RELIABILITY AND FACTORIAL VALIDITY OF POWER TESTS FOR HANDBALL PLAYERS

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Abstract

The main purpose of this study was to define reliability and factorial validity of four field specific handball tests used for the assessment of explosive (throwing) power of elite handball players. The subjects were 18 top level Croatian national handball players. The participants were tested during the middle of the competitive season. Three throws were measured for each test (R4M, R6M, R9MRS and R9MJS). The reliability was assessed through the AVR, ICC and Cronbach's α coefficients, and the validity through the correlations obtained by the principal components factor analysis. The R6M, R9MRS and R9MJS tests had high reliability coefficients (α = 0.93, 0.93 and 0.91). The principal components analysis extracted one statistically significant component. The R4M test had the lowest correlation with the component (r = 0.52), and the other three tests had correlation coefficients between 0.88 and 0.93. The results of the study proved that the most reliable and appropriate tests to assess the explosive (throwing) power of handball players are the R6M and R6MRS tests.

Key words: *handball, field specific tests, explosive (throwing) power*

Introduction

A handball match encompasses a large number of different movement patterns, which are applicable in different situations. 134 typical technical-tactical movement patterns have been identified as most common during a handball match (Vuleta et al., 1999). Logically the most important between those are the ones including ball handling, as well as throwing the ball either to other team players or shooting towards to the opponent's goal from different positions on the court. In almost all of the cases shooting the ball towards the opponent's goal requires a high level of physical fitness, especially in terms of explosive power. When it comes to backcourt players which are positioned at a distance of 9 to 12 meters from the goal ball throwing explosive power comes on top of the priority list, because to score they need to execute strong and fast shots. In addition, approximately one half of all shots during a handball match are executed from the backcourt position (Šibila, 2004). Therefore developing explosive power is one of the most important issues during the preparation of handball players in the pre-season and in-season period. The ability to maintain or increase explosive power and performance during the competitive season is also an important consideration due to the increased demands of technical and tactical training and competition. Therefore in-season strength and conditioning programs are often designed to maintain adequate levels of strength and power over several months (Graham, 2002; Rajić et al., 2004; Newton et al., 2006; Vuleta et al., 2009). There has been a significant amount of studies concerning the effects of different training programs aimed to increase throwing power in handball (Edwards Van Muijen et al., 1991; Barata, 1992; Hoff & Almåsbakk, 1995; Gorostiaga et al., 1999; Gløsen, 2001; Van Den Tillaar, 2004). The same as in other sports which have similar throwing movement patterns (Wooden et al., 1992; Newton et al., 1994; Lachowetz et al., 1998; McEvoy et al., 1998). The studies on training effects can be divided into 4 categories. The first category encompasses specific resistance training with an overload of velocity, the second category includes specific resistance training with an overload of force. Specific resistance training with a combination of overload of force and velocity form the third category, and the last category includes general resistance training according to the overload of force (Van Den Tillaar, 2004). Due to the importance of explosive power in handball it is very important to construct high quality tests to assess the explosive power of handball players. To the author's knowledge studies regarding the reliability and factorial validity of such tests are rare, especially concerning the assessment of explosive (throwing) power with top level handball players. The main purpose of this research was to define reliability and factorial validity of four field specific handball tests used for the assessment of explosive (throwing) power of elite handball players in a movement that involved the upper body, trunk, and lower extremities in its execution.

Methods

Subjects

The research was conducted on 18 top level junior Croatian National team handball players (Mean ± SD; age = 18.52 ± 0.77 years, handball experience = 7.37 ± 2.51, height = 187.88 ± 6.25, weight = 87.13 ± 11.54) which won a gold medal on the European Championship in 2006 and a silver medal on the World Championship in 2007.

All of the subjects were highly trained, internationally experienced and highly motivated. As part of the testing process, each subject was asked to give his written informed consent following an explanation of the nature and purpose of the experiment and of the risks associated with participation. This explanation was in compliance with the Declaration of Helsinki. All experimental procedures were approved by the Ethics Committee of the School of Kinesiology, University of Zagreb.

Testing Procedure

Testing was conducted during the middle of the participants' competitive season 2007/2008. The protocol was explained to the subjects, and they then watched a demonstration of the four ball throws. This was followed by a practice session. Subjects were given as many practice throws as they desired until they were able to make 3 consecutive throws to within of their fastest throw. This was followed by a rest period (typically 20 minutes) before completing the test protocol. The testing consisted of four different types of ball throws that involved a movement pattern similar to that of a throwing a ball or shooting on a goal during a handball match. The ball throws were performed using standard size 3 hand ball which size and mass is regulated by IHF/EHF Rules of the handball game (ball weight 425 g, - 475 g,, ball radius = 58 - 60 cm). Before the testing, the subjects performed their normal warm-up. They were also given several warm-up throws, followed by 3 measured trials in which they attempted to throw the ball as fast as possible. Each throw was measured for speed in kilometers per hour (kph). The speed of the ball was captured with a radar (Stalker ATR, Professional radar, Applied Concepts Inc., Plano, TX U.S.A.) positioned behind the goal. Each trial was followed by approximately 30 seconds of passive rest before the subsequent trial. Testing was conducted so that each subject first performed one throw three measured trials, and when all subjects completed the test the whole group moved to the next test.

Radar 4m throw (R4M)

The handball player was seated on the goalkeeper restraining line with his face turned in the direction of the goal. Then he was given the ball to execute a handball throw. The throw had to be completely executed with the use of the dominant arm and the ball had to be thrown in the goal. During the execution of the handball throw the player was allowed to bend his legs, but was not allowed to stand up on his feet.

Radar 6m throw (R6M)

The handball player was standing on the goal-area line straight in front of the goal with his face turned in the direction of the goal. The player had to stand in a diagonal stance. Then he was given the ball to execute a handball throw. The player was not allowed to make a step in any direction during the throw or after the ball has been thrown. The throw had to be completely executed with dominant arm and the ball had to be thrown in to the goal.

Radar 9m run up shot (R9MRS)

The handball player was standing at a distance of 12m from the goal with his face turned in the direction of the goal. Then he was given the ball to execute the basic handball three steps run up throw. The ball had to be thrown with the use of one arm and the ball had to be thrown in the goal. The player had to execute a throw just before the free throw line and was not allowed to make a step inside the area of 9-meters after the ball has been thrown.

Radar 9M Jump Shot (R9MJS)

The handball player was standing at a distance of 20m from the goal with his face turned in the direction of the goal. Then he was given the ball and had to dribble towards the goal and when he saw fit he had to do a three step run up by holding the ball, after which he executed the jump shot. The ball had to be thrown with the use of one arm and the ball had to be thrown in the goal. The player had to execute a throw just before the free throw line and was allowed to land inside the area between the free throw line and the outer goal line after the ball has been thrown.

Statistical Analyses

The acquired data was analyzed through the use of the statistical package Statistica for Windows (v7.0, Statsoft, Tulsa, OK, USA). Means and standard deviations were determined for each variable as well as measures of skewness and kurtosis. A significance level of p, 0.05 was selected. Pearson correlation coefficients (r) were used to determine the strength of association between each of the variables and their relationship. The reliability was measured by the determination of the average intertrial correlation (AVR), interclass correlation coefficient (ICC) and Cronbach's alpha reliability coefficient (α). The within-subject variation for the tests was determined by calculating the coefficient of variation (CV) (Hopkins, 2000). The normality of the distributions of the tests was determined by the use of the Kolmogorov-Smirnov test. To determine the factor validity of new explosive (throwing) power tests used in handball (R4M, R6M, R9MRS and R9MJS), an inter-correlation matrix of four tests was factorized using a principal components factor analysis. The number of significant factors was determined by the Guttman-Kaiser criterion (Nunnaly & Bernstein, 1994), which retains components with eigenvalues (λ) of 1.0 or greater. The structure matrix was used to determine the factor validity.

Results

All the variables had normally distributed data (R4M - maxD = 0.19, $p > 0.20$; R6M - maxD = 0.14, $p > 0.20$; R9MRS - maxD = 0.19, $p > 0.20$; R9MJS – maxD = 0.14, $p > 0.20$). The reliability α coefficients of the mentioned tests, carried out three times, were very high and varied between 0.89 and 0.93. Of all the explosive (throwing) power tests the R6M, and R9MRS had the same and the greatest reliability (α = 0.93).

Table 1. Descriptive statistics for all tests.

	Mean ± SD	Min	Max	Range	Skew	Kurt
R4M	58.96 ± 3.61	52.70	65.33	12.63	0.46	-0.55
R6M	85.36 ± 6.87	66.03	95.37	29.33	-1.18	2.55
R9MRS	92.61 ± 5.31	81.70	101.63	19.93	-0.54	0.13
R9MJS	90.06 ± 4.31	82.13	97.97	15.83	-0.33	-0.12

Mean - arithmetic mean, SD - standard deviation, Min - minimal result, Max - maximal result, Skew - skewness, Kurt - kurtosis

The same tests also had the greatest ICC. The within subject variation ranged between 4.79% and 8.05%. The lowest value of the CV was found with R9MJS test. The AVR ranged between 0.68 and 0.84. The greatest value of the AVR was noted with the R4M test (0.84) and the lowest value was noted with the R9MJS test (0.68).

Table 2. Reliability statistics for all tests.

	α	AVR	ICC	CV
R4M	0.89	0.84	0.89	6.17%
R6M	0.93	0.83	0.93	8.05%
R9MRS	0.93	0.80	0.93	5.73%
R9MJS	0.91	0.68	0.91	4.79%

α - Cronbach's alpha, AVR - average intertrial correlation, ICC - interclass coefficient of correlation, CV - coefficient of variation

Table 3. Intercorrelation matrix of all tests.

	R4M	R6M	R9MRS	R9MJS
R4M	1.00	0.23	0.40	0.35
R6M	0.23	1.00	0.83*	0.73*
R9MRS	0.40	0.83*	1.00	0.72*
R9MJS	0.35	0.73*	0.72*	1.00

* Significant correlation at 0.05 level (2 tailed)

Correlation coefficients between tests ranged from 0.23 to 0.83. The lowest correlation was found between the R4M test and R6M test (r = 0.23) and the highest between R6M test and R9MRS test (r = 0.83). Statistically significant correlations were determined between the R6M test and R9MRS test, between R6M test and R9MJS test, and R9MRS test and R9MJS test. The principal components factor analysis of the four explosive (throwing) power tests resulted in the extraction of one significant component. The principal component explained 67.60% of the total variance of the four tests.

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

Comp.	λ	% variance	Cum. %
1*	**2.704**	**67.60**	**67.60**
2	0.837	20.93	88.53
3	0.312	7.79	96.33
4	0.147	3.67	100.00

*Significant principal component extracted

The correlation coefficients with the component varied between 0.52 and 0.93. The R4M test had the lowest correlation coefficient with the component (r = 0.52).

But all the other three explosive power tests had correlation coefficients higher than 0.88, and they varied between 0.88 and 0.93. The R4M test had high correlation with the second principal component (0.85), however the second extracted component is not statistically significant.

Table 5. Correlation coefficients of the tests with the extracted principal components.

	Component 1*	Component 2
R4M	0.52	*0.85*
R6M	**0.90**	0.31
R9MRS	**0.93**	0.09
R9MJS	**0.88**	0.10

*Significant principal component

Discussion and conclusion

If the movement pattern that is used in the four tests is observed then it is possible to conclude that in all of the cases it is movement that is highly automated with handball players. Nevertheless, to avoid the motor learning effect each of the subjects had the opportunity to make as many trial throws as possible to achieve their maximal result. Small unsystematic variations were noted in the average values of the trials of all throws. According to the values of SD, Range, Skew, and Kurt the sensitivity of tests are at a satisfying level. The mean results obtained from the tests (Table 1.) point out the fact that in the R6MRS test where the players had to throw to ball from the ground after the three step run up sequence had the highest value (92.61 kph). It is surprising that the players did not achieve the highest score in the R9MJS test since the players were allowed a larger distance to speed up and to generate a larger amount of kinetic energy than in the R6MRS test.

This can be explained with fact that junior players have not yet evolved their full potential to transfer the kinetic energy through the kinetic chain at larger movement speeds due to the inadequate level of explosive (throwing) power. All explosive (throwing) power tests have high AVR, ICC and α reliability coefficients (Table 2.). The reliability values are the highest in the R6M and R6MRS tests, which can be labeled as the most reliable tests to assess the explosive (throwing) power of handball players (Table 2.). Within subjects variations (CV) are high but still acceptable (Table 2.). If the coefficients of correlation between the tests are observed, it can be stated that higher and statistically significant relationships exist between tests that have a similar movement pattern (Table 3.). The highest correlation was determined between the R6M and R9MRS tests (r = 0.83) what points to the fact that in both of the tests a similar movement pattern was used. There was only a slight difference in the execution of the R9MRS test in which the player was allowed a three step run up sequence before the throw, but the kinetic chain of the throw remained almost the same as with the R6M test.

The principal component's analysis resulted in the extraction of one statistically significant component, which extracted 67.60% of the total variance of all four tests. Three of four tests had very high correlations with the first component (r=.88–.93), and only the R4M test had a high correlation with the second principal component (r= 0.85) which is not statistically significant. The first principal component can be named as the handball specific explosive (throwing) power factor. The R9MRS test showed the highest correlation with this factor (r = 0.93), therefore it is evident that the test has the best factorial validity among all analyzed tests. The R4M test had a low correlation with the first principal component (r = 0.52) which can be explained with the fact that the movement pattern used to throw the ball in this test excludes the lower body as well as the movement through space which is often used to generate additional kinetic energy that would later be transferred through the kinetic chain to the ball by the application of right movements in different phases of the handball throw to achieve the fastest throw as possible (Pori et al., 2005.). The optimal functioning of the kinetic chain is based on the energy transfer from the proximal to the distal segments and to the ball (Muller, 1982; Bon, Šibila & Erčulj, 1997,). The kinetic chain of a handball throw has two important characteristics which should be considered. The first is the peak joint centre speed, and the second which is directly effected by the first, the speed of the thrown ball. In a handball jump shot the peak joint speed, which is relevant for the first part of the throw increases in the next order: first the hip (v = 4.92 m/s), then the shoulder (v = 5.59 m/s) followed by the elbow (v = 8.92 m/s) and the wrist (v = 16.45 m/s), after which the thrown ball moved with the speed of 25.74 m/s, or approximately 92.66 kph (Šibila, et al., 2005). It is obvious that such result regarding the speed of the thrown ball is in accordance with the results of this study. In addition to the previous statement the means of the other three tests (R6M, R9MRS and R9MJS) had higher values than the R4M test (Table 1.). Although the second principal component is not statistically significant it can also confirm the previous statement, with the fact that a high correlation of the R4M test with the principal component (0.85) allows the assumption that the factor could be labeled as upper body explosive (throwing) power factor. However the principal component cannot be interpreted because at least 3 tests had to have a correlation higher than 0.50 with the component (Nunnaly & Bernstein, 1994). Future researches in this field should be conducted on the top level senior handball players and if it is possible on a larger sample. The authors also believe that in the future it is of great importance to assess the explosive (throwing) power of top level handball players with tests that are even more specific for example different tests for each playing position (wing players, backcourt players, pivot player) which imply different movement patterns.

This study determined the reliability and factorial validity of 4 specific handball tests. The results of this study point out that all of the 4 observed tests to assess explosive (throwing) power and are reliable for estimating the explosive power of handball players. The R6M, R6MRS and R9MJS tests are proven the most reliable and factorial valid between the selected tests and therefore the most appropriate to assess the explosive power of handball players. Through the obtained results it can also be concluded that R4M test is not appropriate for general use to assess explosive (throwing) power because it excludes the complete throwing kinetic chain.

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POUZDANOST I FAKTORSKA VALJANOST TESTOVA ZA PROCJENU EKSPLOZIVNE SNAGE RUKOMETAŠA

Sažetak

Svrha ovog istraživanja bila je utvrditi pouzdanost i faktorsku valjanost testova za procjenu eksplozivne snage tipa bacanja kod rukometaša. Uzorak ispitanika bili su 18 vrhunskih rukometaša članova Hrvatske nacionalne selekecije. Ispitanici su testirani u natjecateljskom periodu. Tri pokušaja su zabilježana kod svakog testa (R4M, R6M, R9MRS and R9MJS). Pouzdanost je procijenjena kroz utvrđivanje Cronbachove α, interklasnog koeficijenta korelacije i prosječnog koeficijenta korelacije između pokušaja. Kod testova R6M, R9MRS i R9MJS utvrđeni su visoki koeficijenti pouzdanosti (α = 0.93, 0.93 and 0.91). Faktorskom analizom metodom najznačajnijih komponenti utvrđena je jedna statistički značajna glavna komponenta. Test R4M ima najmanju korelaciju s prvom glavnom komponentom (r = 0.52), a ostala tri testa imaju koeficijente korelacije između 0.88 i 0.93. Temeljem rezultata istraživanja utvrđeno je da su najpouzdaniji i najprikladniji testovi za procjenu eksplozivne snage tipa bacanja kod rukometaša testovi R6M, R6MRS I RM9JS.

Ključne riječi: *rukomet, specifični testovi, eksplozivna snaga tipa bacanja*

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