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**Original research paper**

# EFFECTS OF PROGRAMMED TRAINING ON MOTOR ABILITIES OF VOLLEYBALL PLAYERS

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**Katarina Nejić*, Dragan Nejić, Nenad Stojiljković, Tomislav Okičić**

Faculty of Sport and Physical Education, University of Niš, Serbia

**Abstract**. *This study aimed to investigate the effects of programmed training on the changes in the explosive strength, speed, and agility in young male volleyball players. The sample of subjects in this research consists of 40 volleyball players of junior age in the volleyball clubs: OK "Topličanin" (n = 20) from Prokuplje and OK "Nis" from Nis (n = 20). Subjects were divided into two groups: experimental group 1 (E1, n = 20) and experimental group 2 (E2, n = 20). Experimental group 1 consists of volleyball players from OK "Topličanin" from Prokuplje, who, in addition to basic specific – situational training, also had plyometric training sessions twice a week for six weeks. Experimental group 2 consists of volleyball players from OK "Niš" from Niš, who had only specific – situational training sessions in that period. The research is longitudinal, comprising the initial and final measurements. The experimental treatment lasted six weeks and was realized in the preparatory period. The three tests were used to assess the explosive strength: 1) Squat jump 2) Countermovement Jump 3) Counter Movement Jump/Arm Swing. The three tests were used to estimate speed: 1) 5 meters sprint 2) 10 meters sprint 3) 15 meters sprint. The three tests were used to estimate agility 1) Agility t-test 2) 9-6-3-6-9 agility test and 3) 505 agility test. Mancova analysis was used to compare different subsamples of subjects at the initial and final measurements. The results of the research show that volleyball-specific-situational training followed by plyometric training significantly improves motor skills: explosive strength, speed, and agility. The strongest effect was noticed on explosive strength.*

**Keywords**: *junior, explosive strength, agility, speed*

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**Corresponding author:** Katarina Nejić
Faculty of Sport and Physical Education, University of Niš, Čarnojevića 10A, 18 000 Niš, Serbia
Phone: +381 18 510 900 • E-mail: nejickatarina@yahoo.com
* PhD student, Faculty of Sport and Physical Education, University of Niš, Serbia

## 1. INTRODUCTION

Modern volleyball is a sport of high expectations for the manifestation of mobile activities where players with a high level of motor and functional abilities can demonstrate appropriate technique and tactics throughout the match (Borras, et al., 2011). Modern volleyball requires from all players a high level of general and specific motor abilities characteristic for certain positions of players on the field (Bojanić, et al., 2015). Motor abilities are conditionally defined as latent motor structures responsible for an infinite number of motor reaction manifestations that can be measured and described (Findak, 2003). The development of motor abilities is just one of many tasks on the way to creating a versatile personality of volleyball players, capable of creative self - realization and competitive process management (Vranić, 2013). In order to achieve a high level of performance of an element, a player is required not only to improve the technical – tactical elements, but also a high level of motor abilities i.e., explosive strength, speed, and agility (Ziv, & Lidor, 2010).

By analyzing the volleyball game, it can be concluded that with each action during the volleyball game, a certain type of strength is manifested. The fact that during a volleyball match, actions consist of 50-60% of jumps and rapid changes in direction of movement clearly indicates the importance of explosive strength, speed and agility. One of the most common types of training applied in order to develop the explosive strength of the lower extremities is certainly the plyometric method. This is evidenced by numerous studies in which the authors applied this type of training with the aim of developing the explosive properties of volleyball players (Milić, Nejić, & Kostić, 2008; Memagić, et al., 2011; Ho, et al., 2015; Mannan, Johnson & Avalaiah, 2015).

In accordance to state above, this study aimed to investigate the effects of programmed training on the changes in the explosive strength, speed, and agility in young male volleyball players.

## 2. METHODS

### 2.1. Participants

The sample of subjects in this research consisted of 40 volleyball players of junior age in the volleyball clubs: OK "Topličanin" (n = 20) from Prokuplje and OK "Niš" from Niš (n = 20). Subjects were divided into two groups: experimental group 1 (E1, n = 20) and experimental group 2 (E2, n = 20).

Experimental group 1 consisted of volleyball players from OK "Topličanin" from Prokuplje, who, in addition to basic specific – situational trainings, also had plyometric training sessions twice a week for six weeks. Experimental group 2 consisted of volleyball players from OK "Niš" from Niš, who had only specific – situational training sessions in that period.

The experimental groups trained with the same extent and intensity, but E1 had two additional plyometric training sessions. With the E2 group the additional, plyometric trainingsession was not applied.

### 2.2. Procedures (Study design)

The research was longitudinal, comprising theinitial and final measurements. The experimental treatment lasted for six weeks and was realized during the preparatory period. All measurements were performed in the sports hall where the subjectsconducted their

training sessions, using the described measuring instruments according to the standardized protocols.

### 2.3. Motor abilities

#### *2.3.1. Explosive strength*

Since every type of strength must be manifested in every volleyball action, it can be concluded that volleyball techniques differ from each other precisely in the way they show strength in movement. In volleyball techniques, explosive strength is manifested in the combination of all components. The effectiveness of their connection largely depends on the ability of the nervous system to coordinate muscle contractions. The degree of coordination of muscle activity depends on the inherited factors, as well as the training of the organism (Kostić, 1995). Jumping is one of the most important factors on which success in volleyball depends, thus it becomes clear that it needs to be developed as much as possible for athletes to achieve maximum sports results in this collective sport (Nejić, et al., 2010).The height of the jump depends on the speed of its execution, but also on the timing. The speed of the jump is determined by the morphological and physiological characteristics of the athlete, but the training process itself can greatly contribute to its development. The speed of its performance is important for the height of the jump, the most important part of which is the explosive strength of the leg extensor (Nejić & Radisavljević, 2010).

The optojump equipment was used to assess the explosive strength. The reliability of the measuring instrument was confirmed in the previous research studies (Glatthorn, et al., 2011). The three tests were used: 1) Squat jump, 2) Countermovement Jump, 3) Counter Movement Jump/Arm Swing.

#### *2.3.2. Speed*

Speed is defined as the ability of a person to perform a high frequency of movement in the shortest time or to perform a single movement as quickly as possible in given conditions (Malacko & Radjo, 2004). The speed of the reaction is individual and depends primarily on the innate predispositions so that the speed of reaction of different segments of the body of the same person has similar characteristics. The reflex time is hereditary at 95% and the heredity of the reaction rate is 85% (Nejić, et al., 2010). The player arrives from the starting to the final position in just a few steps, so it is clear that the ability to quickly and explosively start, stop and change the direction of movement is extremely important. Also, the ability to move from horizontal to vertical movement is vital. Although speed in volleyball is not crucial, the ability to accelerate is essential (Nejić et al., 2010).

The Witty-microgate was used to estimate speed. The reliability of the measuring instrument was confirmed in the previous research literature (Donath, et al., 2016). The three tests were used: 1) 5 meters sprint, 2) 10 meters sprint, 3) 15 meters sprint.

#### *2.3.3. Agility*

When setting the definition of agility as an important motor ability, it is necessary to point out that it arises due to the cooperation of multiple motor abilities, which are actualized in rapid movement with change of direction, rapid changes in direction of movement of upper and lower extremities, as well as cognitive processes and technique movements (Verstegen & Marcello, 2001).

Agility is extremely important in volleyball, regardless of the player's position, as well as the current position of the player on the field. Based on the above mentioned, it can be concluded that agilityis reflected in the ability to quickly change the direction of movement, achieve full speed in a few steps, and stop when necessary are the characteristics of the top volleyball players (Elif, et al., 2010).

The Witty-microgate were used to estimate agility. The three tests were used 1) Agility t test, 2) 9-6-3-6-9 agility test and 3) 505 agility test.

### 2.4. Training interventions

The subjects had the usual specific – situational training sessions five times a week, lasting 90 minutes.

During these training sessions, the volleyball players of both groups worked on maintaining physical preparation and practicing technical and tactical elements. The specific – situational training sessions are based on technique and are designed to develop the technique of playing with overhead passing and forearm, service, spike, block, defense and ability to position.

The experimental group 1 conducted plyometric training sessions twice a week for 20 minutes. The plyometric training sessions were designed in such a way that in the first weeks the load was less and progressively increased, the exercises were arranged so as to provide in the first weeks less demanding exercises, with fewer series and repetitions, and in later weeks more complex exercises were performed with the increased number of repetitions and series, respecting the principle of gradual increment, or going from easier to harder.

### 2.5. Statistical analysis

The SPSS program (IBM SPSS Statistics 23) was used for detailed statistical analysis. The arithmetic mean (Mean) and standard deviation (SD) are shown for the dependent variable included in this study, as well as the range of minimum and maximum and statistical significance of the results (Sig). In this study, the discriminability of the measurements was determined using the Kolmogorov-Smirnov test. MANCOVA analysis was used to compare different subsamples of subjects at the initial and final measurements.

## 3. RESULTS

Table 1 shows that at the initial measurement there are statistically significant differences between the arithmetic means for the explosive strength variables (CMJ, CMJa, SJ). The differences are large and in favor of E1, while there are no statistically significant differences between the groups in speed. However, for agility there are statistically significant differences in the arithmetic means of the variables T TEST and T505. The differences are also large and in favor of the better results of E1. There is no statistically significant difference between the groups in the variable T9-6-3-6-9.

At the final measurement there are statistically significant differences between the arithmetic means for the explosive strength variables (CMJ, CMJa, SJ). The differences are large and in favor of E1, while there are no statistically significant differences between the groups in speed, however, for agility there are statistically significant differences in the arithmetic means of the variable T TEST. The difference is moderateand in favor of the better

results of E1. There is no statistically significant difference between the groups in the variables T505 and T9-6-3-6-9.

**Table 1** Effects of the programmed training on the male volleyball players motor abilities

| Variables | E1 | | E2 | | TE1 | TE2 | ES1 | | ES2 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean (In.) (S±SD) | Mean (Fin.) (S±SD) | Mean (In.) (S±SD) | Mean (Fin.) (S±SD) | | | Sig. | VU | Sig. | VU |
| CMJ | 38.09± 4.61 | 39.79± 4.80 | 30.52± 3.74 | 31.02 ± 4.11 | 0.00 | 0.24 | 0.63 | V | 0.08 | U |
| CMJa | 45.49± 5.83 | 47.08± 6.13 | 37.62± 5.77 | 38.64 ± 6.4 | 0.01 | 0.12 | 0.41 | V | 0.14 | V |
| SJ | 35.21± 5.12 | 36.55± 5.77 | 27.48± 3.67 | 27.21 ± 3.6 | 0.07 | 0.53 | 0.23 | V | 0.02 | U |
| SPRINT5 | 1.15 ± 0.07 | 1.07 ± 0.07 | 1.15 ± 0.10 | 1.10 ± 0.10 | 0.00 | 0.03 | 0.68 | V | 0.24 | V |
| SPRINT10 | 1.89 ± 0.09 | 1.82 ± 0.10 | 1.96 ± 0.17 | 1.91 ± 0.15 | 0.00 | 0.03 | 0.51 | V | 0.24 | V |
| SPRINT15 | 2.59 ± 0.22 | 2.51 ± 0.22 | 2.70 ± 0.23 | 2.65 ± 0.21 | 0.01 | 0.05 | 0.43 | V | 0.21 | V |
| T TEST | 10.70± 0.71 | 10.23± 0.65 | 11.89± 1.35 | 10.84 ± 0.96 | 0.00 | 0.00 | 0.62 | V | 0.55 | V |
| T9-6-3-6-9 | 8.05 ± 0.62 | 7.93 ± 0.62 | 8.27 ± 0.72 | 8.08 ± 0.74 | 0.13 | 0.07 | 0.17 | V | 0.18 | V |
| T505 | 3.65 ± 0.22 | 3.57 ± 0.26 | 30.52± 3.74 | 3.78 ± 0.44 | 0.08 | 0.12 | 0.22 | V | 0.14 | V |

*Legend*: E1 - experimental group1; E2 - experimental group2; Mean (In.) - initial measurement; Mean (Fin.) -final measurement; TE1- difference between theinitial and final measurement in theexperimental group1concerning variables for the assessment of the basic motor abilities of the male volleyball players; TE2- difference between theinitial and final measurement in theexperimental group2 concerning variables for the assessment of the basic motor abilities of the male volleyball players; ES1 - effect of the sizeanalysis in theexperimental group 1; ES2- effect of the size analysis in theexperimental group 2; Sig.-statistical significance of the difference in the effect size analysis; VU-the effect size analysiseffect; U-moderate difference; V-large difference.

In terms of explosive strength, statistically significant differences in arithmetic means between the initial and final measurements of E1 in the CMJ and CMJa variables were found. The numerical differences are large and in favor of better results on the final measurement. In terms of speed, a statistically significant difference between the arithmetic means of the initial and final measurements was found for the T TEST variable. The differences are large and in favor of better results at the final measurement. In terms of agility, statistically significant differences between the arithmetic means of the initial and final measurements at E1 were noted. The differences are large and in favor of the final measurement.

In terms of explosive strength, no statistically significant differences in arithmetic means between the initial and final measurements at E2 were found. Numerical differences are in favor of better results on the final measurement. In terms of speed, a statistically significant difference between the arithmetic means of the initial and final measurements was found for the T TEST variable. The differences are large and in favor of better results on the final measurement.In terms of agility, statistically significant differences between the arithmetic means of the initial and final measurements at E2 were noted. The differences are large and in favor of the final measurement.

Table 2 shows the univariate differences in variables for the assessment of explosive strength between the two experimental groups at the final measurement with neutralization and partialization of the results at the initial measurement. There are no statistically significant values. In terms of explosive strength, the numerical differences between the mean values are mainly in favor of the better results of the experimental group 1. Consideringspeed, the numerical differences between the mean values are mainly in favor of the better results of the experimental group 1. Related to agility, the numerical differences between the mean values are mainly in favor of the better results of the experimental group 1.

**Table 2** Results of the univariate analysis of covariance of motor ability tests between experimental groups at the final measurement

| Variables | Adj. Mean diff. (E1-E2) | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|
| CMJ | 1.27 | 2.243 | .146 | .077 |
| CMJa | -0.49 | .172 | .682 | .006 |
| SJ | 1.38 | 1.819 | .189 | .063 |
| SPRINT5 | -0.02 | .538 | .470 | .020 |
| SPRINT10 | -0.02 | .098 | .756 | .004 |
| SPRINT15 | -0.02 | .252 | .619 | .009 |
| TTEST | 0.08 | .101 | .750 | .004 |
| T9-6-3-6-9 | -0.25 | 2.810 | .110 | .094 |
| T505 | -0.08 | .410 | .530 | .015 |

*Legend*: Adj. Mean diff.(E1-E2 ) – Diffrences between corrected arithmetic means; F – F test; Sig. – statistical significances; Partial Eta Squared – influence size

**Table 3** Effects of trainings between the expreimental groups

| Motor space | Wilks' Lambda | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|
| Expolosive strength | .844 | 1.544 | .228 | .156 |
| Speed | .968 | .280 | .839 | .032 |
| Agility | .887 | 1.058 | .385 | .113 |

*Legend:* Wilks' Lamdba – Wilcoxon test of rank; F- F test; Sig.-statistical significanceof the difference in size analysis effect; PartialEta Squared- influence size

Table 3 shows the results in which there are no statistical differences in the set of tests for the assessment of explosive strength, speed and agility.

## 4. DISCUSSION

In our research, the results indicate that experimental group 1, which, in addition to specific-situational training introduced additional plyometric training twice a week, achieved a statistically significant improvement in all motor tests compared to experimental group 2, which had undergone only specific-situational training. Such results indicate that the applied eight-week experimental treatment had positive effects on the development of explosive strength, speed and agility.

Experimental group 1 in our study showed a statistically significant improvement compared to experimental group 2 between the initial and final measurements in terms of explosive strength. By comparing the effect size of the experimental treatment based on the partial eta squared (Partial Eta Squared) between CMJ (Partial Eta Squared = .077), CMJa (Partial Eta Squared = .006) and SJ (Partial Eta Squared = .063), it can be observed that the largest value, and therefore the largest effect was recorded in the CMJ test, followed by the SJ test, while the smallest effect was recorded in the CMJa test. Kukić, et al. (2020) obtained similar results, as they found a statistically significant improvement in explosive strength in CMJ (53.6%) and CMJa (37.8%) after an eight-week experimental treatment. The sample consisted of 13 female volleyball players, aged = 20.02 ± 3.95 years, who underwent a combined training process consisting of situational conditioning training; endurance training and strength training.

Also, in terms of speed on the 5m, 10m and 15m sprint tests, experimental group 1 achieved a statistically significant improvement compared to experimental group 2 between the initial and final measurements, which is in accordance with the research conducted by Trajković, Milanović, Sporiš, Milić, & Stanković, (2011) investigating the effects of a six-week specific and situational fitness training on the motor skills of 16 volleyball players, average aged 22.3 ± 3.7 years. Sprint speed at 5m and 10m was tested. Compared to the initial state, there was a significant improvement in the 5m and 10m sprints. Gabbett et al., 2006 obtained similar results in their study conducted on a sample of 26 junior volleyball players, designed to examine the effects of the specific and situational conditioning training on technique and motor skills. The program lasted 8 weeks, agility was assessed by the T-test and sprint speed at 5 m and 10 m. After the repeated measurement, it was determined that there was a statistically significant difference in the expression of speed and agility at the level of significance $p < 0.05$.

In volleyball explosive strength is not only reflected in reaching a certain height when jumping, but also in choosing the right moment for its execution (Lehnertet al., 2009). This is achieved by adequate reactions and quick changes in the direction of movement in a relatively small area in order to achieve the most adequate position for the successful execution of a certain volleyball technique. The obtained results showed that in terms of agility, experimental group 1 achieved a statistically significant improvement compared to experimental group 2 between the initial and final measurements. The obtained results indicated a significant improvement in the results when it comes to the 9-6-3-6-9 test (Partial Eta Squared = .094), such results being expected considering that the mentioned test is characterized by sprints in a relatively small area with sudden stops and rapid changes in the direction of movement, precisely these kinds of movements which abound in volleyball. This is in accordance with the research of (Veličković, 2017), as he determined a statistically significant improvement in agility tests: Hexagon agility test, Illinois agility test, 9-6-3-6-9 test, Japan agility test, 505 agility test, Step-hop agility test, after a twelve-week program where, in addition to basic technical and tactical training, the experimental group introduced additional plyometric training twice a week.

Comparing the size of the influence of the experimental treatment based on the parameter Partial Eta Squared between motor abilities explosive strength, speed and agility it can be concluded that the Partial Eta Squared for explosive strengthis (Partial Eta Squared = .156), speed (Partial Eta Squared = . 032) and for agility (Partial Eta Squared = .113), which implies that there is a difference in the mean values for both groups in all three tests. From this comparison, it can be observed that the highest value, and therefore the strongest effect of the experimental treatment, is on explosive strength, followed by agility, while the least significant effect can be observed on speed. Given that weaker results were recorded in the motor ability of speed, these results can be attributed to the fact that plyometric training is more related to the development of explosive strength.

## 5. Conclusion

The results of the conducted research show that volleyball specific-situational training followed by plyometric training significantly improves motor skills: explosive strength, speed and agility. The strongest effect was noticedon explosive strength, which is one of the main characteristics of the top volleyball players and it is manifested to the greatest

extent in volleyball matches. This study shows that volleyball coaches and experts should integrate plyometric training into the work of volleyball clubs in order to improve their motor skills, primarily explosive strength as one of the necessary factors to achieve success in this sport, reducing the chances of injuries. The program implemented in this research meets these criteria, which is confirmed by the obtained results.

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# EFEKTI PROGRAMIRANOG TRENINGA NA MOTORIČKE SPOSOBNOSTI ODBOJKAŠA

*Ovo istraživanje je imalo za cilj da utvrdi efekte programiranog treninga na promene u eksplozivnoj snazi, brzini i agilnosti kod mladih odbojkaša. Uzorak ispitanika u ovom istraživanju čini 40 odbojkaša juniorskog uzrasta odbojkaških klubova: OK „Topličanin" (n=20) iz Prokuplja i OK „Niš" iz Niša (n=20). Ispitanici su podeljeni u dve grupe: eksperimentalnu grupu 1 (E1, n = 20) i eksperimentalnu grupu 2 (E2, n = 20). Eksperimentalnu grupu 1 čine odbojkaši OK „Topličanin" iz Prokuplja, koji su pored osnovnih specifično – situacionih treninga, imali i dva puta nedeljno pliometrijske treninge u trajanju od šest nedelja. Eksperimentalnu grupu 2 čine odbojkaši OK „Niša" iz Niša, koji su u tom periodu imali samo specifično – situacione treninge. Istraživanje je longitudinalnnog karaktera sa inicijalnim i finalnim merenjem. Eksperimentalni tretman je trajao šest nedelja i realizovan je u pripremnom periodu. Za procenu eksplozivne snage korišćena su tri testa: 1) Skok iz čučnja 2) Skok iz čučnja sa pripremom 3) Skok iz čučnja sa pripremom sa zamahom ruku. Za procenu brzine korišćena su tri testa: 1) sprint na 5 metara 2) sprint na 10 metara 3) sprint na 15 metara. Tri testa su korišćena za procenu agilnosti 1) t-test agilnosti 2) test agilnosti 9-6-3-6-9 i 3) test agilnosti 505. Za poređenje različitih subuzorka ispitanika na inicijalnom i finalnom merenju, korišćena je Mancova analiza. Rezultati istraživanja pokazuju da odbojkaški – specifično - situacioni trening praćen pliometrijskim treningom značajno poboljšava motoričke sposobnosti: eksplozivnu snagu, brzinu i agilnost. Najjači efekat je zabeležen u eksplozivnoj snazi.*

Ključne reči: *juniori, eksplozivna snaga, agilnost, brzina*