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Research article

THE INFLUENCE OF A TEN-WEEK TRAINING PROGRAM ON THE BIOMECHANICAL PARAMETERS OF MADE JUMP SHOTS IN YOUNG BASKETBALL PLAYERS

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Abstract. *The aim of this study was to determine the influence of the specific training program on the kinematic parameters of made jump shots in basketball. Participants were 31 basketball players, aged 15.32±0.65. All participants trained according to a specific training program for 10 weeks. Data obtained at the initial and final measurements were processed by nonparametric statistics. Data processing was carried out in the direction of determining the difference in kinematic parameters within the group between the initial and final measurements. After that, the level of impact of a specific training program on the mentioned parameters was determined. The obtained results indicated that there are differences between initial and final measurements in eight out of 10 (80%) kinematic parameters and the influence of the specific training program existed in the same eight (80%) kinematic parameters.*

Key words: *kinematics, basketball, jump shot, smart ball, specific training program.*

INTRODUCITON

Shooting at the basket is certainly the most known basic basketball technique (Chen, Lo, Lee, Wang, & Shiang, 2005). Its importance lies in fact that it is the main component of any attack, with the purpose of hitting the basket (Taborda, Dorst, & Leite, 2007). That is the reason why most of the coaches define the jump shot, or any kind of shot, as the most important basketball skill (Kant, 2014). Based on that, a proper shot at the basket is the most important technique that needs to be mastered in basketball (Varghesea & Shelvam, 2014).

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The good biomechanics of the jump shot in basketball are the correct and precise movements of the upper extremities, as well as a well-balanced and powerful vertical jump (Krause, Meyer, & Meyer, 2008; Chen, Lo, Lee, Wang, & Shiang, 2005). For a player to perform an effective jump shot, biomechanical parameters play an important role (Okubo & Hubbard, 2006; Fontanella, 2007), but the balance of the body is also very important (Millslagle, 2002; Button et al., 2003; Lam et al., 2009). For this reason, basketball represents a sport that requires great accuracy of the movement of both upper and lower extremities (Erčulj & Supej, 2006). The jump shot in basketball stands out as the most important and most common shot of all shots in the game (Hess, 1980; Çetin & Muratl, 2014). Its purpose, besides achieving points, is to create an advantage of the attacker over the defender.

According to some researchers (Hay, 1994; Miller & Bartlett, 1996; Rojas, Cepero, Ona, & Gutierrez, 2000; Chen, Lo, Lee, Wang, & Shiang, 2005) the main factors that determine the flight of a ball during the jump shot, beside distance from where the shot was taken, are: the speed of the release, the angle of the release and the height at which the ball is released. The technique of the jump shot may look similar in all basketball players, but every player has a different style because of these factors (Erčulj & Supej, 2006).

In order for the ball to have the best chance of going through the rim, it should enter vertically through it. It can be said that to do this is practically impossible, because it would mean that the point of the release should be either directly below or above the basket. The angle of the release, from any distance, is in a positive relation with the ball entry angle through the basket (Miller & Bartlett, 1996). The release angle from the closer distance of the basket is usually 52° - 55°, while it is slightly smaller from a greater distance and is usually 48° - 50° (Miller & Bartlett, 1993; 1996; Rojas, Cepero, Oña, & Gutierrez, 2000). There are many factors that can have an influence on the release angle. According to some authors (Satern, 1993; Miller & Bartlett, 1996) the distance from the basket and the shooter's height can be one of them, but it can also be the shoulder angle (Satern, 1988), as well as the defender and his presence. The shooter's height can have an influence on the height from which the ball is released, as well as the height of the jump and the position of the body (Miller & Bartlett, 1996; Struzik, Pietraszewski, & Zawadzki, 2014). The height from which the ball is releases is important because, the higher the throw point, the easier for the player to shoot the ball over his guard. What needs to be noted is that there is one angle that will make the shot ideal, but that there is a right combination of the release speed and the angle of the release. It can simply be said that all factors are interdependent (Erčulj & Supej, 2006).

For a precise jump shot, a proper shots model plays an important role (Varghesea & Shelvam, 2014). Different trainings and shooting exercises with various tasks, targets and dosing, can help make such a model. So, trainings for practicing jump shot needs to be brought as close as you get to realistic conditions (for a certain time to make a shot, shoot over the players, make a position for a shot with the defense). That will help the player to become more confident with his shot, which is really important for shooting.

METHODS

Sample of participants

The sample of participants consisted of 31 cadet age male basketball players. The average age of the participants was 15.32 ± 0.65 years. All of the participants had a training status for more than a year.

Measuring instruments

Initial measurement was done before the program started and the final measurement was done after the program was completed.

For measuring kinematic parameters such as release speed of the ball (RSB) and angle of release (AOR), a smart basketball “94 fifty” was used. The “94 fifty” ball looks like a normal basketball, but it has a chip that gives it the possibility to connect to a smart phone via Bluetooth and give information or parameters in real time.

The values other kinematic parameters such as the in the elbow joint at the time of release of the ball (AEJR), height of the body center of gravity at the time of release (HCGR) and the height of the release point (HRP) were obtained from videos recorded with a high-speed camera Casio Exillim F1 and then analyzed with software for kinematics analysis of motion "Kinovea" 0.8.25.

Each player performed a jump shot from the left wing, right wing and from the position against the basket. After making three shots, the player moved to the next position. Shooting positions were set at a distance of five meters for two points and 6.75 m for thee points. The other two players grabbed the ball and passed it directly to the shooter.

Experimental procedure

The specific training program lasted 10 weeks with three practices per week and a pause between training days of one (24h) to two (48h) days for recovery. The program consisted of a combination of polymeric and shooting exercise, dosed with 50%:50% at one practice. Every practice lasted 90 min. with introductory, preparatory, main and final part of the practice session. The introductory part of the practice consisted of warm-up exercises and the preparation of muscles for the main part of practice. In the preparatory part of practice, the participants were introduced to the exercises of the main part of practice. In the main part, the participants were subjected to an appropriate combination of exercises, planned for that practice. The final part of the training was used for relaxation and recovery of the muscles.

The plyometric program had six levels of exercise load intensity, depending on the week. The first week was with low intensity. The second, third and fourth week was low - medium intensity. The fifth and sixth week was medium - high intensity of exercise. The seventh week was a pause. The eighth and ninth was highest intensity and the last week, the tenth one, was a high mid-intensity of plyometric program. Plyometric exercises consisted of all kinds of jumps (Forward Bounds, Plyo Lunges, Stance Jumps, Matrix Jump, Depth jumps and jumps similar to the game of basketball: Backboard Touches, Toss & Catch and so on) with both legs or on one leg, with and without a ball or medicine ball depending on the week and load intensity. There were also exercises for upper body like various types of pushups (on the basketball, with a basketball as a footrest) dips and various ways of throwing and caching a medicine ball.

The shooting part of the program consisted of shooting exercises, shooting tasks as well as mutual competitions. From week to week, the shooting program was made more difficult in terms of bringing the tasks closer to real situations on the court during one game. That means that the time for scoring was decreasing, distance was increasing, the defender was bring in to guard the shooter and other similar tasks where added. Some of the workouts were jump shots after one dribbling, a jump shot after running in, five in a row, exercise called seven of seven, rotating the cones to the basket, jump shot after zig-zag running and so on.

Data processing

To determine the impact of a specific training program on the kinematic parameters of the made jump shots, the nonparametric statistics, more precisely, the formula in Fig. 1 was used. The value "N" represents the number of processed data, in other words, these are thee made jump shots form three positions (left wing, right wing and position against the basket), for two and three points. In order to get the values of "Z", the difference between the initial and the final measurement was determined using the Wilcoxon test.

$$r = \frac{Z}{\sqrt[2]{N}}$$

Fig. 1 Formulas for calculating influence

RESULTS

The results of difference between the initial and the final measurement in kinematic parameters of the made jump shots are shown in Table 1. The impact of a specific training program on kinematic parameters of the made jump shots are shown in Table 2.

Table 1 The difference between the initial and the final measurement in kinematic parameters of the made jump shots

Kinetic Parameters	Z	Med.	Sig.
RSB2p - RSB2pF (s)	-11.76	1.11 - 0.90	**0.00**
RSB3p - RSB3pF (s)	-7.97	1.12 - 0.98	**0.00**
AOR2p - AOR2pF (deg)	-4.82	49.00 - 50.00	**0.00**
AOR3p - AOR3pF (deg)	-4.52	49.00 - 50.00	**0.00**
AEJR2p - AEJR2pF (deg)	-0.78	161.00 - 161.00	0.44
AEJR3p - AEJR3pF (deg)	-1.32	161.00 - 162.00	0.19
HCGR2p - HCGR2pF (cm)	-10.05	127.35 - 130.75	**0.00**
HCGR3p - HCGR3pF (cm)	-13.14	128.06 - 133.30	**0.00**
HRP2p - HRP2pF (cm)	-8.24	234.85 - 240.13	**0.00**
HRP3p - HRP3pF (cm)	-10.65	228.90 - 237.32	**0.00**

2p – two-point shot, 2pF – two-point shot at the final measurement, 3p – three-point shot, 3pF – three-point shot at the final measurement, Med. – average values, Sig. - statistical significance.

Based on the values obtained in the column Sig., it was concluded that there is a statistically significant difference between the initial and the final measurement in eight kinematic parameters: in release speed of the ball (RSB2p and RSB3p), in the angle of release (AOR2p and AOR3p), in height of the body center of gravity at the time of releasing a ball (HCGR2p and HCGR3p) and in height of release point (HRP2p and HRP3p). The level of significance for all of these parameters is $p \leq 0.00$ and it indicates that the difference is not accidental. With the remaining two parameters, the angle in the elbow joint at the time of releasing a ball (AEJR2p and AEJR3p), there was no statistically significant difference.

Table 2 The influence of the specific training program on kinematic parameters of the made jump shots

Kinematic parameters	N	√N	Z	r
RSB2p (s)	558	23.62	11.76	**0.50**
RSB3p (s)	558	23.62	7.97	**0.34**
AOR2p (deg)	558	23.62	4.82	**0.20**
AOR3p (deg)	558	23.62	4.52	**0.19**
AEJR2p (deg)	558	23.62	0.78	0.03
AEJR3p (deg)	558	23.62	1.32	0.06
HCGR2p (cm)	558	23.62	10.05	**0.43**
HCGR3p (cm)	558	23.62	14.48	**0.61**
HRP2p (cm)	558	23.62	8.24	**0.35**
HRP3p (cm)	558	23.62	10.65	**0.45**

2p –two-point shot, 3p – three-point shot, N – total number of data, √N - square root of the total number of data, Z – values form Table 3, r – level of significance.

Analyzing the values in column "r", it was concluded that the specific training program had a different level of influence on eight kinematic parameters. The specific training program had the highest impact on height of the body center of gravity at the time of releasing the ball for two points (HCGR3p r = 0.61), release speed of the ball for two points also (RSB2p r = 0.50), height of release point for three points (HRP3p r = 0.45) and on height of the body center of gravity at the time of releasing the ball for three points (HCGR2p r = 0.43). The medium impact of the specific training program was on the release speed of the ball for three points (RSB3p r = 0.34) and on height of the release point for three points (HRP3p r = 0.45) and for two points (HRP2p r = 0.35). For the remaining two parameters, angle of release for two and three points (AOR2p and AOR3p), it can be said that the specific training program had a low-medium impact on them. More precisely, the impact values are r = 0.20 for AOR2p and r = 0.19 for AOR3p. These results coincide with results of differences in kinematic variables between the initial and final measurements obtained by the Wilcoxon test.

DISCUSSION

The aim of this study was to determine the influence of a specific training program (combination of plyometric and shooting training) on kinematic parameters of the made jump shots as well as determine the difference between initial and final measurement in the same parameters. Observing the results, it can be concluded that the values of the kinematic parameters have changed in the right direction after the specific training program. This actually means that the values, depending on the parameters, have increased or decreased. According to that, at the values of parameters like height of the body center of gravity at the time of releasing the ball (HCGR2p and HCGR3p) and height of the release point (HRP2p and HRP3p) increased. With the height of the body center of gravity (i.e. a high jump) and even more importantly, with the height of the release point, the shooter has a better chance to make a jump shot. There are several reasons for this. One of them is that during the performance of such a jump shot, important space between the shooter and defender is created. The other reason is that if the release point is high, blocking the shot is difficult for the defender, it requires a higher jump and good explosiveness. One more reason can be the reduction of the distance between the shooter and the rim with a high jump and high release point, which can be attributed to plyometric part of the practices because there are many studies (Wilson, Murphy, & Giorgi, 1996; Fatouros et al., 2000; Matavulj, Kukolj, Ugarkovic, Tihanyi, & Jaric, 2001; Tricoli, Lamas, Carnevale, & Ugrinowitsch, 2005; Lehance, Croisier, & Bury, 2005; Kotzamanidis, 2006; Markovic, 2007; Markovic, Jukic, Milanovic, & Metikos, 2007) about the positive influence of plyometric exercises on vertical jump. On the height of release point during the jump shot, beside the height of the shooter, jump height and body position (Miller & Bartlett, 1996; Struzik, Pietraszewski & Zawadzki, 2014), the presence of a defending player also has an effect (Rojas, Cepero, Oña, & Gutierrez, 2000) as one of the main factors.

According to many studies (Miller & Bartlett, 1993, 1996; Rojas, Cepero, Oña, & Gutierrez, 2000; Okazaki & Rodacki, 2012; Tapera, Gundani, Makaza, Amusa, & Goon, 2014a, 2014b) decrease in the height of the jump and the height of release point comes at long distance shots. The reason is that during the performance of the jump shot, the player needs to have good balance, but with an increase in the height of the jump, body stability is affected. The position of the body and the position of the body parts should actually provide the shooter with the best balance and stability when performing a jump shot. However, by comparing the median values of height of the body center of gravity at the time of releasing the ball for the three-point shot (HCGR3p) with the median values of the same parameters for the two-point shot (HCGR2p), higher values were noticed. On the other hand, comparing the median values of height of the release point for the three-point shot (HRP3p) with the height of release point for the two-point shot (HRP2p), lower values were noticed. According to that, the results of this study cannot confirm the facts from previous research, but some authors (Kant, 2014; Tapera, Gundani, Makaza, Amusa, & Goon, 2014a) concluded in their studies that for a successful shot, release of the ball should be done at a higher point. However, the important thing is that there is a significant difference between the initial and the final measurement in the form of an increase in the values of HRP and HCGR, which is the result of the plyometric part of the practice. With this statement, some of the previous studies (Matavulj, Kukolj, Ugarkovic, Tihanyi, & Jaric, 2001; Markovic, 2007; Santos & Janeira, 2008; de Villarreal, Kellis, Kraemer, &

Izquierdo, 2009; Shallaby, 2010; Santos & Janeira, 2011; Sharma, 2012) agree about the positive influence of the plyometric part of the training on the height of the jump during the performance of the jump shot and other kinetic parameters. Based on this, the specific training program had a positive influence on these parameters.

In order not to reduce the accuracy of the shots from a longer distance, the changes should be done in the angle of releasing the ball and the release speed of the ball (Miller & Bartlett, 1996; Okazaki & Rodacki, 2012).

In previous studies (Satern, 1993; Miller & Bartlett, 1996; Okazaki & Rodacki, 2012) it has been determined that the release speed of the ball increases with the increase in the shot distance. These results have also been confirmed in this study. Analyzing the results, a single drop in value is observed for the release speed of the ball (RSB2p and RSB3p). That acutely means that the release speed of the ball was increased. The increase of the speed can also be due to plyometric training because of the strength in the muscles of the upper extremities, but the shooting part of the practice played its part too. Constant repetition of the movement and training speed performance during exercise surely played its part. So, once more the specific training program had a positive influence on the mentioned kinematic parameter, as the results now show. It should be noted that an increase in the release speed can affect the accuracy of the jump shots from a longer distance and that, therefore, there may be a change in the other parameters.

The last parameter on which the specific training program had a positive influence is the angle of release. The angle under which the ball enters the basket is closely related to the angle of ball release. With a bigger attack angle, the possibility of error when the ball enters the rim is significantly reduced. With an angle of 90°, which is practically impossible, the ball has the greatest chance of passing through the rim. On the other hand, these angles depend on the distance from which the shot is made. In earlier research (Ryan & Holt, 1989; Elliott & White, 1989; Satern, 1993; Miller & Bartlett, 1996) it was concluded that the angle of the shooters hand increases as the distance increases. Although, according to the opinion of many authors (Miller & Bartlett, 1996; Taborda, Dorst, & Leite, 2007; Okazaki & Rodacki, 2012), distance plays a major role in determining the angle of releasing the ball, this kinematic parameter also depends on the player's position on the team (backs, wings and center) (Tapera, Gundani, Makaza, Amusa, & Goon, 2014b; Çetin & Muratlı, 2014).

By comparing the mean value of the angle of releasing the balls (AOR), obtained in this study, they indicate that increasing the distance did not increase the angle at either the initial or the final measurement. However, what matters is that the parameter value has increased for two and three points (AOR2p and AOR3p) in the final measurement compared to the initial one. Referring to the above, the importance of the large attack angle and its close relationship with the angle of release, it can be concluded that the specific training program had a positive influence on this kinetic parameter.

A smaller angle of release, which is obtained when performing a jump shot from a longer distance, can be seen as an attempt to reduce the need for high muscle strength of the upper extremities. If there is no reduction in the angle of release during the jump shot, this move requires more effort from the shooter for the release of the ball. This means in fact that if there is no change in the angle of release during the shots from larger distances, the use of larger force to shoot the ball into the basket, the accuracy of the shot is endangered (Miller and Bartlett, 1993, 1996; Satern, 1993; Walters, Hudson, & Bird, 1990; Okazaki & Rodacki, 2012).

Such a planned training program obviously can have a positive impact on kinematic parameters. Based on that, there are some previous studies (Oudejans, Koedijker, Bleijendaal, & Bakker, 2005; Kocić, Berić, & Bojić; 2009; Chen, 2010; Zambová & Tománek, 2012) in which it was confirmed that appropriate training, whether with situational shooting exercises or by simply increasing the distance of the shot, can positively affect the performance of the jump shot.

CONCLUSION

The results of this study have shown that after a ten-week specific training program, consisting of a combination of plyometric and shooting exercises during one practice, there is a difference between the initial and final measurement in most of the kinematic parameters, and when it comes to shots from a closer and further distance. Mentioned kinetic parameters are: release speed of the ball (RSB2p and RSB3p), the angle of release (AOR2p and AOR3p), height of the body center of gravity at the time of releasing the ball (HCGR2p and HCGR3p) and height of the release point (HRP2p and HRP3p). The obtained results also showed that the mentioned training program had a big influence on the same kinematic parameters, which is logical. Based on this study, it can be concluded that a properly designed plan and program can have an influence on most of the kinematic parameters of the jump shot. Also, it is important to pay attention to the mistakes that occur during the practice of the jump shot and to start correcting them as soon as possible.

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UTICAJ DESETONEDELJNOG PROGRAMA NA BIOMEHANIČKE PARAMETRE POSTIGNUTIH KOŠEVA IZ SKOKA MEĐU MLADIM KOŠARKAŠIMA

Cilj ovog istraživanja bio je da se utvrdi uticaj specifičnog programa obuke na kinematičke parametre postignutih koševa iz skoka u košarci. U istraživanju je učestvovao 31 košarkaš, starosti 15.32 ± 0.65. Svi učesnici obučavani su u skladu sa specifičnim programom obuke tokom 10 nedelja. Podaci dobijeni na inicijalnom i finalnom merenju su obrađeni neparametrijskim statističkim procedurama. Obrada podataka je izvršena radi utvrđivanja razlika u kinematičkim parametrima, unutar grupe, između inicijalnog i finalnog merenja. Nakon toga, nivo uticaja specifičnog programa obuke na navedene parametre je utvrđen. Dobijeni rezultati ukazuju na razlike između inicijanog i finalnog merenja kod 8 od 10 (80%) kinematičkih parametara, i da je specifični trening program uticao na te iste (80%) kinematičke parametre.

Ključne reči: *kinematika, košarka, skok-šut, smart ball, specifičan program obuke.*