

Original Article

Impact of Explosive Strength on Shot Speed in Handball

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Abstract

Shooting is among the most important elements of the handball game that determine the success of the result. The aim of this research was to examine the impact of explosive strength on the shot speed of handball players. The sample of participants consisted of 20 handball players, aged $18 \text{ to } 30 \pm 0.3$ years. The sample of measuring instruments consisted of five variables for evaluating explosive strength and four variables for evaluating shot speed in handball. The impact of explosive strength on shot speed in handball was determined using linear regression analysis. The results showed that the space of explosive strength is dominantly defined by the vertical jump test (VJ), while the latent space of shot speed is defined by the variable of jump shot with direct arm swing (SSD). Applying linear regression confirms that there is a statistically significant impact of explosive strength on shot speed in handball.

1. Introduction

Handball is a highly intermittent team sport that involves repeated transitions between attack and defence and frequent movement changes where periods of high intensity activities are interspersed with periods of low to moderate intensity activities (García-Sánchez, Navarro, Karcher, & de la Rubia, 2023). The basic

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characteristic of modern handball is that movements such as running, sprinting, jumping, catching and passing, blocking, pushing and shooting are constantly changing (Oikonomou, Yannakos, & Acsinte, 2021). According to most authors, handball belongs to polystructural complex sports with unpredictable dynamics of cyclic and acyclic type activities (Leuciuc, 2018; Ilić, Stanković, & Ilić, 2020; Kayacan, Makaracı, Ucar, Amonette, & Yıldız, 2023). Like other team sports, handball has its own standard rules and a certain organization with established roles and tasks defined by player positions, both in attack and defence. Today it is played in more than 183 countries of the world and is a very attractive and popular game, in which two teams with seven players each (six players and one goalkeeper) compete to score as many goals as possible against the opposing team (García-Sánchez et al., 2023).

Achieving top results is conditioned by a high level of physical preparation of handball players, focused primarily on the development and maintenance of motor skills that represent predictors of success in the game (Marković, 2020). In addition to technical and tactical skills, a high level of muscle strength and shooting speed represent the most important factors that provide a clear advantage in achieving better results in top handball (Ilić, 2015). In order to improve the quality of the handball game, numerous studies were conducted, the aim of which was to investigate the influence of motor skills on success in handball (Póvoas et al., 2014; Fieseler et al., 2017; Bojić, Živković, Kocić, Veličković, & Milenković, 2019; Wilczyński, Cieślik, Maszczyk, & Zwierzchowska, 2022). Certainly, one of the most important motor abilities for success in handball is explosive strength (Srhoj, Marinović, & Rogulj, 2002; Pavlović et al., 2018; Aksović, Bjelica, Ilić, Ilić, & Miletić, 2021). Explosive strength is 80% genetically determined and primarily depends on the number of simultaneously activated motor units and is defined as the athlete's ability to perform one short, fast and strong movement (Zatsiorsky, Kraemer, & Fry, 2020). In order to achieve success, the players must fulfil the basic goal of the game, which is to score more goals. Accordingly, shooting is classified as one of the most important technical and tactical elements of the handball game. Saleh, & Khaleel, (2022) indicate that handball players who have a higher shooting speed have a higher chance of scoring a goal. The combination of accuracy, shooting speed and explosive strength are the most important factors for scoring a goal, because accurate and fast shooting leaves little time for defenders and goalkeepers to react (Gorostiaga, Granados, Ibanez & Izquierdo, 2005). The positive impact of explosive strength on the speed of the ball shot in handball is confirmed by other studies (Bayios, Anastasopoulou, Sioudris, & Boudolos, 2001; Rogulj, Foretić, Srhoj, Čavala, & Papić, 2007; Hermassi et al., 2019). Van den Tillaar, & Ettema (2009) clearly indicate that the sequence and timing of movements in the kinetic chain are important for achieving high ball speed when shooting. When performing a certain movement, mobility is the basis, because it is of great importance to achieve a balance between mobility and stability of the kinetic chain of the shot itself when performing a shot (Sæland, 2015). Also, it should be emphasized that the increased range of shoulder rotation can allow handball players to improve the efficiency of

the internal rotator muscles and thus enable shooting at a higher speed (Davila, Garcia, Montilla, & Ruiz, 2006). However, in addition to all of the above, it should be emphasized that the most adequate, specific model for examining the relationship between strength and shooting speed in handball has not yet been found.

Therefore, the aim of this research was to examine the impact of explosive strength on the shot speed of handball players.

2. Material and methods

Participants

The research was conducted on a sample of 20 players of the "Bane" handball club from Raška, aged 18 to 30 ± 0.3 years. All participants are registered players, are included in the regular training process and have continuous competitive experience.

Sample of variables

Explosive strength of handball players was tested with the following battery of tests: standing long jump (SUD), 20-meter run (T20), 1 kg supine medicine ball throw (BML), 1 kg seated medicine ball throw (BMS) and vertical jump (VJ). The following variables were used to evaluate handball shot speed: jump shot with circular arm swing (SSK), jump shot with direct arm swing (SSD), ground shot with circular arm swing (SPK), ground shot with direct arm swing (SPD).

Procedures

In order to measure shot speed, all shots were recorded in 120 frames per second video using the *D5300* camera (Nikon, Japan). *PMML 5 A2* (Parkside, Germany) range finder was used in order to calculate the distance travelled by the ball from the spot where the shot was made to the goal line. Both the camera and range finder were connected to a laptop and their data was imported in real time to *Adobe Premier Pro* software (Version 22.2) for video analysis. The video time was converted to milliseconds. After establishing the time and distance travelled, the software calculated the shot speed in kilometres per hour (km/h).

Statistical analysis

The data obtained by the previously described procedure was processed with the SPSS 20 statistics program (Statistical Package for Social Sciences, v20.0, SPSS Inc., Chicago, IL, USA). For all the data obtained by testing, the basic central and distribution parameters of the variables were calculated: minimum value (Min), maximum value (Max), arithmetic mean (M), standard deviation (SD). The normality of the distribution of variables was tested with the Shapiro-Wilk test. In order to adequately determine the structure of the observed areas of explosive strength and shooting speed of the tested handball players, a factor analysis was applied. The impact of explosive strength on shot speed was determined using linear regression analysis.

3. Results and Discussions

The results of the descriptive statistical analysis of the explosive strength and shot speed variables obtained using the applied tests are presented in Table 1.

Table 1. Descriptive analysis of handball explosive strength parameters

| Variables | N | Min | Max | M | SD | S-W |
|-----------|----|--------|--------|--------|--------|------|
| SUD | 20 | 139.00 | 241.00 | 181.25 | 28.410 | .210 |
| T20 | 20 | 2.98 | 6.70 | 4.54 | 0.994 | .706 |
| BML | 20 | 9.20 | 15.60 | 12.33 | 2.315 | .026 |
| BMS | 20 | 9.30 | 14.80 | 11.89 | 2.032 | .024 |
| VJ | 20 | 31.00 | 61.00 | 46.05 | 10.190 | .153 |
| SSK | 20 | 74.48 | 105.06 | 86.01 | 8.926 | .082 |
| SSD | 20 | 64.67 | 95.14 | 80.46 | 8.564 | .481 |
| SPK | 20 | 61.79 | 88.97 | 76.19 | 7.736 | .439 |
| SPD | 20 | 62.87 | 88.18 | 73.64 | 7.611 | .214 |

Legend: N - number of participants, Min - minimum value, Max - maximum value, M - mean, SD - standard deviation, S-W - Shapiro-Wilk test.

Descriptive analysis of the parameters of explosive strength and shooting speed show the expected parameters for this level of the group of subjects taking into account their playing status. The Shapiro-Wilk test of normality of distribution shows that the explosive strength tests of the supine medical throw (BML) and the sitting medical throw (BMS) do not meet the criteria of a normal distribution, which is why their results were not taken into account in the rest of the study. Given that descriptive statistics, normality and distribution tests were satisfactory, factor analysis was applied.

The results of the factor analysis show that in the area of explosive strength, one component was extracted that explains 90.81% of the total variance (Table 2). The resulting communalities are satisfactory. The highest result in the examined area was shown in the vertical jump test (VJ - vertical jump), with an isolated factor of 0.969.

Table 2. Factor Analysis of the Explosive Strength

| Variables | Factor | |
|---------------|--------|----------------|
| | 1 | h ² |
| VJ | .969 | .925 |
| SUD | .962 | .861 |
| T20 | -.928 | .938 |
| Eigenvalue | 2.725 | |
| % of Variance | 90.819 | |
| Cumulative % | 90.819 | |

Factor analysis of shooting speed shows that also only one component was extracted, explaining 90.13% of the total variance. The communalities of all variables are satisfactory. Analysing the results of the factor analysis, it was determined that the highest projection on the shot speed is achieved by the jump shot with direct arm swing (SSD) with an isolated factor of 0.980.

Table 3. Factor Analysis of the Shooting Speed

| Variables | Factor | |
|---------------|--------|----------------|
| | 1 | h ² |
| SSD | .980 | .859 |
| SPK | .969 | .960 |
| SSK | .927 | .939 |
| SPD | .921 | .848 |
| Eigenvalue | 3.605 | |
| % of Variance | 90.136 | |
| Cumulative % | 90.136 | |

After the components of the factor analysis were extracted, the z values (z-score) of the examined spaces were calculated.

Table 4. Table of coefficients

| | B | SE | β | t | p | 95% CI | |
|---------------------------|------|------|---------|--------|------|--------|-------|
| | | | | | | LL | UL |
| Explosive strength | .940 | .080 | .940 | 11.688 | 0.00 | .771 | 1.109 |

Notes. $R^2=.88$, $F(1.18)=136.62$, $p<0.01$

Linear regression analysis was used to assess whether the explosive strength significantly predicts shooting speed (table 4). The results of the regression suggested that the explosive strength explained 88% of the variance, $R^2=.88$, $F(1.18)=136.62$, $p<0.01$. The conclusion is that explosive strength significantly predicted shooting speed, $B=0.940$, $t=11.69$, $p<0.01$.

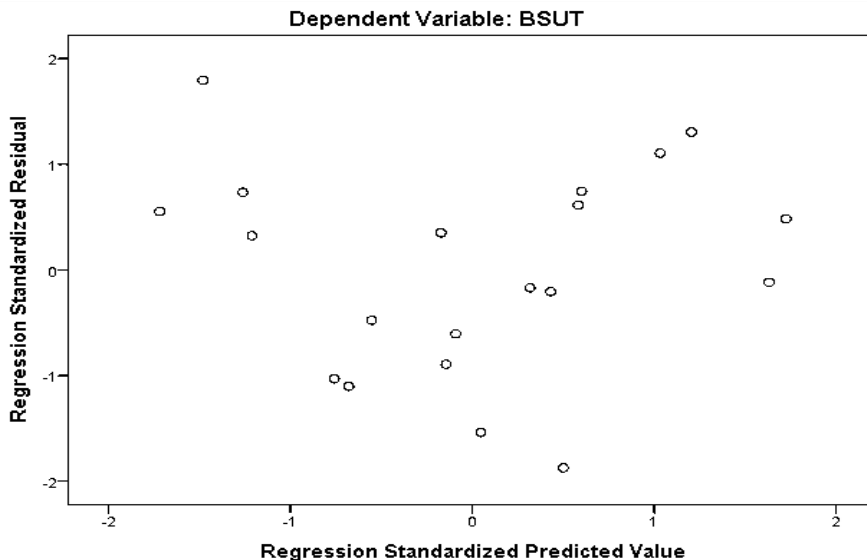


Figure 1. Scatter plot of the latent shot speed variable

By looking at the relationship between regression standardized residuals and regression standardized predictor values of the latent shot speed variable (BSUT) (Fig. 1), it can be concluded that there is no noticeable pattern of distribution of results, i.e. that there is no occurrence of heteroscedasticity, which confirms the validity of the results.

Discussions

The primary purpose of the study was to examine the effect of explosive strength on shot speed in handball. Looking at other research in relation to the gender, playing status and chronological age of the participants, it could be said that the obtained results were to be expected. Rivilla-García, Valdivielso, Rodriguez, & Molinuevo (2012) in the conducted research through descriptive analysis obtained worse results of the explosive strength of amateur handball players than the results of top handball players.

The authors attribute the poor results to their competition rank. Such results were actually logical because handball players with better performance of motor skills compete in a higher level of competition (Stanković, & Malacko, 2008; Przednowek et al., 2019). Similar results are confirmed by Zapartidis, Kororos, Christodoulidis, Skoufas, & Bayios (2011), where the authors obtained the expected results of explosive strength and shooting speed taking into account the chronological age of the subjects, where the results clearly showed that there are differences in explosive strength and shot speed in relation to the playing position in the team.

The results of the descriptive analysis of the shooting speed of handball players are satisfactory for the level of competition in which they perform. Rogulj et al. (2007) confirmed that handball players of a higher level of competition possess a higher shooting speed.

The area of explosive strength in this research is dominantly defined by the VJ variable, where the importance of the vertical jump in elite handball players is confirmed. Interesting and completely opposite results were obtained in a study (Aksović et al., 2022), where the results showed that there are no differences in the vertical jumps of young basketball players with an average age of 14 and professional handball players with an average age of 24.

As an explanation, the authors state that in basketball, the jump in attack and defense is performed with the maximum vertical jump, which is not the case in handball, i.e. when handball players perform a shot on the goal from moving, they perform it with the stronger leg.

Carvalho, Mourão, & Abade (2014) show that handball is a very complex sports activity, where the successful execution of shots especially depends on the explosive strength of the throwing type, horizontal jumps, as well as the basic strength of the trunk. Similar results are confirmed by (Cherif et al., 2012), which indicate that the explosive strength of the throwing type is particularly important for success in handball. Therefore, it would be interesting to examine the differences in horizontal jumps on the same or a similar sample of subjects, or to examine the differences in vertical jumps in handball players after applying an experimental

program (for example, plyometric training), which is a recommendation to future researchers on this or a similar topic.

Based on previous research, it was expected that the area of explosive strength would be defined by the variables vertical jump or long jump, considering that these tests define the strength of the muscles of the whole body (Chang, Norcross, Johnson, Kitagawa, & Hoffman, 2015; Ciacci, & Bartolomei, 2018). Chelly, Hermassi, & Shephard (2010) came to the result that there is an equally positive influence of the explosive strength of the upper and lower extremities on the shooting speed in handball. These results show that the shooting speed of handball players is influenced by the explosive strength of the whole body muscles which is best defined by the MVJ variable.

The shot speed area of handball players is dominantly defined by the SSD variable. The vertical jump mobilizes muscle groups of the whole body, while the jump shot with a direct swing relies dominantly on the explosive strength of the whole body. Rogulj et al. (2007) point out that the significance of the impact of explosive strength on the speed of a handball player's shot is understandable and expected because when shooting, the strength of the muscles of the whole body is activated.

In research conducted by Serrien, Clijsen, Blondeel, Goossens, & Baeyens (2015), it was determined that the shot speed is higher in elite male handball players than in elite female handball players. As an explanation, the authors state that the better result of explosive strength in male handball players is caused by a larger muscle mass compared to female handball players. Given that the results of this research showed that there is a statistically significant impact of explosive strength on the shot speed of handball players, this research corresponds to previous research aimed at the impact of explosive strength on the shot speed in handball (Debanne, & Laffaye, 2011; Rivilla-Garcia, Lorenzo Calvo, & Van den Tillaar, 2016).

Despite the interesting results, certain limitations of the study should be emphasized. The first limitation of this study is the insufficiently small sample of participants ($n=20$). Second, although our findings provide valuable insight into elite handball players, the applicability of these results remains limited in regard to playing position, sex, age category and competition rank of the handball players.

4. Conclusions

This study, despite its limitations, shows that shot speed in modern handball is recognized as a very important success factor. Explosive strength has the greatest projection on shot speed. The results showed that the area of explosive strength is dominantly defined by the variable VJ, while the area of shot speed is defined by the variable SSD. A high, statistically significant influence of explosive strength on the shot speed of handball players was proven ($p=.000$).

The direction of future research can be reflected in increasing the number of participants, including female handball players, looking at subjects of different ages and levels of competition, as well as examining the differences in relation to the playing position of elite handball players.

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