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THE EFFECT OF PRACTICING WITH A REDUCED DIAMETER RIM ON THE EFFICIENCY OF FREE THROWS WITH YOUNG BASKETBALL PLAYERS

UČINEK VADBE Z ZMANJŠANIM OBROČEM NA UČINKOVITOST IZVAJANJA PROSTIH METOV PRI MLADIH KOŠARKARJIH

ABSTRACT

Even though free throws account for approximately 20% of all points in a basketball game, practicing free throws is often not given enough attention. We analyse the efficiency of practicing free throws with a reduced diameter rim to monitor the changes of successful free throws and the changes of the angle of ball entry. Our sample included 57 top young basketball players, aged 15 to 18. After the experimental programme of practicing free throws, the efficiency of the free throws did not increase (neither during testing nor during competition) and neither did the angle of ball entry. The angle of entry with a standard and a reduced diameter rim are strongly correlated (r = 0.86) – most players retain their own shooting trajectory, regardless of the diameter of the rim. It seems that using a reduced diameter rim by itself, without instruction, does not lead to an increase of the angle of entry.

Keywords: Basketball shooting, performance, angle of entry, technology

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IZVLEČEK

Čeprav s prostimi meti dosežemo približno 20 % vseh točk na košarkarski tekmi, se treningu prostih metov praviloma namenja premalo pozornosti. V pričujoči raziskavi smo se odločili analizirati učinkovitost treninga prostih metov s pomočjo obroča z zmanjšanim premerom (Ø = 37 cm) v smislu njegovega vpliva na učinkovitost (natančnost) zadevanja in vpadnega kota žoge pri metu na koš. V ta namen smo v vzorec merjencev vključili 57 mladih košarkarjev, starih od 15 do 18 let. Po končanem eksperimentalnem programu treninga prostih metov, se učinkovitost metov ni izboljšala (niti na posebej izvedenih testiranjih, niti na tekmi), prav tako pa se ni povečal vpadni kot žoge. Pokaže se visoka korelacija (r = 0.86) med vpadnim kotom žoge pri metih na običajni in zmanjšani obroč, kar pomeni, da se pri večini metov ohrani zelo podobna trajektorija leta žoge, ne glede na premer obroča. Očitno obroč z zmanjšanim premerom ne vpliva na vpadni kot žoge, če hkrati igralcem ne damo navodil naj povečajo izmetni kot žoge.

Ključne besede: košarka, met, uspešnost, vpadni kot, tehnologija

INTRODUCTION

In basketball, free throws are awarded after a personal or other type of foul. It is a relatively simple shot from medium distance (4.2 m), characterized by being performed in stable and constant conditions and more or less automatically (Filippi, 2011; Fontanella, 2006).

Free throw efficiency differs among players. Some (e.g. Stephen Curry) have a 90% success rate (https://www.basketball-reference.com/players/c/curryst01.html), while it is not uncommon for top basketball to have a free throw success rate below 50% (Erčulj, 1999).

Teams typically score between 15 to 20 points in a game from free throws, which is approximately 20% of all points (Erčulj, 1999). Often, the efficiency of free throws determines the winner of the game. Free throw efficiency is even more important in tight games, where the winner is decided by only a few points of difference.

Although an important factor, relatively little has been written about practicing free throws in professional and scientific literature. Free throw training is not situational and functional enough and, in our opinion, practicing free throws technique does not receive enough attention. This is one of the reasons why we find basketball players with relatively poor free throw technique even at the highest competitive level.

There are several training tools available for practicing free throws, but are seldom used in training. With rare exception, the efficiency of these tools (and their effect the efficiency on free throw accuracy) has not been studied.

A simple and, according to some research, an effective tool for shooting practice is using a rim with a reduced diameter. This special rim is fastened inside the regular rim and has a smaller diameter. Shooting with a reduced diameter requires greater precision and, according to research (e.g. Khlifa, Aouadi, Shepard, Chelly, Hermassi, & Gabbett, 2013; Khlifa, Aouadi, Hermassi, Chelly, Jlid, & Gabbett, 2012), it also affects the trajectory (parabola) of the shot (release angle and angle of ball entry). The minimal angle of entry that allows for a direct success increases with reducing the rim. The basketball players should therefore increase the release angle and with it the trajectory of the shot and the angle of ball entry.

Khlifa et al. (2012, 2013) researched the effects of practicing with a reduced rim (Ø = 35 cm) with young basketball players. After 10 weeks and 20 practice sessions (each player performed 150 free throws per session) they discovered a statistically significant increase in free throw successs (an average of 22.7% increase relative to start). The release angle of the ball also increased significantly (from 52.7^0 to 55.2^0). The authors conclude that the reduced rim is an an efficient tool for free throw training, especially with young basketball players. However, they also recommend that the effects of such a regimen on shooting accuracy during competition is investigated.

We analyse the efficiency of free throw training with a reduced diameter rim and whether the findings from related work can be replicated on a sample of top young basketball players from Slovenia and Serbia. In particular, we were interested if the reduced diameter rim forces basketball players to adopt a shooting technique with a higher angle of ball entry. Additionally, we investigate how free throw training with a reduced sized rim effects shooting efficiency in competition and how long it takes for the effect of the experimental programme to wear off.

METHODS

Participants and procedure

Our research was divided into two independent parts. First, we tested the efficiency of the free throw training programmes with a standard and reduced rim and monitored the increase of the angle of ball entry and the efficiency of the shots. Second, we analysed the effect of using a reduced diameter rim on the parabola of the shot (angle of entry).

The first part included basketball players from KD Slovan, aged 15 to 17 (16.4 ±0.52 years), who play in the 1st Slovenian Junior (U17) league. The experimental programme of practicing free throws, performed in the season 2016/17, was carried out by 11 basketball players 173 to 200 cm tall (186.9 ± 9.35 cm) and weighing between 67 and 87 kg (77.8 ± 7.09 kg).

In the second part included 46 top basketball players from four clubs from 1st Serbian Junior (U17 and U19) league (KK Partizan, KK Crvena zvezda, KK Mega Bemax, KK Dynamic) and are between 15 and 18 years of age (16.5 ± 0.94 years), from 182 to 206 cm tall (196.6 ± 6.23 cm) and weigh between 64 and 112 kg (86.2 ± 10.80 kg).

Before the start of the experimental programme all participants and their parents signed a formal agreement of cooperation. The study was approved by the Ethics Committee of the Faculty of sport, University of Ljubljana according to the Helsinki Declaration.

Training intervention

The players carried out the experimental programme of practicing free throws twice a week. In each session they performed 150 free throws in series of 20, 25, 30 and 35 shots. The experimental programme was divided into two parts. In the first part, which lasted 5 weeks, the players carried out 10 sessions with a standard rim with a diameter of (Ø = 45 cm). In the second part, they practised with a reduced diameter rim ((Ø = 37 cm) in a period of 10 weeks (20 practices). Before and after the completed programme the players continued with their standard basketball training, which did not include free throws training with a reduced diameter rim and was not particularly focused on free throws.

Testing interventions

Before, during and after both parts of the experimental programme, we carried out preliminary, intermediate and final tests. For each test players shot 60 free throws with a standard rim. After 8 practices we analysed 5280 free throws of 11 basketball players. In every test we recorded the percentage of successful free throws and measured the angle of ball entry. The effects of the training were monitored for a month after the completed training, with four tests at weekly intervals.

The tests were carried out in the following order:

1. Preliminary,
2. Intermediate 1 (after 10 practices with the standard rim),
3. Intermediate 2 (after 10 practices with the reduced rim),
4. Final 1 (after 20 practices with the reduced rim),
5. Final 2 (one week after program completion),
6. Final 3 (two weeks after program completion),
7. Final 4 (three weeks after program completion),
8. Final 5 (four weeks after program completion).

We further tested free throws success in 26 official games played by the team.

Additional testing

In the second part of the research, we additionally tested 46 basketball players, each performing 60 free throws (3 series of 20 shots) with a standard rim and then the same number of free throws with a reduced rim, for a total of 5520 shots. We were primarily interested in how much the reduced diameter rim by itself influences the parabola of the shot (entry angle, angle of approach). The participants did not receive any instruction to adapt their shooting technique in any way. The only instruction was to be as successful as possible.

Equipment

In our research we used a special rim with a reduced diameter, named “DOUBLE DOUBLE” (SKLZ, Chris Sports, Philippines), which was fastened at the standard hoop. This training tool reduced the diameter of the rim from 45 cm to 37 cm, which required higher precision from the players when executing free throws. At the same time, a reduced rim led to an increase of the angle of ball entry under which the ball could still go directly in for approximately 9^0 (from 32^0 to 41^0).

Figure 1. Special rim with a reduced diameter ‘’Double double”.

Technology 94Fifty® or the so-called “smart (instrumented) basketball” (InfoMotion Sports Technologies, USA) of standard weight and size was used to measure the angle of ball entry. Simultaneously, the ball is the recipient of forces with which the basketball player works on the ball when shooting at the hoop. The ball contains integrated motion sensors, which allow us to obtain precise feedback on the angle of ball entry. A special application allows us to download real-time data to our computer or mobile device via Bluetooth (www. http://shop.94fifty.com).

Abdelrasoulb et al. (2015) reported that the 94Fifty instrumented basketball provides reliable and accurate information and immediate feedback for both players and coaches on shot angle. They found a high degree of accuracy but also validity and reliability in measuring shot arc degree. Cronbach’s alpha reliability coefficient between the 94Fifty software and Dartfish video analysis was 0.998 and 137 out of 140 angles measured were within +/-1 degree discrepancy.

Statistical analysis

We analysed the data in the R programming language and presented it with the help of descriptive analytics. The differences between individual data groups were analysed on the basis of the overlap of lower and upper limits of 95% confidence interval for the expected value assessment. We estimated the confidence intervals using bootstrap.

Figure 2. ''Smart ball'' with the mobile application (94Fifty, 2014).

RESULTS

Table 1. Angle of ball entry in each testing*

Test	N	M	2.5%	97.5%
1.	660	45.0	44.7	45.3
2.	660	44.7	44.3	45.0
3.	660	44.7	44.4	45.0
4.	660	44.2	43.9	44.5
5.	660	44.7	44.4	45.0
6.	660	44.7	44.4	45.0
7.	660	44.6	44.4	44.9
8.	660	43.5	43.3	43.8

* The grey indicates the period of the programme of practicing free throws. The 2nd testing was completed after 10 practices of shooting in a standard rim (dark grey). Practicing shooting in a reduced diameter rim took place between the 2nd and 4th test (light grey).

Legend: Test – serial number of testing; N – total number of analysed shots; M – average value of the angle of ball entry in ^{0}; 2.5%, 97.5% – upper and lower limits of 95% confidence interval for the expected value assessment.

Table 1 shows the estimated mean angles of ball entry for each test. The values are at a similar level, regardless of whether the training was carried out with the standard rim or reduced size rim. Surprisingly, the angle of entry was the highest at the first (preliminary) testing and there is a slightly decreasing trend. After completion of the programme, the values of the angle of entry remained unchanged for three more weeks, while we can notice lower values of the angle of entry in the final test.

Table 2. Angle of entry during the time of training with a reduced diameter rim and standard rim and in the period without trainings

Training	N	M	2.5%	97.5%
0	3300	44.5	43.3	45.3
1	1320	44.4	44.2	44.7
2	660	44.7	44.3	45.0

Legend: Training 0 – the period without training; training 1 – the period when we carried out the programme of practicing free throws with a reduced rim; training 2 – the period when we carried out the programme of practicing free throws with a standard rim; N – total number of shots; M – average value; 2.5%, 97.5% – upper and lower limits of 95% confidence interval for the expected value assessment.

To simplify comparison, we divided the data into two groups: the ones acquired during the programme of practicing free throws and the ones acquired at the time without training (Table 2). There is no discernible difference in angle when the free throws were performed with a standard (2) or special rim (1) or were not performed at all (0).

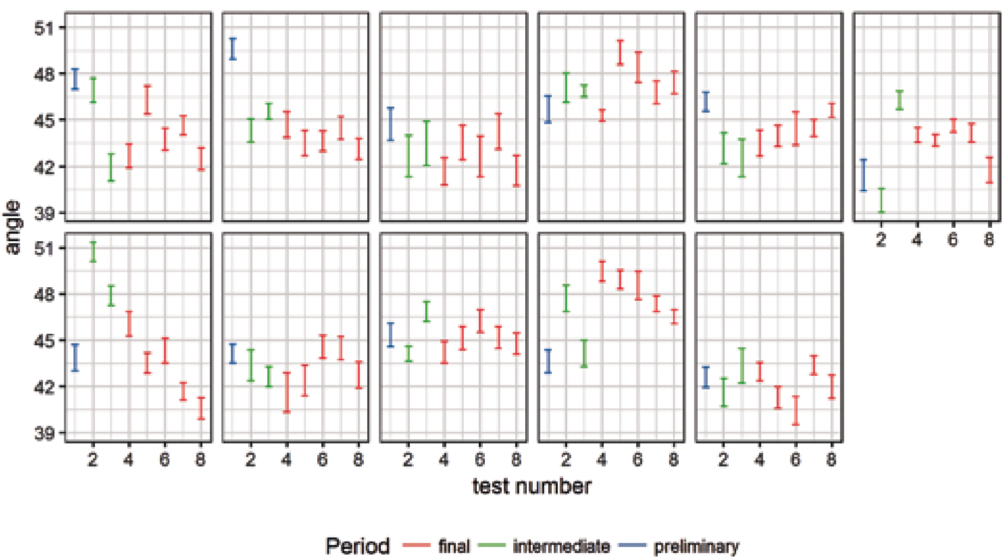

Figure 3. Angle of entry according to individual players during different testing periods.

Figure 3 shows angle estimates for individual players and further illustrates that we cannot make any conclusions regarding how the reduced diameter rim affects the angle. For some players the angle of entry increased when practicing free throws with a reduced rim, for others the angle decreased or remained approximately the same.

Table 3. Angle of ball entry with a standard rim and a reduced diameter rim

Training	N	M	2.5%	97.5%
1	2260	41.29	41.27	41.31
2	2260	41.90	41.88	41.92
0		0.61	0.45	0.76

Legend: 1 – free throws with a reduced rim, 2 – free throws with a standard rim; 0 – difference between the shots with a standard and reduced rim; N – total number of shots; M – average value; 2.5%, 97.5% – upper and lower limits of 95% confidence interval for the expected value assessment.

Results on the second and independent sample of participants are similar (see Table 3). The angle of ball entry with free throws mainly remains the same, on average, regardless of the rim used. We also cannot speak of differences between the angle of entry while shooting at a standard or a reduced rim. Angle of entry with a standard and a reduced rim for a player were strongly correlated (Pearson coeff. = 0.86, 95% CI: 0.84-0.89). This means that the majority of players with a low parabola of the shot maintain a low parabola even when using a reduced rim.

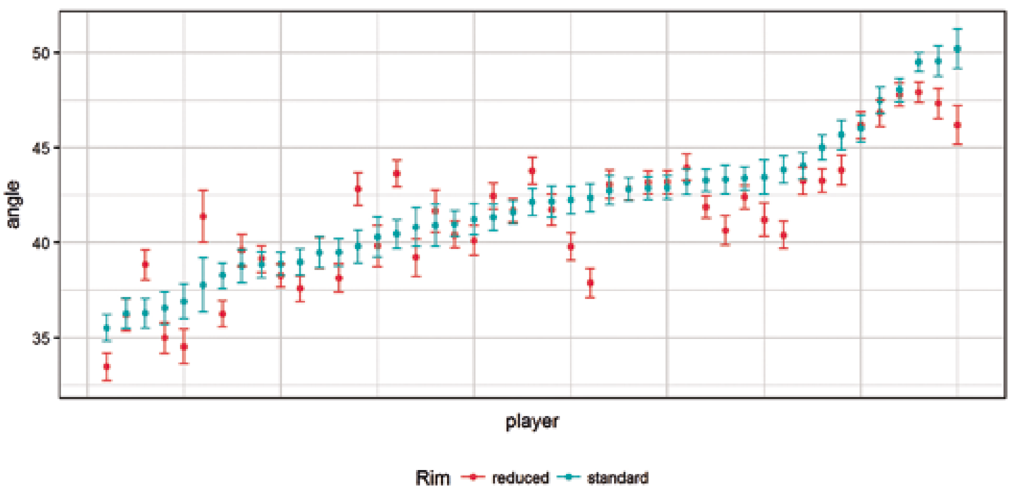

Figure 4. The angle of entry with a standard rim and a reduced diameter rim according to individual players.

Figure 4 provides further information on how each individual player's angle differs between standard and reduced size rim. The only noticeable pattern is that players with the highest angles of entry at most decreased their angle.

When it comes to shot efficiency, we quickly see that the highest percentage of successful shots (69%) is surprisingly achieved at the first test, i.e. before the beginning of the programme. While there is some variability in estimated means, the between-test differences are all within the estimated CI. Therefore, there is no discernible difference in shooting efficiency between these periods.

Table 4. Estimated shot efficiency at individual tests

Test	N	M	2.5%	97.5%
1.	660	68.9	65.3	72.4
2.	660	64.4	60.7	68.0
3.	660	63.8	60.1	67.4
4.	660	58.4	54.6	62.1
5.	660	64.7	61.0	68.2
6.	660	66.1	62.4	69.6
7.	660	59.7	55.9	63.4
8.	660	59.2	55.5	62.9

* The grey indicates the period of the programme of practicing free throws. The 2nd test was completed after 10 practices of shooting in a standard rim (dark grey). Practicing shooting in a reduced diameter rim took place between the 2nd and 4th testing (light grey).

Legend: Test – serial number of test; N – total number of shots; M – average percentage of successful shots; 2.5%, 97.5% – upper and lower limits of 95% confidence interval for the expected value assessment.

Table 5. The efficiency of practicing free throws in the period of practicing with the standard rim and the rim with a reduced diameter and in the period without training.

Training	N	M	2.5%	97.5%
0	3300	63.7	55.5	72.4
1	1320	61.1	58.4	63.7
2	660	64.4	60.7	68.0

Legend: Training 0 – the period without trainings; training 1 – the period when we carried out the programme of practicing free throws with a reduced rim; training 2 – the period when we carried out the programme of practicing free throws with a standard rim; N – total number of shots; M – average value; 2.5%, 97.5% – upper and lower limits of 95% confidence interval for the expected value assessment.

The data in Table 5 show that the efficiency of practicing free throws in tests was at a very similar level, regardless of whether the programme was performed with the standard (2) or special rim (1) or not performed at all (0). The overlap in CI again indicates that there are no discernible differences.

Figure 5 shows that practicing free throws with a reduced rim had a very different effect on the efficiency of performing free throws when it came to individual players. For most players, the efficiency while training with a reduced rim was worse than while training with a standard rim.

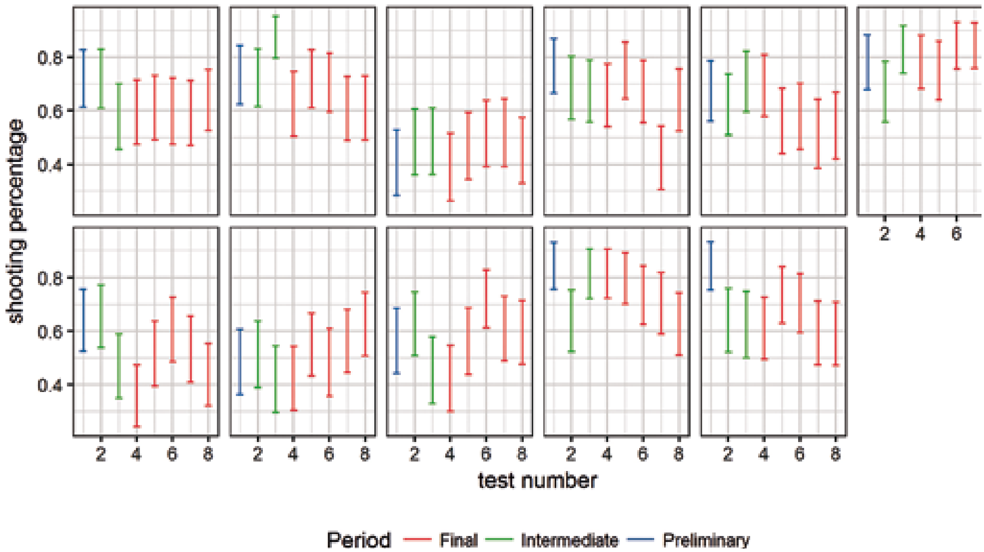

Figure 5. Individual players' shot efficiency in different tests.

Table 6. Efficiency of performing free throws at competitions during the research

Period	1st (6 games, 114 shots)	2nd (6 games, 119 shots)	3rd (10 games, 233 shots)	4th (1 game, 22 shots)
Efficiency %	72.6	71.4	57.5	62.3

Legend: 1st period – the period when we have not performed the special training of free throws yet, 2nd period – the period of practicing free throws with a standard rim, 3rd period – the period of practicing free throws with a reduced diameter rim, 4th period – the period when we were not carrying out the special training of free throws any more. Efficiency – the percentage of successful free throws in an individual period.Finally, Table 6 shows the players' free throws efficiency in competition. We can see that the efficiency (percentage of successful free throws) is greatest in the six games played before training. A very similar efficiency of performing free throws at games was noted in the period when we carried out the special training with a standard rim. During the period of practicing free throws with a reduced diameter rim the efficiency decreased below 60%. Unfortunately, in the period after we completed the special programme, only a single game (22 shots) was carried out, since the competition season was coming to a close.

DISCUSSION

Contrary to the findings of Khlifa et al. (2012, 2013), training with the special rim with a reduced diameter failed to prove effective when it came to increasing the angle of ball entry. Even though some individuals did show an increase of the angle of entry, this effect cannot be generalized to all participants. We also cannot claim that the angle of entry increased with those players who threw the ball at a lower angle (Khlifa et al. (2012, 2013) recommend the use of a rim with a reduced diameter for such players). The results of our research show that the angle of entry with free throws remains at a similar level, regardless of whether the basketball players have previously undergone the training with a special rim, standard rim or have not carried out the training programme with free throws at all.

If training with a reduced diameter rim fails to lead to an increase of the angle of ball entry, we are faced with the question whether the players even increase the parabola of the shot (angle of entry) when shooting at a reduced rim or whether they keep to their usual shooting kinematics and merely try to be as precise as possible. Further analysis, performed on a relatively large sample of participants, a large number of free throws and without instruction on how to adapt the shot to a reduced size rim suggests that a reduced rim by itself does not influence the parabola of the shot (angle of entry) and that, regardless of the rim used, basketball players largely retain their own shooting trajectory and do not increase the trajectory of the shot when shooting at a reduced diameter rim. This is also true for the players that have a lower angle of entry than is optimal. Some players (especially the ones with a high angle of entry) even decrease the parabola of the shot.

These findings suggest that reduced rim training is not efficient if the players are not also simultaneously instructed to increase their angle. An interesting question arises – could similar increases in efficiency be achieved by training with a standard rim and only instructing the players. Of course, this only makes sense with players that have such a low angle of ball entry that it influences their shooting efficiency (this can only be detected and controlled with the use of technology that allows accurate measurements of the angle of ball entry in real time).

The optimal angle of ball entry especially depends on the release height and the distance to the rim (Hamilton & Reinschmidt, 1997; Okubo & Hubbard, 2006; Podmenik, Supej, Čoh, & Erčulj, 2017; Podmenik, Supej, & Erčulj, 2011; Okazaki, Rodacki, & Satern, 2015) and is from 10^0 to 15^0 lower than the release angle (Fontanella, 2006). Most authors agree that the ideal angle of entry with free throws and shots from a middle and long distance ranges between 42^0 and 48^0 (Miller & Bartlett, 1996; Satti, 2004; Crowley 2011). The angle of entry of 44^0 or 45^0, which we have measured with the majority of our participants, is therefore appropriate so there is no need to increase it. Namely, such an angle allows a successful free throw even in the event of shooting at a reduced angle. This is probably why the majority of basketball players did not decide on increasing the parabola when shooting at the reduced diameter rim (ring). It is also possible that it is easier for some players to adapt to the new requirements of a reduced rim, while for others this is harder so they need more time.

In the case of determining the impact of the effectiveness of practicing with a reduced rim on the efficiency (accuracy) of the free throws, we can conclude that our findings are not consistent with the findings of Khlifa et. al. (2013), who reported a substantial increase of the efficiency of performing free throws (22%) after 10 weeks of training with a with reduced rim. We found no discernible improvement neither in tests nor in competition, which is an aspect that was not researched in Khlifa et. al. (2013).

We identify two directions for further work. First, research on the effects of free throw training on players with an extremely low parabola of the shot (e.g. those with the angle of entry below 38^0). And second, we need more precise research of relationship between the angle of entry and the success rate of free throws.

We conclude that using a reduced hoop diameter rim by itself does not have a positive effects on the increase of the angle of ball entry if the coaches fail to monitor and control the values of the angle of entry and do not warn the players of the possible standards surrounding that.

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