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THE RELATIONSHIP BETWEEN KINEMATIC AND ANTHROPOMETRIC VARIABLES OF THREE-POINT JUMP SHOT FROM TWO DIFFERENT ZONES AND THE ANGLE OF THE BALL'S ENTRY INTO THE BASKET OF THE NATIONAL MALE BASKETBALL PLAYERS OF IRAN

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ABSTRACT

Three-point jump shot is the most important way to gain points and taking the lead for teams in basketball games. Therefore, factors influencing its success have always got the researchers' attention. The objective of this study was to examine the relationship between kinematic parameters of three-point jump shots from two different zones and the angle of the ball's entry into the basket in National male basketball players of Iran. Thirty right-handed basketball players who were all excellent three-point shooters from Iran's national teams were chosen (age: 23.63+2.3 years). All 30 players were chosen using the availability sampling method and were distributed to Participants have made three three-point jump shots from the two zones of "in front of the hoop" and "the side of the hoop" (from distances of 6.75 and 6.6 meters), and kinematic and anthropometric data from the players were collected and processed by two cameras and caliper and meters. To determine the relationship between kinematic and anthropometric data with the angle of the ball's entry into the basket, the Pearson's correlation coefficient and the multivariate linear regression at the "$\alpha = 0.01$" level was used. Furthermore, t-test was used to investigate the relationship between the means of the variables between the two areas, using SPSS software at the level of ($p=0.01$). All three kinematic variables of height, speed, and angle of release from both zones showed a significantly positive relationship with the angle of the ball's entry into the basket, of which the "height of release" indicated more influence than the other two variables. Also, there was a significantly positive relationship between anthropometric variables of shoulders widths, arm length, and player height, and the angle of the ball's entry into the hoop. In this regard, the arm length and player height played a more significant role. Results showed the variables of height, speed, and the ball's angle of release, and also, shoulders widths, arm length, and player height have a positive relationship with the ball's entry into the basket.

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Introduction

In basketball, the main goal of the players is to score against the competing team and to succeed; the most effective individual technique in basketball games is shooting. Among the various techniques of shooting in basketball, jump shots, and even more important than that, 3-pointer jump shots greatly affect scores and help teams win. Therefore, identifying factors which influence the success of these shots, has always been at the center of the attention of basketball coaches and players [1, 2]. In the Spanish super league, one of the most successive shots is jump shots. 41% of the scores obtained by players is through jump shots (ECB, 1997). In order to shoot well in basketball, one needs to perform well in the sport and, for that, on needs to be well built [3].

In the biomechanical research, the emphasis was placed on various angles such as the basic shooting technique (13 & 7), differences in male and female players in basketball performance (25), and player characteristics in different levels (15). Baker (2004) has spoken of the way a player should stand and player height (including the legs, pelvis, shoulders) prior to receiving the ball and the way the ball should leave the player's hand for the ball to perform [4]. All these emphasize the correct use of all body pivots (arms and legs) in order to perform a successful jump shot. Palobinskas (2005), in his study, stresses the

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relationship between fingers and the place where the elbow and the knee are at the time of performing a shot (before and after shooting), and the angles needed for elbows and knees before, during, and after the basketball jump shot has been taken [5]. Scougland (2004), when comparing the shots of three experienced, semi-experienced, and amateur groups, asserted that the reason why armatures do not score with jump shots is the lack of coordination they have when performing a jump shot, due to the player's angle of the elbow [6].

Among these studies, some have also analyzed the number techniques in men's jump shots [3, 6-9], and some have also analyzed the number of techniques in women's jump shots [10, 11]. Shiba Kava (1975), before others, has comprehensively studied the path the ball covers [12]. The research included a precise study of the effect a foul has on the two factors of the ball's angle and speed when it is released. It was concluded that by only studying the angle of release, an angle range of 49 to 55 degrees is most definitely the best angle of release. Additionally, if the speed of release is studied in this regard, angles of 52 or 53 degrees would probably be better. In other words, it is obvious that the angle of release of 52 to 55 degrees is probably the best condition for scoring. In another research, Kava studied shots which entered the basket exactly after hitting the board. The researcher concluded balls that are thrown this way are more likely to enter the basket than those thrown directly for the basket. Also, Kava proved the possibility of scoring when the ball is backspin increases when the ball hits the board before entering the basket.

Hudson (1982) has studied the level of skill in free throws in basketball biomechanically [13]. The study indicates that free shots in basketball are divided into two branches of athletic skills. First, this is a precision act, and second, most players need the highest speed; therefore, for the highest speed, it is suggested to use unlimited mixes of and the cooperation of different parts of the body, angles, and high speeds. In addition, the act of the different parts of the body in cooperation with each other at the time of shooting (a successful shot), is most important. The results of this research show more stability (stability of the center of gravity and the style of the upright body) and also the higher height of release, all depends on the skill of the player. But, the angle and speed of release have no dependence on the player's skill. T. Sarokas et al. (1999), have studied the biomechanical analysis of the free throw, announcing that the prime aspect is the path of the ball after release, which is in the form of a parable, although two spots of the parable are almost the same for tall players and also in analyzing the angle and height of the ball's release, the situation of the ball is known to be an antecedent of releasing the ball [14]. Additionally, initial and final angles of different parts of the body with the horizontal surface show that they are not related to the free throw scoring. Furthermore, the lower part of the body is effective in the vertical position of the ball; moreover, the effect of the body's height on the horizontal and vertical direction of the ball should not be neglected. The hands are effective in both situations.

Sati (2004), when comparing successful and unsuccessful free throws, found out that there are no isolated factors responsible for a successful shot, but a correct combination of the two factors of angle and speed create a successful shot (25) [15]. Miller (1996), considers the angle velocity of the shooting arm and the linear velocity of the shooting shoulder, both at the time of the release of the ball, as the most important factors in the speed at the time of release (21) [16], however, Clearly (2001), showed there is a wide range of release angles which are related to the rate of success of the shot, and suggested the mid-range of jump shots to be 19 to 55 degrees (8) [1].

From the kinetic point of view, few studies have researched the jump shots. In the studies conducted by Yaits (1982) and Hudson (1982), shots performed by very skilled women basketball players, as compared to the shots performed by less skilled players showed less horizontal movement in its center of gravity during the shot (16, 30) [17, 18]. Shahabi Kaseb (2004), in a study, mentioned that there is no significant statistical difference between the mean of the reaction force of the ground (vertical force) and movement in the center of pressure in mid-side and back-front vectors (2). Heydar Sadeghi et al. (2009) studied the biomechanics of performing a successful and unsuccessful jump shot of National basketball players and asserted that changes in the angle of joints at the time of release and the position of the center of pressure at the time of curving are effective in the result of the jump shot, and added that at a distance of 4.25 meters from the basket, the changes in the angle of the arm wrist, leg, and foot wrist, and at a distance of 6.25 meters from the basket, changes in the angle of the leg and the foot wrist have a significant role in the success or failure of a jump shot.

In the biomechanical studies of some researchers, jump shots have been studied based on throw, which depends on characteristics such as speed, angle, and height of release [9, 16, 19-21]. Sepro and Rojas (2000) mentioned more speed and height of release as effective in the success of shooters, as the shooter is fronted with an opponent [3]. For example, Tee Sie et al. (2006) studied the kinematic analysis of the 3-pointer shot after a high-intensity program [22]. The aim of the research is to analyze the kinetic and kinematic parameters of a 3-point shot captured by high-speed cameras. Results showed the angular velocity of the elbow, wrist, leg, and foot wrist, excluding the knee, decrease after performing the high-intensity program and also the angle of start and the take-off initial increase.

Aladdin and Hassan Ali (2011) have studied the biomechanics comparison of a 3-point shot before and after the changes in the regulations of basketball, in which differences in angle and direction of the body parts in shooting 3-pointers between a jump shot from a distance of 6.25 meters and 6.75 meters from the basket were studied [23]. Results showed the primary state of the body while shooting from a distance of 6.75 meters from the basket has not changed; the distance from the basket has a direct relationship with the speed of the shooting in a sense that the speed of shooting and the distance from the basket have a polar relation with the angle of the release of the ball. Players in the phase of shooting (when they engage in the act of shoot)

need an initial velocity to help them, meaning from a distance of 6.75 meters, players need more speed than when they are shooting from a distance of 6.25 meters. With an extra movement of the wrist, the player attains the needed velocity to begin with and can direct the ball in a way that the main part has a great effect on the direction, velocity, and angle of release of the ball.

Ban (1972) studied the real relationship between the accuracy of a shot and the distance from which the shot was taken during a game [24]. Ban also showed on the average, a shot taken from a distance of 2.47 meters is better than one taken from a distance of 7.32 meters, or a shot taken from a distance of 92 centimeters is better than two shots taken from a distance of 4.57 meters, or three shots taken from a distance of 7.32 meters. In another level, Ban studied and compared shots taken with defense from a distance of 4.57 meters and found that only 28% of the shots were successful, whereas shots taken from the same distance and without defense had a success rate of 60% to 70%. This phase of Ban's research showed that the success rate of a shooter depends on the defense during the game and that defense decreases the players' precision in shooting.

Okazaki and Rodaki (2012) studied the effect of increasing the distance from the basket at the time of the jump shot [25], from the three distances of 2.8 meters (close), 4.6 meters (average), and 6.4 meters (far), and found that increasing the distance from the basket decreases the height of release of the ball; shooting from a distance of 2.8 meters, as compared to 6.4 meters, allows the player to release the ball at the maximum height at which he can release. Also, the angle of release, when the ball is being released from a distance of 2.8 meters from the basket (65.60 degrees), as compared to when it is released from a distance of 4.6 meters (65.60 degrees), decreases, as long as the speed of release has increased from 4.39 meters per second (close) to 5.75 meters per second (average) and up to 6.89 meters per second (far). When the distance has increased, changes in height, angle, and speed of the ball's release affect the accordance of the acts which are the main factors of the jump shot, mentioned before. Moreover, the speed of the ball's release (outcome of the vertical and horizontal) increased in all tested situations. This increase showed itself in the farther distance from the basket, as compared to the nearer distance, and the rise in the distance from the basket increased the horizontal velocity in the center of the mass [25-28].

In reviewing the studies and researches done in this regard, no study was found that had tried to find the relationship between kinematic and anthropometric features of the 3-point jump shot with the angle with which the ball enters the basket. Thus, the hypothesis that there is a relationship between kinematic and anthropometric features with the angle of the entrance of the ball into the basket in the 3-point jump shot, the current study has been conducted aiming to find the relationship between kinematic and anthropometric features with the angle of the 3-point jump shot from two different zones with the angle of the entrance of the ball into the basket in Iran's professional male basketball players.

Methodology

In this research, all professional Iranian male basketball players, between the ages of 17 to 29 who took part in all Iranian National Basketball Teams' camps, were studied (N=120). The statistical sample in this study included 30 of the best three-point shooters among the national players (some of them were the best shooters in Asia) of Iran, whom all were right-handed and their (average age, height, and weight were respectively 23.63 years, 187.8 centimeters, 85.52 kilograms). The samples were chosen through convenient sampling and were divided into three groups of the National Adults Team A, the National Adults Team B, and the National Youths Team.

In the study, two Casio cameras with a frequency of 100 Hz were used for filming and the data gathered were analyzed by the Kinova software. Also, a standard basketball court in Azadi Sports Complex was used. Each player made 3 shots from the front of the basket from a distance of 6.75 meters from the center of the basket and 3 shots from the side of the basket from a distance of 6.60 meters from the center of the basket. One of the cameras was placed alongside the line of the basket (in 3.05 meters above the ground) to gather data related to the angle of entry of the ball into the basket, and the other camera was placed next to the player on the ground to record their movement while shooting.

After gathering the information and changing them into numbers to analyze the data, the descriptive statistical method was used to write the tables and graphs relating to the athletes' information and also an inferential statistical methods were used which includes the Pearson correlation coefficient to determine the relationship between the player's kinematic and anthropometric features of a 3-point jump shot from the two different zones with the ball's angle of entrance into the basket and to predict the relationship between the kinematic and anthropometric variables with the angle of the ball's entrance into the basket a multivariate linear regression was used, and also a t-test was used to study the relationship between the mean of variables in the two zones using the SPSS software at the level of $p=0.01$.

Results

Results show the mean of kinematic variables including the angle of the ball's entrance into the basket and the velocity and the angle of the ball's release decreased as the distance from the basket declined from 6.75 meters to 6.60 meters from the center of the basket (see table 1), in other words, it was observed that with the increase in the distance of the 3-point shot from the basket, the angle and velocity of the ball at the time of release and the direction at which the ball enters the basket increases

also increases. In addition, it was seen that the height at which the ball was released from both zones (from a distance of 6.75 meters and 6.60 meters from the center of the basket) were almost the same.

Table 1: Mean and Standard Deviation Kinematic Variables

Distance From The Center Of The Ring	Kinematic Variables	Mean	Standard Deviation
6.60m	Angle Of The Ball's Entrance	44.10°	4.74
6.60m	Height Of The Ball's Release	2.38m	0.15
6.60m	Velocity Of The Ball's Release	6.46m/s	0.22
6.60m	Angle Of The Ball's Release	41.47°	3.95
6.75m	Angle Of The Ball's Entrance	51.87°	7.41
6.75m	Height Of The Ball's Release	2.36m/s	0.12
6.75m	Velocity Of The Ball's Release	7.30m/s	0.38
6.75m	Angle Of The Ball's Release	44.87°	6.29

Results from the Pearson coefficient correlation test showed that there is a significant relationship between the kinematic variables of the study and the angle at which the ball enters the basket (ρ=0.01) from both zones (i.e. from a distance of 6.75 meters and 6.60 meters from the center of the basket; see table 2). In other words, a direct and positive relationship was found between the height, velocity, and angle of the ball's release and the angle at which the ball enters the basket. Also, results from the test regarding the anthropometric variables are as follows: the player's arm length, shoulder width, and height have a meaningful relationship with the angle at which the ball enters the basket (ρ=0.01) and also the relationship is of a direct and positive kind (see table 2).

Table 2: Result of Pearson Coefficient Correlation Test for Kinematic and Anthropometric Variables

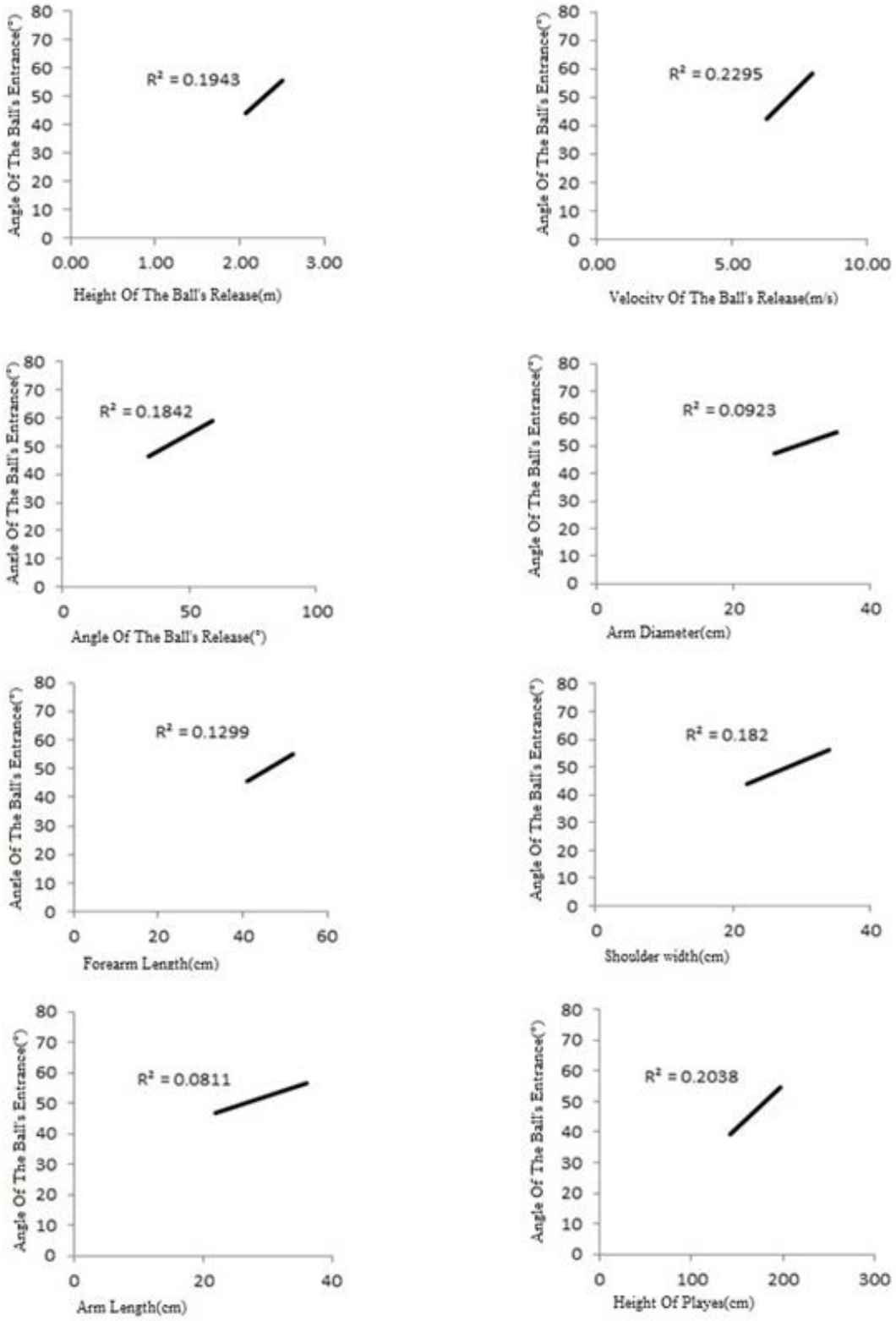
Kinematic and Anthropometric Variables	**Pearson Coefficient Correlation** (From 6.75m)	**Pearson Coefficient Correlation** (From 6.60m)
Height Of The Ball's Release	0.441*	0.428*
Velocity Of The Ball's Release	0.479*	0.468*
Angle Of The Ball's Release	0.429*	0.427*
Arm Length	0.427*	0.362
Forearm Length	0.285	0.169
Shoulder width	0.360**	0.496*
Arm Diameter	0.304	0.310
Height Of Players	0.451*	0.194

*ρ = 0.01 ** ρ = 0.05

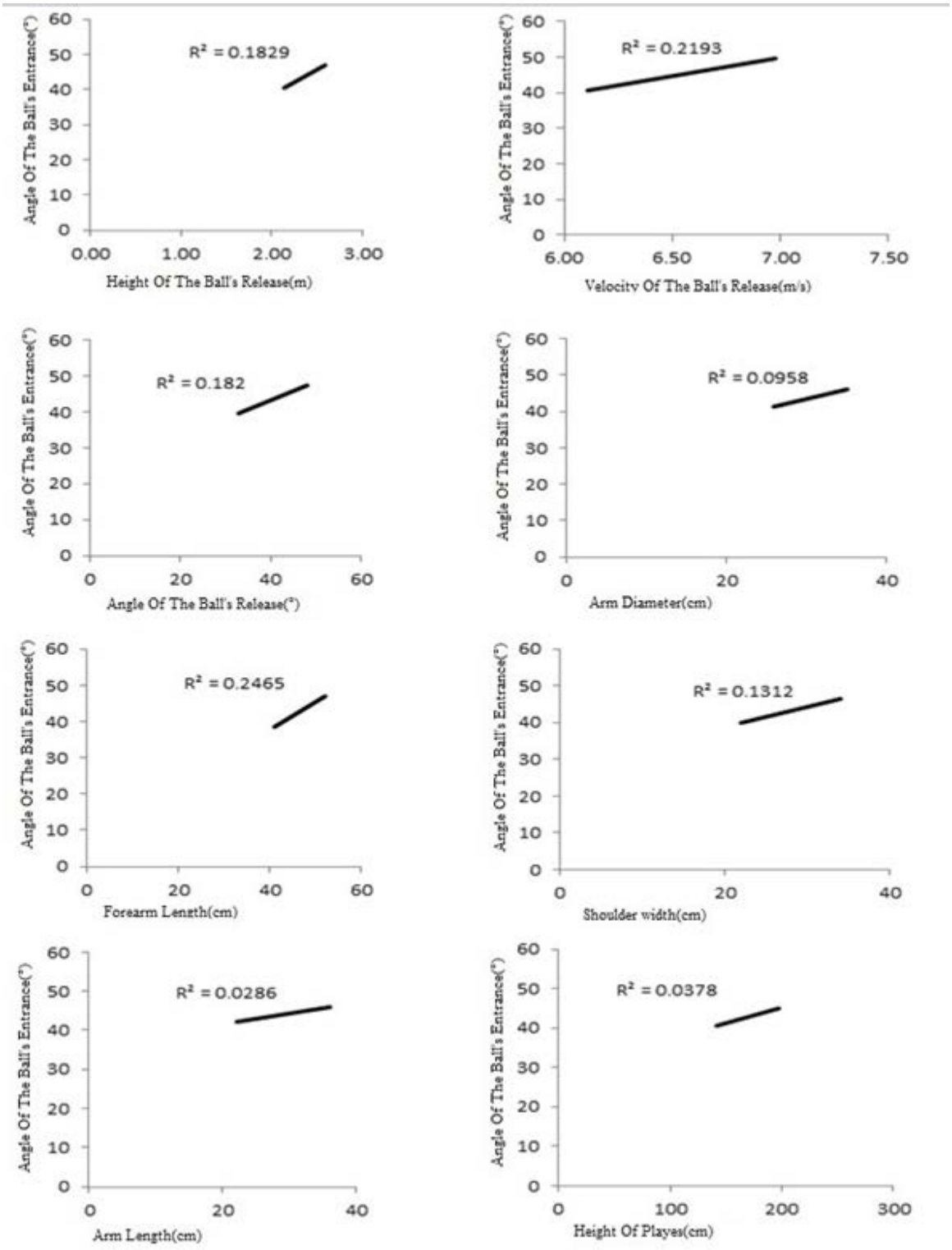
Moreover, no meaningful difference was found between the player's arm length and height from a distance of 6.60 meters from the center of the basket and the shoulder width of players from a distance of 6.75 meters from the center of the basket, and more data is needed (table 2). The mean of the anthropometric variables acquired in this study has been mentioned in table 3. Linear regression vectors (vectors 1 & 2) which all have positive inclination, shows the direct relationship between kinematic and anthropometric variables with the angle of the ball's entrance into the basket on a ρ=0.01 level.
Results from the t-test on a meaningful level with an α=0.01 show the meaningful difference between the means of kinematic and anthropometric variables from a distance of 6.60 meters from the basket with a distance of 6.75 meters from the center of the basket.

Table 3: Mean and Standard Deviation Anthropometric Variables

Anthropometric Variables	Mean	**Standard Deviation**
Arm Length	31.27	2.73
Forearm Length	29.10	2.99
Shoulder width	48.43	3.07
Arm Diameter	29.60	3.11
Height Of Players	187.8	12.07



Vector 1: Linear Regression Vectors (6.75m)



Vector 2: Linear Regression Vectors (6.6m)

Discussion and Conclusion

This study was conducted under the title "the relationship between kinematic and anthropometric features of the 3-point jump shot from two different zones with the angle of the ball's entrance into the basket in leading Iranian male basketball players" so that, by acquiring more information on the relationship between kinematic and anthropometric features of players and the ball's angle of entry into the basket, factors effective in performing 3-point jump shots could be identified. Knowing these factors can directly affect a team's success in matches and help amateur and expert players, elementary and advanced coaches, athletic committees around the country, and finally, the country's federation to promote the 3-point shot in their field of work

both quantitatively (statistically) and qualitatively (having a correct and standard method of shooting). In other words, it can be said that by knowing the mentioned information, coaches can revise their lesson plan for their amateur players and also advanced coaches can alleviate technical problems their expert players have in the shooting. Moreover, the federation and athletic committees can elevate the quantitative and qualitative level of jump shots, especially 3-point jump shots, in an acceptable, orchestrated, steady, and effective fashion.

In general, factors effective in the 3-point jump shot are kinematic and anthropometric variables. Other researchers such as, Okazaki and Rudaki (2012), Hassan Ali and Aladdin (2010), Rojas and Sepro (2000), Hay (1994), Miller and Bartlet (1996), Brankazino (1981), Ban (1972), Rahimi (1992), have proved this point whereas the angle at which the ball enters the basket is dependent on kinematic and anthropometric variables [3, 16, 20, 23-25, 29]. This study showed that in a 3-point jump shot, the height at which the ball is released is limited and decreases as the shooter's distance from the basket increases, but the higher the ball is released, the better the angle at which the ball enters the basket; hence, a better chance of scoring is created. Nevertheless, energy consumption in players should not be neglected and this means, the maximum height of the ball's release in a 3-point jump shot, as compared to other shots (shots taken closer to the basket than 3-pointers), will be less and the acquired mean in this study is 2.36 meters. Researchers such as Okazaki and Rudaki (2012), Hassan Ali and Aladdin (2010), Miller (2002), Rojas and Sepro (2000), Indiman (2000), Kadson (1993), Hay (1994), Miller and Bartlet (1996), Brankazino (1981), Ban (1972), Rahimi (1992) have reached similar results from distances closer than 6.5 (5.75) (ρ=0.01) [3, 9, 16, 19-21, 23-25, 29].

However, as the release angle of the ball increases, a better entrance angle of the ball into the basket is created and the likelihood of scoring increases. Energy consumption in players should not be neglected; therefore, the angle of release must be an optimum one. In the current study, the optimum angle of release from a distance of 6.5 meters has been calculated to be 41.47 degrees with a standard deviation of 3.95 degrees and from a distance of 6.75 meters, the optimum angle of release has been calculated to be 44.78 degrees, with a standard deviation of 6.3 degrees. Researchers such as Okazaki and Rudaki (2012), Hassan Ali & Aladdin (2010), Miller (2002), Rojas & Sepro (2000), Indiman (2000), Kadson (1993), Satti (2004), Hay (1994), Miller & Bartlet (1996), Brankazino (1981), Shiba Kava (1975), Ban (1972), Rahimi (1992) have reached similar results from distances of closer than 6.5 (6.75) to that of the current study (ρ=0.01) [3, 9, 12, 15, 16, 19-21, 23-25, 29].

Therefore, results of studying the anthropometric variables of players are as follows: there is a significant relationship between player arm length, shoulder width, and player height and the angle at which the ball enters the basket with a level of 99% certainty (ρ=0.01) whereas no significant difference was found between the length of the player's forearm and the girth of the player's arm.

Results from the research showed the increase in the length of the player's arm has a direct relationship with the angle at which the ball enters the basket and this is how the mean of the length of the players' arms reached 29.1±3 and the mean of the width of the players' shoulders reached 29.6±3.1. Additionally, the mean of the height of the players who had taken part in this study reached 187.8±12. In the present study, an increase in height normally and logically helps to increase the height of release; therefore, an increase in the height of the players definitely has a direct and positive relationship with the ball's angle of entry into the basket. As a result, the increase in the length of the players' arm increases the angular velocity of the ball's release and this increase in speed helps to attain the optimum angle and velocity of the ball's release for the ball to enter the basket. In this regard, to show the relationship between the width of the players' shoulders and the ball entering the basket, the result has been as follows: the greater the width of the players' shoulders, the less the shoulder's need for flexion will be, and the player will have the needed force to produce the optimum speed and angle for release; therefore, there is a direct and positive relationship with the angle at which the ball enters the basket. Researchers such as Okazaki & Rudaki (2012), Hassan Ali & Aladdin (2010), Rojas & Sepro (2000), Scogland (2004), Hay (1994), Miller and Bartlet (1996), Brankazino (1981), Ban (1972), Rahimi (1992) have found similar results from shorter distances than 6.60 (6.75) from the basket [3, 6, 16, 20, 23-25, 29]. In contrast, the anthropometric variables mentioned, arm girth and forearm length in players, and the angle at which the ball enters the basket have no meaningful relationship. However, in the multivariate linear regression test, the study showed that all introduced anthropometric variables were directly, dependently, positively, and significantly fully related to the ball entering the basket. Very few studies were found that have researched this matter, but some researchers such as Okazaki & Rudaki (2012) [25], Miller & Bartlet (1996) [16], Brankazino (1981) [29], and Heydar Sadeghi et.al. (2009) have proved this matter (in a different way) in similar studies.

As for the other studies conducted in this research was the difference between shots taken from the distances of 6.60 meters and 6.75 meters from the basket. In both zones, certainty levels of 99% produced meaningful differences, and this means a significant difference was found between the means of kinematic and anthropometric variables in taking 3-point jump shots from a distance of 6.60 meters and 6.75 meters from the basket. Okazaki & Rudaki's (2012), and Miller and Bartlet's (1996 & 1993) studies bore similar results [9, 16, 25].

Conclusion

In general, height, velocity, and the angle of release have a positive and direct relationship with the angle at which the ball enters the basket in 3-point jump shots; also, anthropometric features of arm length, shoulder width, and player height have a direct and positive relationship with the angle at which the ball enters the basket in 3-point jump shots. Furthermore, an increase

in the previously discussed kinematic and anthropometric features is very much effective in promoting the players' performance in making 3-point jump shots. Coaches are advised to use tall players with the anthropometric features previously discussed in this study for the mentioned posts (shooting behind the 3-point line) and place special planning and training for the kinematic variables of players (height, velocity, the angle of release) to better their performance.

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