

**Research article**

**DIFFERENCES IN EXPLOSIVE STRENGTH OF ELITE FEMALE  
HANDBALL PLAYERS DURING THE COMPETITION SEASON**

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**Abstract.** *The aim of our research was to determine the explosive strength of the legs i.e., the height of the jump of the top-ranked female handball players during the season. 15 female players underwent the following tests for estimating the explosive strength of the legs: SJ, CMJ, CMJ free arm, CMJ right leg and CMJ left leg. The Student's t-test was applied for establishing the changes between the measuring sessions during the season. The results obtained show that there were statistically significant changes and better results at the end of the season in the following parameters: CMJ right leg=.002 and CMJ left leg= .018, whereas no significant changes occurred in all the other two-leg jumps. Taking into consideration the fact that in performing different throws and goal shooting the most prominent movements in handball are done on one leg, the results were expected. It is recommended that throughout the season the training process should include additional exercises for improving and maintaining the ability of the handball players to jump (plyometric, proprioceptive and the combination of the two with the common strength improving exercises), since their positive effects have been proven by quite a few studies.*

**Key words:** *Female Handball Players, Explosive Strength of the Legs, Changes, Playing Season*

INTRODUCTION

Continuous changes in and amendments to the official rules since 1999 to date have significantly increased the attractiveness of the game itself, its dynamics and the reduction in foul contacts in duels between the players (Bojić, Kocić, Veličković, & Nikolić, 2017). The parameters of the game such as the number of offences and defenses, the total number

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of goals, jumps and shots, as well as assists have increased, which, in turn, has led to changes in the ways both male and female players should be prepared for top achievements. The new training process focuses on specific physical preparation, which is realized through the use of means and methods similar to the situational movements of the players and the physiological requirements on the part of modern handball. Handball experts and coaches, who analyse the effectiveness of their players' performances by standardised parameters during each competition, can precisely determine the contribution of each player to the success of the team, as well as how successful the team was as a whole (Ohnjec, Vuleta, Milanović, & Gruić, 2008). Therefore, top-ranked female handball players need to develop strength and muscle endurance to maintain the highest levels of applying technical and tactical skills throughout the game. The results of the previous studies have confirmed that performance in handball largely depend on a specific motoric factor based on particular agility and explosiveness (Čavala, Rogulj, Srhoj, Srhoj, & Katić, 2008). This contributed to the strategy that during the playing season all physical parameters should be maintained at a high level but should also be in accord with the specific abilities of a handball player.

Periodization of strength training in handball is a significant issue. Intense motor conditions that players in competitive sports are exposed to require continuous strength training throughout the annual training cycle. This is particularly significant in handball, in which a classic division of the annual training macrocycle is applied, because the players participate in competitions throughout the year. Maintaining and even improving the levels of the muscle strength developed in the preparatory period of the season is the main task during the playing season. However, applying strength training during the playing season is also a demanding task since all the other motor abilities need to be maintained at high levels avoiding tiring out the players, which can lead to the state of their being overtrained (Spieszny & Zubik, 2018; Silvestre et al., 2006).

Understanding technical and physiological demands of the game is essential. If we are aware of the fact that this sport is dominated by fast movements and stops, sudden and swift changes of direction, explosive jumps and passes, different landings and duels between the players, then what should be applied in the training process are specific means and methods which can bring about the successful realization of the afore mentioned elements of the game. The basis of those activities are muscle strength, speed and endurance, which are crucial for the successful performance of all the technical and tactical tasks set for the players (Ohnjec et al., 2008; Granados, Izquierdo, Ibañez, Bonnbau, & Gorostiaga, 2007). The role and importance of explosive strength in handball have been the subject matter of a lot of research (Spieszny & Zubik, 2018; Mir & Bari, 2017; Marques, 2010; Gorostiaga, Izquierdo, Iturrealde, Ruesta, & Ibanez, 1999; Hoff & Almasbakk, 1995). The explosive strength of the lower extremities is responsible for the realization of various types of jumps, running speed and acyclic handball-specific movements (Carvalho, Mourão, & Abade, 2014; Čavala et al., 2008). In this sport a player needs to generate strength for small outside forces (e.g. throwing) and large ones (e.g. fighting for the position on the court, defence). This is the reason why different load training sessions should equally be included in power and maximal strength development (Spieszny & Zubik, 2018). Vertical jumps are predominant in the realization of the majority of technical and tactical requirements in handball. Two-leg vertical jumps are more dominant in defence (jump and block). For the pivots, two-leg vertical jumps are the most relevant elements when it comes to shooting efficiency. Single-leg vertical jumps characterize all the positions on the team since they are used while performing passes and shooting.

The application of various means and methods for improving the explosive strength of jumps has had positive results in working with younger players as well as with top-ranked male and female handball players. The most commonly used method for improving jump height among handball players is the plyometric method (Hammami, Gaamouri, Aloui, Shephard, & Chelly, 2018; Hermassi et al., 2014a; Carvalho et al., 2014; Ghuman & Godara, 2013), followed by neuromuscular and proprioceptive training (Gioftsidou et al., 2012; Chappell & Limpisvasti, 2008; Šimek-Šalaj, Milanović, & Jukić, 2007; Holm et al., 2004), and, finally, maximum strength training (Carvalho, et al., 2014; Hoff & Almasbakk, 1995).

The ability to sprint is one of the most decisive factors in team sports, and it has been proven that strength training significantly contributes to the increase in speed (McGuigan, Wright, & Fleck, 2012). As the importance of movement speed with and without the ball in handball is extremely important, many studies have shown that there are positive correlations between the lower extremities and the ability of handball players to sprint (Hermassi, et al., 2014b; Ingebrigtsen & Jeffreys, 2012). However, there has not been much research into the changes in the explosive strength parameters during the playing season in top-ranked male and female handball players (Pavlović, Bojić, Stojiljković, Đorđević, & Radovanović, 2018; Granados, Izquierdo, Ibanez, Ruesta, & Gorostiaga, 2008; Marques & Gonzalez-Badillo, 2006; Gorostiaga et al., 1999; Hoff & Almasbakk, 1995). When it comes to female handball players, only Granados et al. (2008) determined the variations in the jump height (the explosive strength of the legs) during the playing season.

The aim of research was to determine the differences in the explosive strength of the legs i.e., the jump height of the top-ranked female handball players during the playing season.

## METHODS

### Participants

Fifteen top-ranked female handball players of the female H.C. "Naisa" from Niš (aged  $23.7 \pm 3$  years, height  $173.5 \pm 6$  cm, and body mass  $68.1 \pm 8.0$  kg) participated in the research. All of them competed in the Serbian Super League in the 2016/17 season. The testing was conducted before the beginning of the championship and at the end of competition within the Serbian Super League 2016/17. Both testing situations were organized in the morning.

### Measures

In this research we used five tests for the evaluation of explosive power. Tests were used to evaluate the height of the vertical jumping (Bosco, Luhtanen, & Komi, 1983): the Squat Jump (SJ); Countermovement Jump (CMJ), Countermovement Jump Free Arm (CMJ free arm), Single-Leg Vertical Countermovement Jump - Right Leg (CMJ right leg) and Single-leg Vertical Countermovement Jump - Left Leg (CMJ left leg). The evaluation of vertical jumping was carried out on a flat surface using a system of electric photocells (Optojump, Microgate, Bolzano, Italy) which displayed excellent validity and reliability when testing these types of jumps (Glatthorn et al., 2011).

### Procedures

The differences between the initial (at the beginning of the season) and the final measurements (at the end of the season) of the participants were established with the Student's t-test. The SPSS set was used for the statistical data analysis.

### RESULTS

The Student's t-test was used for determining differences between the two testing situations (Table 1). The results obtained show that there are statistically significant changes only in two tests which estimated the height of the one-legged jump with the left leg and the right leg take off (CMJ right leg = .002 and CMJ left leg = .018).

**Table 1** Differences in the explosive strength of the female handball players during the playing season

Measurements	N	Student t-test		T-value	p
		Mean (1. testing)	Mean (2. testing)		
SJ (cm)	15	24.65	25.13	-.44	.667
CMJ (cm)	15	26.91	26.74	.19	.849
CMJ free arm (cm)	15	31.71	30.99	.73	.475
CMJ right leg (cm)	15	12.48	14.61	-3.78	<b>.002</b>
CMJ left leg (cm)	15	12.49	14.51	-2.67	<b>.018</b>

In the other tests there were numerical changes, so slightly higher values were obtained on the SJ test, whereas lower values at the end of the playing season were obtained in the CMJ and CMJ free arm tests. We discovered similar results among female handball players, and in those there were no changes in the explosive strength at the end of the season (Pavlović, Bojić & Radovanović, 2015; Gorostiaga, Granados, Ibanez, Gonzalez-Badillo, & Izquierdo, 2006). On the other hand, contrary to our results, Granados et al. (2008) obtained significantly better values of the jump height at the end of the season among Spanish female handball players. 16 top-ranked female handball players (who competed in the First National Spanish League) participated in the research. At the end of the season, the authors determined a significant increase in the two-legged vertical jump height (CMJ free arm) of  $12 \pm 7.2\%$  comparing to the initial values, obtained at the beginning of the season.

### DISCUSSION

The significance of vertical jumps (both one-legged and two-legged) in handball is great. Female handball players use them to realize defence actions, various passes and shots in all the positions on the team. Two-legged take offs are essential for the pivots, and one-legged take offs are mostly used by the other players, including the goalkeepers. Observing the changes in jumps throughout the season, we noticed that there was an increase in the values of only one-legged take offs at the end of the season. Such results are justified, considering the fact that one-legged take offs are the most prominent ones in different passes and shootings in handball. In other types of jumps, done with the two-legged take

off, there were no statistical changes. However, the numerical values show slightly poorer results in all the applied jumps at the end of the season, except for the CMJ free arm. The obtained results are contrary to the ones that Granados, et al. (2008) got. The female handball players in their research significantly increased the two-legged vertical jump height ( $12 \pm 7.2\%$ ) at the end of the playing season. Having in mind the fact that in sports science fewer studies were conducted with female than with male participants, we have discovered no studies with a similar aim. However, there are quite a few studies in which the authors determined the effects of the programmed, specific training on the increase in the jump in handball (e.g. plyometric training, proprioception, maximum strength training and the combination of those). The application of the plyometric training with different number and duration length within a microcycle showed positive effects on the vertical jump height among female handball players during the season (Hammami, et al., 2019; Hammami, et al., 2018; Hermassi et al., 2014a; Carvalho, et al., 2014; Ghuman & Godara, 2013; Cetin & Ozdol, 2012). The last decade has seen the application of neuromuscular and proprioceptive trainings more often (both in the laboratory and on the court), as well as examining their influence on the explosive strength of the legs, that is, the ability to jump, among male and female handball players (González-Ravé et al., 2014; Panics, Tallay, Pavlik, & Berkes, 2008; Holm, et al., 2004). The combination between the maximum strength and the proprioceptive training and the plyometric exercises had positive effects on the increase in the values of jumps in female handball players (Hammami et al., 2019; Hammami, et al., 2018; Spieszny & Zubik, 2018; Carvalho, et al., 2014; Gorostiaga, et al., 1999; Hakkinen & Komi, 1985). The explanation for the results obtained in research could probably be found in the length of the playing season and the tiredness of the players due to the high-intensity load. The playing season lasted from the middle of September until the end of May, with the 38 games played (the National Championship and the Cup, plus two games of the European Challenge Cup). A few days before the testing, the play off and the Championship had ended, so along with tiredness there was also weak motivation, which all had a negative impact on the test results. It is recommended that additional plyometric and proprioceptive training should be included in the plan and programme of the training process for the purpose of developing and maintaining the explosive strength of the legs, it being the most dominant ability responsible for the success of female handball players.

## CONCLUSION

Modern handball requires that the players should be in great shape throughout the season. Explosive strength as one of the most dominant abilities is the prerequisite for the successful realization of almost all technical and tactical activities in handball. Sprints with and without a ball, all the jumps, sudden and swift changes of directions are all largely dependent on the explosive strength of the lower extremities. The playing season leads to the changes in majority of physical abilities and the aim of research was to determine the differences in the explosive strength of the legs, that is, in the vertical jump height (both one-legged and two-legged) among female handball players. The results obtained show that there were statistical changes and improvements at the end of the season in the one-legged vertical jump height (with the right and left leg take offs), but that there were no changes in the other types of two-legged jumps (SJ, CMJ, CMJ free

arm). One-legged jumps and shots are more common in handball, so these results were expected. Tiredness among the players due to the length of the playing season, atypical two-legged jumps in handball and the lack of motivation for undergoing the testing might provide a plausible explanation as to why there were no changes at the end of the season. The application of the additional plyometric and proprioceptive trainings (which have been proven to have positive effects on the increase in the values of jumps) could maintain and/or improve the high level of the explosive strength of the legs of top-ranked female handball players throughout the season.

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## **RAZLIKE U EKSPLOZIVNOJ SNAZI VRHUNSKIH RUKOMETAIŠICA TOKOM TAKMIČARSKE SEZONE**

*Cilj istraživanja bio je da se utvrde razlike u eksplozivnoj snazi nogu (visini skoka) vrhunskih rukometašica tokom takmičarske sezone. Na uzorku od 15 rukometašica primenjeni su sledeći testovi za procenu eksplozivne snage nogu: SJ, CMJ, CMJ free arm, One leg CMJ right leg i One leg CMJ left leg. Studentov t-test je primenjen za utvrđivanje promena između merenja tokom takmičarskog perioda. Dobijeni rezultati pokazali su statistički značajnu promenu i bilje rezultata na kraju takmičarske sezone u jednonožnim skokovima (CMJ right leg=.002 i CMJ left leg=.018), dok u ostalim sunožnim skokovima nisu zabeležene značajne promene. Obzirom da su u izvođenju različitih bacanja i šutiranja na gol u rukometu najzastupljeniji jednonožni skokovi, dobijeni rezultati su*

*očekivani. Preporuka bi bila da se u trenažni proces tokom cele sezone uvrste dodatni treninzi za poboljšanje ali i održavanje skočnosti rukometašica (pliometrijski, propioceptivni i njihove kombinacije sa klasičnim treningom snage), čiji su pozitivni efekti višestruko dokazani u dosadašnjim istraživanjima.*

*Ključne reči: rukometašice, eksplozivna snaga nogu, promene, takmičarski period*