, the average value of the Aahperd shooting test 19.80±2.098, and the game point average 7.86±6.480.

Table 3. The Relationship between the Vertical Jump, Plank Test (core) and Game Points Average Values of the Participants

Variables		Vertical Jump	Plank Test (core)	Game Point Averages
Vertical Jump	**r**	1		
	p	-		
Plank Test (core)	**r**	,219	1	
	p	,543	-	
Game Point Averages	**r**	,837	,285	1
	p	,003*	,425	-

***p<0,05 **p<0,001**

When Table 3 is examined, a high level of positive correlation was found between the vertical jump test and the game point average of the athletes (r=,837, p=,003).

Table 4. The Relationship Between the Vertical Jump, Plank Test (core), and Aahperd Shooting Test Results of the Participants

Variables		Vertical Jump	Plank Test (core)	Aahperd Şhooting Test
Vertical Jump	**r**	1		
	p	-		
Plank Test (core)	**r**	,219	1	
	p	,543	-	
Aahperd Şhooting Test	**r**	,852	,193	1
	p	,002*	,594	-

***p<0,05 **p<0,001**

When Table 4 is examined, a high level of positive correlation was found between the vertical jump test and the Aahperd Shooting Test of the athletes (r=,852, p=,002).

Table 5. The Relationship Between Participants' Aahperd Shooting Test and Game Point Average Values

Variables		Aahperd Şhooting Test	Game Point Averages
Aahperd Şhooting Test	**r**	1	
	p	-	
Game Point Averages	**r**	,553	1
	p	,097	-

***p<0,05 **p<0,001**

When Table 5 is examined, it has been determined that there is no significant relationship between the Aahperd shooting test results and the game points average of the 10 female athletes participating in the study (p>0,05).

Table 6. Investigation of the Effect of Vertical Jump on Shooting Test Performance

	β	**t**	***P***	***R***	***R²***	**F**	**P**
Vertical Jump and Shooting Test	,852	4,594	,002	,852	,725	21,104	,002

When Table 6 is examined, it can be seen that there is a significant relationship between vertical jump and shooting performance (R=,852, R^2=,725; p<0,05). When the t-test results regarding the significance of the regression coefficient were evaluated, it was found that the vertical jump level (t = 4,594, p =, 002) affected the shooting accuracy rate and shooting performance (%72).

Table 7. Investigation of the Effect of Vertical Jump on Game Point Average

	β	**t**	***P***	***R***	***R²***	**F**	**P**
Vertical Jump and Game Point Average	,837	4,322	,003	,837	,700	18,684	,003

When Table 7 is examined, it can be seen that there is a significant relationship between the vertical jump and the game points average of the athletes (R=,837, R^2=,700; p<0,05). When the t-test results regarding the significance of the regression coefficient were evaluated, it was determined that the vertical jump level (t = 4,322, p =, 003) affected the shooting accuracy rate and shooting performance (70%).

Discussion

This study, in which 10 elite female athletes over the age of 20 who play in the Turkish Basketball League voluntarily participated, was carried out to reveal whether there is a statistically significant relationship between the vertical jump, plank test (core), average points per game and Aahperd shooting test values of the basketball players.

The mean age of the 10 female athletes participating in this study was determined as 23.60±4.3, their average height was 174±6.815 cm, their average body weight was 76.92±17.35 kg, and their Body Mass Index was 25.27±4.627 kg/m^2.

The obtained data of the study has shown certain similarities and differences in comparison to the data in current literature. For instance, Garcia-Gil et al. (2018), in their study they determined in which 41 elite female basketball players from 4 teams competing in the Spanish League participated, showed the average age of the athletes as 25,6±5,5 years, height 179,6±7,9 cm, body they determined their body weight as 70,8±12,3 kg and their body mass index as 21,9±2,1 kg/m2 (Garcia-Gil et al., 2018). In a study by Doma et al. (2018), participating 10 elite female basketball players descriptive statistics were determined as the age was between 17-32, their average height was 1,79±0,7 cm and their body weight value as 76,7±8,3 kg (Doma et al., 2018). In a study by Cherni et al. (2019) in which a total of 26 elite female basketball players voluntarily participated in order to evaluate 13 basketball players in the experimental group and 13 basketball players in the control group, they determined the mean age of the athletes was 20,9±2,6 years, their height as 1,72±0,06 cm, their body weight as 65,1±8,8 kg and their body mass index as 21,9±2,1 kg/m^2 (Cherni et al., 2019). Examination of the average age, body weight, height and body mass index values of 10 elite athletes participating in this study has shown that there are values that show similarities and differences with the values in other studies in the literature. Especially at Cherni et al.'s (2019), it can be seen that body mass index averages are lower than the group in our study. It is thought that the reason for this may be due to the lower average age.

It has been determined that there is a high level of positive correlation between the vertical jump test results and the Aahperd shooting test results of 10 female athletes who participated in this study (r=,852, p=,002). In addition, it was determined that there was a high level of positive correlation between the vertical jump test results of the athletes and the game point averages (r=,837, p=,003).

When the relevant literature is examined, there are research findings showing that vertical jump performance positively affects shooting performance in basketball players. These findings are similar to the findings we obtained in the study.; Okazaki and Rodacki (2018), after the data obtained in the study, in which a total of 30 people participated, children and adults playing basketball, they made evaluations by comparing the

vertical jump and shooting performances of children and adults. In their evaluation, they stated that adults can shoot at a smaller angle than children, as they reach higher vertical height during the shooting, and thus a more successful shooting is achieved (Okazaki & Rodacki, 2018). Pojskic et al. (2018), in their study, in which a total of 38 basketball players from 4 different teams in Bosnia and Herzegovina participated, they determined that there was a positive relationship between these two parameters after the vertical jump and dynamic 2-point shooting test ($r=0,34$, $p<0,05$), dynamic three-point test ($r=0,49$, $p<0,05$) and static 3-point shooting tests ($r=0,39$, $p<0,05$) applied to the basketball players (Pojskic, Sisic, Separovic, & Sekulic, 2018). In another study, Sztruzik et al. (2014), in their study on 20 basketball players, found that lower extremity core strength exercises regularly performed by the athletes had a positive contribution to the vertical jump and shooting performance of the basketball players (Struzik, Pietraszewski, & Zawadzki, 2014).

In this study, it was determined that there was no significant relationship between the plank test (core), the average points per game and the Aahperd shooting test results of the 10 female athletes participating in this study ($p>0.05$).

Lukose (2018), in his study in which 45 randomly selected male basketball players aged 18-25 participated, stated that regular 12-week core training contributed positively to the shooting performance of basketball players ($p<0.05$), and showed a significant improvement (Lukose, 2018). Yüksel et al. (2016) in their study 30 basketball players participated (15 controls, 15 experimentals), they found that after 8 weeks of regular core training have increased basketball players 2-points ($F=43,130$; $p<0.005$) and 3-points ($F=28.639$; $p<0.005$) average per game (Yüksel et al., 2016). Şahiner and Koca (2021), in their study in where 22 athletes aged 16-18 (experimental group: 11, control group: 11), participated, the control group while applied only regular basketball training in an 8-weeks period, the experimental group applied basketball trainnings and applied 2 days core training program per a week (Şahiner & Koca, 2021). When the pre-test and post-tests of both groups in this study were examined, it was stated that there was no significant relationship between the shoot test results between the control group and the experimental group ($p>0,05$), while they found a significant relationship between the vertical jump performance between the control group and the experimental group ($p<0,05$). When we examine the studies, it can be seen that there is a significant relationship between the core performances of the athletes and their shooting and vertical jump performances. The reason for this relationship is thought to be the effect of the 8-12-week core training program applied. In the study we have done, it is thought that there is no similar effect since the current situation of the athletes is evaluated. Similarly, it is thought that core training applications are not included in the current training programs of the participants.

Conclusion

As in all other sports branches, one of the most important criteria in basketball is competition performance. Considering that one of the important factors affecting competitive performance in basketball is shooting performance, we it can be concluded that it is important to examine the relationship between shooting tests and competition performances and to analyze other factors affecting this. In this study, the relationship with 2 different parameters that may affect the shooting performance of the athletes was examined. For these reasons, for the purpose of the research, the core test performances and vertical jump performances were compared to shooting test performances and average points per a game values of the athletes. As a result;

- When the test results of the basketball players were analyzed, it was determined that there is significant positive relationship between the vertical jump performances and the shooting test results.
- When the test results of the basketball players were analyzed, it was determined that there is significant positive relationship between the vertical jump performances and the average points per game values.
- Research group results of the core test, the results of the shooting test and average points per game values when were analysed there is no significant relationship could be found between them.
- Considering that there are studies that have found a relationship between core performance and shooting performance in basketball players, it is thought that the inclusion of core training into the training programs will improve or protect shooting performance.
- When the findings obtained from the research report and the literature are examined, we can state that there are very few studies comparing the results obtained from performance tests with basketball competition shooting performances. When we evaluate this research report specifically, it is thought that it is important to examine the relationship between the results of shooting tests and average points per a game value performance of the competition. With the increase in the number of similar studies which is examining basketball competition shooting performance analyzes in the literature, it can be evaluated that it will be possible to plan the transfer of field test results to basketball competition shooting performance in more detailed.

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