RELIABILITY AND FACTORIAL VALIDITY OF BASKETBALL SHOOTING ACCURACY TESTS

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Preliminary communication

Abstract
The aim of the study was to determine reliability and factorial validity of six basketball shooting accuracy tests. Fifty five healthy basketball players (age 19.1 ± 3.1 years; body mass 83.4 ± 12.5 kg; height 189.1 ± 8.2 cm; body fat percentage 13.1 ± 4.1) from four Bosnian basketball teams participated in this research. The applied tests have been constructed in order to measure basketball shooting accuracy from three different distances and under different intensity loads. The standard statistical parameters were calculated for each trial of all six basketball shooting tests (arithmetic mean, standard deviation and range). The average intertrial correlation coefficients (AVR), interclass correlation coefficients (ICC) and Cronbach's alpha reliability coefficients (α) were used to determine the between-subject reliability of basketball shooting tests. The within-subject variation for the tree tests was determined by calculating the coefficient of variation (CV). In order to determine the factorial validity of six basketball shooting tests, an intercorrelation matrix of the six tests was factorized using a principal component factor analysis. Structurally and physiologically more demanding tests performed from longer distances, produced higher variation in the applied tests. The most reliable tests are those that were performed from short distances in physiologically and structurally less demanding conditions. Results showed that all six tests have a similar measurement goal, that is to say basketball shooting accuracy, but they do not measure the same aspects of basketball shooting accuracy. As reliable and valid instruments, the tests can be used in future studies, but also can help coaches to evaluate players' accuracy in more realistic conditions, or to use the tests as training drills for improving basketball accuracy and players' fitness.

Key words: *fatigue protocol, field tests, basketball players*

INTRODUCTION

Basketball is probably one of the most attractive sports in the world. Flashy scoring, mostly by slam dunks or powerful lay-ups, but also by long distance shoots, that very often, in last seconds of a game, determine a winner, is something that attracts spectators all around the globe.

Previous researches showed that free throw percentage, field goals and three-point shots distinguish winning and losing basketball teams (Trninić et al., 2002; Pojskić et al., 2009). In order to achieve high shooting percentage every team has to have players who can score in all stages of the game and under different conditions, so it can be said that accuracy is one of the most important motor ability in basketball.

Many field tests were used to evaluate shooting precision of basketball players to present day (Karalejić, 1998), but they are mostly performed in stationary conditions without high physiological load or fatigue effect, so knowing a fact that basketball is a sport with a high anaerobic component produced by intensive active periods and short rest periods of a game (Abdelkrim et al., 2007; Crisafulli et al., 2002; Hoffman, 2002; McInnes et al., 1995), those tests are not so appropriate for measuring basketball shooting accuracy. More valid data about basketball accuracy could be obtained using tests that reflect real game situations i.e. more physiologically intensive tests that generate fatigue as a disturbing factor for basketball shooting precision.

Recent studies have showed that fatigue is a very complex phenomenon that includes both psychological and many physiological factors (Astrand and Rodahl, 2003), that negatively influence cognitive abilities (Fleury and Bard, 1987), basketball passing accuracy (Lyons et al., 2006), basketball shooting accuracy (Erčulj and Supej, 2009). Physiological demands of basketball and fatigue effects of the game impose a need for constructing new field tests that evaluate basketball shooting accuracy in physiologically more demanding conditions that produce fatigue.

One of the goals of this study was to construct three new tests for measuring basketball shooting accuracy that would be structurally and physiologically similar to real situations during a competition. In this way the tests would have bigger applicable value. The other goal of the research was to determine reliability and factorial validity of the new tests in order to apply them in everyday practice and some future researches.

METHODS

Participants

Fifty five healthy basketball players (age 19.1 ± 3.1 years; body mass 83.4 ± 12.5 kg; height 189.1 ± 8.2 cm; body fat percentage 13.1 ± 4.1) from four Bosnian basketball teams participated in this research. All players had played basketball at least five years and they were without any neuromuscular diseases or reported injuries in the past six months. They signed a written consent to participate in the study, after we informed them about the purpose of the study, testing protocols, research benefits and potential risks. All testing procedures followed the Declaration of Helsinki (recommendations guiding researchers in biomedical studies involving human subjects).

Testing procedures

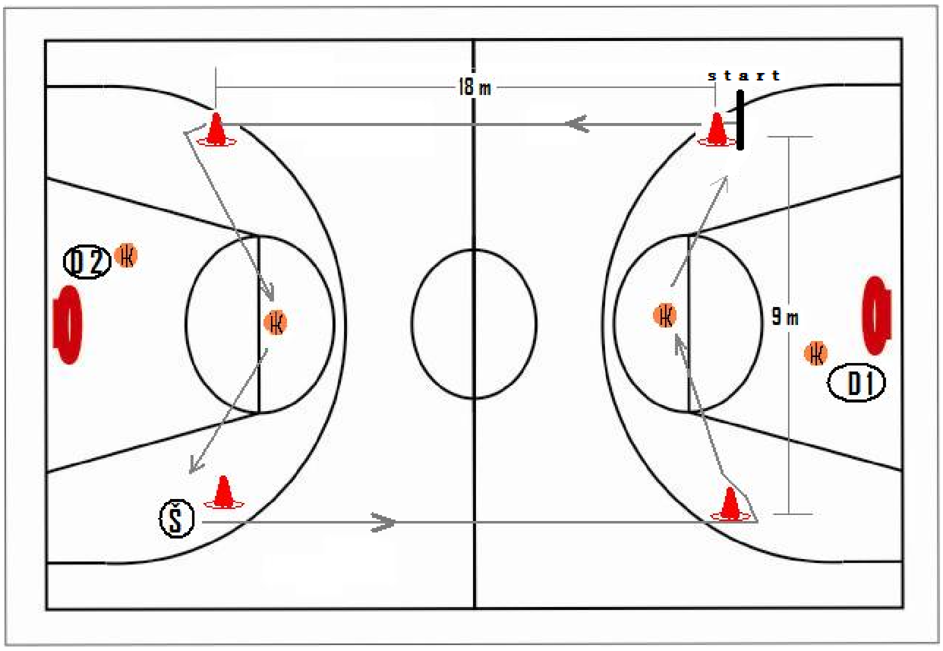
All participants were randomly assigned to one of three testing groups (one test, one group) which were tested on three separated days (Monday, Wednesday, and Friday) during morning training sessions, between 10 a.m. and 12 a.m. After one of the groups completed testing, they would take a shower and the other group would start warming up and going through testing procedure. Before testing protocol, every group accomplished 10 minutes of general warm up with the ball, 7 minutes of dynamic stretching and 12 minutes of specific basketball shooting drills. The first testing session included testing of free throw accuracy, the second included testing of field goal shooting accuracy and the third session included testing of three point shooting accuracy. All testing sessions were performed in random order. Every test was performed three times with a five-minute rest period between each trial.

Basketball shooting accuracy tests

S1P - free throw shooting without fatigue protocol
After a warm-up protocol, described in the testing procedures, every player performs three series of ten three throw shoots, with a 3-minute rest period between the series. Two players are positioned below the hoop and they pass the ball to the testee. After one player completes ten shots, the other comes to the free throw line and performs the same task.

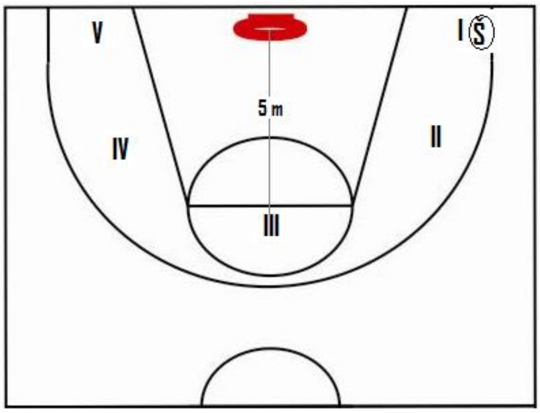
S1P60 – free throw shooting during 60 seconds

fatigue protocol
For easier organization of the testing we used volleyball court lines (Picture 1). Each player performed five series of two free throws with running between the series. Each series has to be completed in 12 seconds. A player starts the test with 18-meter sprint (volleyball court sideline), makes a turn around a cone and runs 4.6m to free throw line. After performing two free throws he/she runs 4.6m to another cone where he/she waits for a signal to start the next series. One tester uses a stop watch to measure 12 seconds, and to give a signal to player. Other tester counts the number of made free throws. Two other players pass the balls to the testee. A stop watch, a whistle, four cones and four basketballs are needed for the testing.



Picture 1

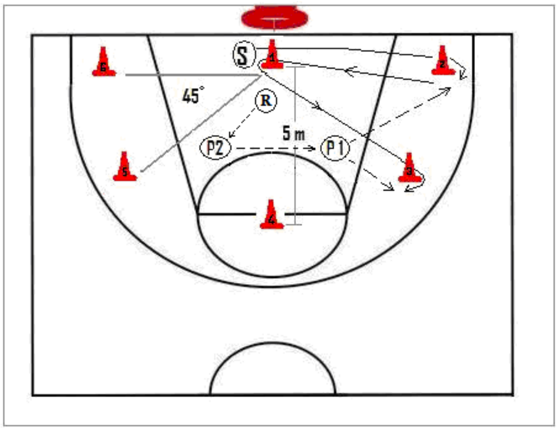
S2P – two point shooting without fatigue protocol
Each player, in one of three series, performs two jump shots from five different positions, i.e. ten shots in total (picture 2). Player's starting position is on the right wing; at position number I. Shooting positions are set at distance of five meters from the vertical projection of the hoop's center on the floor. There is no time limit for the shots. Two other players catch the ball and pass it back to the testee. There is a three-minute rest period between each shooting series.



Picture 2

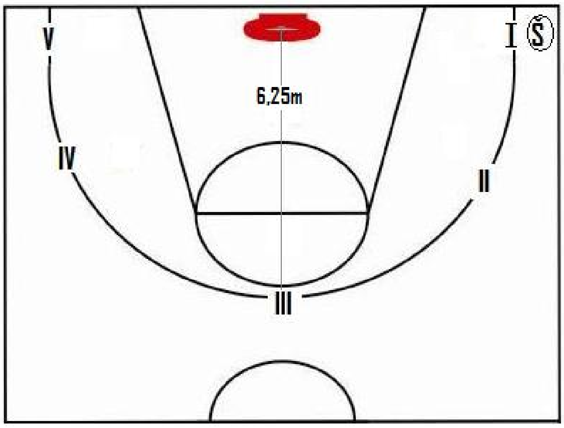
S2P60 – two point shooting during 60 seconds

fatigue protocol
Player's starting position is below the hoop, next to the cone number one (Picture 3). After the tester's sound signal he/she runs 5m to the wing (cone 2) where he/she receives the ball from the passer (P1). Then he/she runs again around the cone 1 toward cone 3 where he/she receives the ball again from the other passer (P1). After completing the same procedure for cones 4, 5 and 6 he/she continues with the test by running in the opposite direction toward the fifth cone, fourth cone and so on depending on the time. The test is finished when 60 s run out. Players are encouraged to run as fast as they can and to perform as many shoots as they can. One rebounder and two passers are needed for the testing procedure. Rebounder (R) grabs all made shots and passes the ball to passer 2. Passer 2 always receives the ball from the rebounder and passes it to passer 1. Passer 1 always passes the ball to the testee.



Picture 3

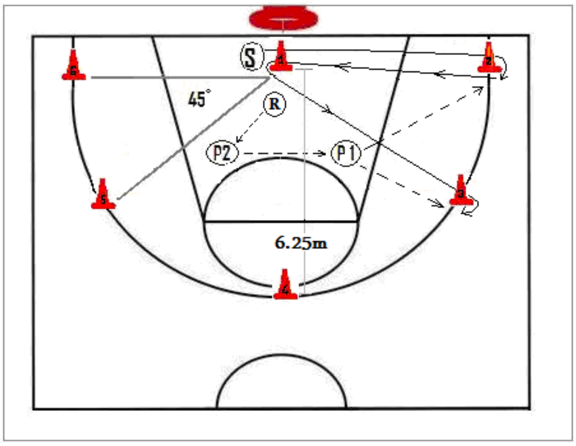
S3P – three point shooting without fatigue protocol
Each player, in one of three series, performs two jump shots from five different positions, i.e. ten shots in total (picture 4). Player's starting position is on the right wing; at position number I. Shooting positions are set at distance of six meters and twenty five centimeters from the vertical projection of the hoop's center on the floor. There is no time limit for the shots. Two other players catch the ball and pass it back to the testee. There is a three-minute rest period between each shooting series.



Picture 4

S3P60 – three point shooting during 60 seconds

fatigue protocol
Player's starting position is below the hoop, next to the cone number one (Picture 5). After the sound signal he/she runs 6.25m to the wing (cone 2) where he/she receives the ball from the passer (P1). Then he/she runs again around the cone 1 toward cone 3 where he/she receives the ball again from the other passer (P1). After completing the same procedure for cones 4, 5 and 6 he/she continues with the test by running in the opposite direction toward the fifth cone, fourth cone and so on depending on the time. The test is finished when 60 s run out. Players are encouraged to run as fast as they can and to perform as many shoots as they can. One rebounder and two passers are needed for the testing procedure. Rebounder (R) grabs all made shots and passes the ball to passer 2. Passer 2 always receives the ball from the rebounder and passes it to passer 1. Passer 1 always passes the ball to the testee.



Picture 5

Statistical analysis

SPSS (16.0; SPSS, Inc., Chicago, IL, USA) was used for statistical analysis. The standard statistical parameters were calculated for each trial of all six basketball shooting tests (arithmetic mean, standard deviation and range). The average intertrial correlation coefficients (AVR), interclass correlation coefficients (ICC) and Cronbach's alpha reliability coefficients (α) were used to determine the between-subject reliability of basketball shooting tests. The within-subject variation for the three tests was determined by calculating the coefficient of variation (CV) as outlined by Hopkins, 2000. In order to determine the factor validity of six basketball shooting tests, intercorrelation matrix of the six tests was factorized using principal component factor analysis. Number of significant factors was determined by the Kaiser-Guttman criterion, which retains principal components with eigenvalues of 1.0 or greater. The structure matrix was used to determine factorial validity of tests. Factorial validity is 1 form of construct validity and was identified in the test showing the highest correlation with the extracted factor (Nunnaly and Bernstein, 1994; Marković et al., 2004, Sporiš, et al., 2010). Significance was set at $p \leq 0.05$.

RESULTS

No violation of homogeneity of variance was found using Levene's test (table 1). Descriptive parameters, reliability and validity coefficients for all six basketball shooting tests are presented in Table 2. Very small unsystematic variation was found between the trials. No statistically significant differences between the trials was found using a Tukey post hoc analysis. Relatively small, but statistically significant systematic variation was found between all tests' mean values.

Table 1
Test of Homogeneity of Variances

Variables	Levene Statistic	df1	df2	Sig.
S1P-I	1.155	2	162	.318
S1P60-I	1.648	2	162	.196
S2P-I	.147	2	162	.863
S2P60-P-I	.073	2	162	.930
S3P-I	.172	2	162	.843
S3P60-P-I	.697	2	162	.500

Three-trial test retest reliability coefficients (α) of all basketball shooting tests, were pretty high (0.75 - 0.92). The greatest reliability coefficient was found for test S1P (α = 0.92). The same test also had the greatest values of average inter item correlation and interclass correlation (AVR = .79; ICC = .92).

Within-subject variation in the tests ranged between 21.1 and 45.9%. The lowest variation was found in test S1P and the highest in test S3P60. The biggest mean value of shooting tests was found in test S1P (free throw shooting without fatigue protocol) and the lowest mean value was found in test S3P60. Overall, by observing the mean values, one can see that the highest values were achieved after the tests performed without fatigue protocol.

Table 2a
Descriptive, reliability and validity statistics for all basketball shooting tests

Test (trials)	**Mean**	**SD**	**Range**	**CV (%)**	**AVR**	**ICC**	**α**
S1P	7.86	1.30	5.0	16.64	.79	.92	.92
S1P-I	7.84	1.39	6.0				
S1P-II	7.93	1.16	6.0				
S1P-III	7.82	1.37	6.0				
S1P60	6.69	1.41	6.3	21.12	.61	.82	.82
S1P60-I	6.76	1.47	8.0				
S1P60-II	6.53	1.21	5.0				
S1P60-III	6.67	1.36	6.0				

Table 2b
Descriptive, reliability and validity statistics for all basketball shooting tests

Test (trials)	**Mean**	**SD**	**Range**	**CV (%)**	**AVR**	**ICC**	**α**
S2P	5.82	1.64	5.7	28.26	.60	.82	.82
S2P-I	5.91	1.53	7.0				
S2P-II	6.13	1.58	5.0				
S2P-III	5.95	1.58	6.0				
S2P60	5.42	1.84	8.3	34.00	.50	.75	.75
S2P60-I	5.98	1.98	7.0				
S2P60-II	5.71	1.85	9.0				
S2P60-III	5.70	1.89	9.0				
S3P	4.25	1.81	7.0	42.77	.65	.85	.85
S3P-I	4.42	1.96	7.0				
S3P-II	4.64	2.05	7.0				
S3P-III	4.43	1.94	9.0				
S3P60	4.00	1.83	8.0	45.90	.60	.81	.81
S3P60-I	3.91	1.49	8.0				
S3P60-II	3.98	1.70	7.0				
S3P60-III	3.96	1.67	9.0				

Mean = arithmetic mean; SD = standard deviation; CV = coefficients of variation; AVR = average intertrial correlation; ICC = infraclass correlation coefficient; α = Cronbach's alpha reliability coefficients

Table 3 represents intercorrelation matrix of basketball shooting tests. All correlations, except correlations between tests S1P60 and S2P, are statistically significant and the coefficients are moderately high. This means that all used tests have similar testing purpose i.e. measurement of basketball shooting accuracy. The strongest correlation is between tests S2P and S3P ($r = .55$, $p \leq .01$).

Factorial validity of the tests was examined using principal component factor analysis. One significant principal component was extracted, which explained 51.68% of the total variance of all applied basketball tests (Table 4). Correlation coefficients of all basketball shooting tests with the extracted principal component are pretty high and range between .59 and .83 (table 5).

Table 3
Intercorrelation matrix of basketball shooting tests

	S1P	S1P60	S2P	S2P60	S3P	S3P60
S1P	1					
S1P60	.400**	1				
S2P	.420**	.120	1			
S2P60	.377**	.281*	.493**	1		
S3P	.523**	.473**	.548**	.440**	1	
S3P60	.368**	.357**	.382**	.525**	.520**	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 4
Eigenvalues (λ) and the percentage of explained variance for all principal components (λ %)

Component	Total λ	% of Variance	Cumulative %
1*	3.101	51.68	51.68
2	.923	15.38	67.06
3	.695	11.58	78.65
4	.506	8.43	87.08
5	.466	7.77	94.86
6	.308	5.14	100.00

* Significant principal component extracted

Table 5
Correlation coefficients of all basketball shooting tests with the extracted principal component

Tests	Component 1
S1P	.717
S1P60	.585
S2P	.697
S2P60	.728
S3P	.827
S3P60	.738

Extraction Method: Principal Component Analysis.
a. 1 component extracted.

DISCUSSION

There were medium to high unsystematic variations in the average values of the trials of all basketball tests. The highest variation was found in three point shooting tests, then two point shooting tests. The smallest variation was found in free throw shooting tests. The variation can be attributed to the sample of participants which consisted of small players (shooting guards, guards, small forwards) and big players (centers, power forwards). This is understandable because small players are, as a result of their training technology and game role, more familiar with shooting tasks than big players. This is highly expressed in the tests performed from longer distances, so it can be said that the longer shooting distance the higher variation.

In addition, higher variation was found in tests that were performed in time limited condition, during fatigue protocol comparing them with the tests that were performed without time limit and extra fatigue protocol. The differences found in the tests' unsystematic variation can be explained by the tests' structure familiarity. More familiar tests produced less variation (free throw shooting tests against newly constructed tests). Structurally and physiologically more demanding tests produced higher variation in the applied tests and worse average shooting results.

No significant differences between the trials were found using ANOVA Tukey post hoc test, i.e. there was no significant systematic variation between trials of each test.

All tests show medium to high AVR, ICC and α (Cronbach's alpha reliability coefficients). The highest values were found in shooting tests performed from shorter distances (free throws), and without time limit and fatigue protocol, but the smallest values were found in tests performed from longer distances and with time limit and fatigue protocol. The most reliable test was S1P (ICC =.92; α = .92), but the least reliable test was S2P60 (ICC =.75 ; α = .75).

The highest average score was achieved in test S1P (7.86), but the lowest in test S3P60 (4.0). Players showed better shooting accuracy in short-distance tests, physiologically low demanding tests and structurally more simple tests in comparison with shooting tests performed from longer distances in physiologically more demanding conditions.

Although results of the factor analysis (only one extracted factor) indicate that all tests have a similar measurement goal, that is to say basketball shooting accuracy, some of the tests show very small shared variance. For instance, correlation between tests S1P60 and S2P was r =.12 with only 1.5% of shared variance, or between tests S1P60 and S2P60 was r = .28 with only 8% of shared variance. This small shared information between the tests is a product of different measurement procedures that were set up in order to evaluate players shooting accuracy from different distances and under different physiological and structural shooting conditions. The highest shared variance was between tests S2P and S3P (30%) which are physiologically and structurally very similar.

Based on one extracted factor, which can be named factor of basketball shooting accuracy, it can be said that there is a good factorial validity of the tests used in the study, but based on the total variance (51.68%) explained by the tests, that is not so high and based on the values of intercorrelation coefficients, that are also not so high, it can be concluded that applied tests are not constructed to measure the same aspects of basketball shooting accuracy. The strongest correlation with the extracted factor and the best factor validity were shown by the following tests: S3P (.83), S3P60 (.74), S2P60 (.73). The weakest correlation and the worst factorial validity were shown by S1P60 test (.58).

CONCLUSION

The highest variation was shown by the tests that were performed from long distances and in time limited condition that produced a fatigue effect. Structurally and physiologically more demanding tests produced higher variation in the applied tests and worse average shooting results. The most reliable test was free throw shooting without fatigue protocol, but the least reliable test was two-point shooting test with fatigue protocol. It can be concluded that the most reliable tests are those that were performed from short distances in physiologically and structurally low demanding conditions.

Results showed that all six tests have a similar measurement goal, that is to say basketball shooting accuracy, but they do not measure the same aspects of basketball shooting accuracy. The tests can be used in future studies as reliable and valid instruments. Also, measurement of basketball accuracy using the tests can help scientists, basketball coaches and experts to evaluate players' accuracy in more realistic, game related conditions. In addition, the tests can be used as training drills for improving basketball accuracy and also for improving players' fitness.

POUZDANOST I FAKTORSKA VALIDNOST TESTOVA ZA PROCJENU KOŠARKAŠKE PRECIZNOSTI

Prethodno saopštenje

Sažetak

Cilj rada je bio da se utvrdi pouzdanost i faktorska validnost šest testova za procjenu košarkaške preciznosti. Istraživanje je sprovedeno na pedeset pet zdravih košarkaša (uzrast 19.1 ± 3.1 godina; težina tijela 83.4 ± 12.5 kg; visina 189.1 ± 8.2 cm; postotak masnog tkiva 13.1 ± 4.1) iz četiri kluba koji su nastupali u prvoj i drugoj bosanskoj ligi. Primjenjenim testovi su konstruisani da mjere košarkašku preciznost šutiranja sa tri različe distance i pod različitim uslovima fiziološkog opterećenja. Za svaki od tri pokušaja izračunati su aritmetička sredina, standardna devijacija i raspon. S ciljem da se utvrdi pouzdanost testova izračunati su prosječna korelacija između pokušaja (AVR), koeficijent unutrašnje koinzistencije podataka (ICC) i Cronbach alpha koeficijent pouzdanosti (α). Varijabilnost testova među ispitanicima je određena koeficijentom varijacije (CV). S ciljem da se utvrdi faktorska validnost testova, matrica interkorelacija testova je faktorizirana koristeći komponentnu faktorsku analizu. Dobijeni rezultati govore da je najveća varijabilnost kod testova koji se izvode sa većih distanci, te koji su strukturalno i fiziološki zahtjevniji, i suprotno najpouzdanijim su se pokazali testovi koji su se izvodili sa manjih udaljenosti te koji su bili fiziološki i struturalno manje zahtjevni. Također, rezultati pokazuju da svih šest testova ima jednak cilj mjerenja, to jest košarkašku preciznost, ali da ne mjere svi isti aspekt preciznosti. Kao pouzdani i validni instrumenti, testovi se mogu koristiti u nekim budućim istraživanjima, ali mogu pomoći trenerima da procjenjuju preciznost igrača u takmičarski realnijim uslovima ili da ih koriste kao trenažne vježbe za poboljšanje preciznosti i fizičke pripremljenosti košarkaša.

Ključne riječi: *protokol zamora, terenski testovi, košarkaši*

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