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Original research article

DIFFERENCE IN THE EXPLOSIVE STRENGTH OF LOWER EXTREMITIES BETWEEN ATHLETES AND NON-ATHLETES: A PRELIMINARY STUDY*

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Abstract. *From the biomechanical aspect, explosive strength is required in athletic sport disciplines like long jumping, high jumping and throwing. Particularly, it is required in technical gestures like take off and landing in vertical jumping. The aims of the current research were to determine difference in the explosive strength of lower extremities between: 1) athletes and non-athletes; 2) the participants in relation to gender; 3) athletes in relation to their sport activity. The sample of participants consisted of 240 individuals (120 athletes and 120 non-athletes, i.e., 106 male and 134 female participants, respectively), chosen from the population of high-school students. All of the participants performed five CMJ without the arm swing in order to determine, by using the Myotest device (Sion, Switzerland) the following variables of explosive strength: Height (expressed in cm); Power (expressed in W/kg); Force (expressed in N/kg) and Velocity (expressed in cm/s). For the statistical analysis and interpretation of the results, the statistical package SPSS 13.0 was used. The results were expressed by descriptive statistics, while in order to calculate the statistically significant difference in the explosive strength of lower extremities between participants in relation to their sport activity and gender, the t-test, ANOVA and POST HOC (LSD) test were used. The best results for the variables Height, Power, and Velocity were achieved by basketball players, while the best results for variable Force were achieved by non-athletes. In general, athletes and male participants performed better on functional tests than non-athletes and female participants, respectively. The statistically significant differences were determined between groups of athletes for all the variables, except for the variable Force. It can be*

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supposed that a yearlong basketball practice represents a good basis for the development of superior jumping abilities in basketball players, in comparison to other athletes in the current research. In general, the results were similar when the athletes and non-athletes, who participated in the current research, were compared: certain sport activities contribute to the difference in explosive strength of the lower extremities.

Key words: *Explosive strength, countermovement jump, athletes, non-athletes, gender, differences.*

INTRODUCTION

From a biomechanical aspect, explosive strength is required in athletic sport disciplines like long jumping, high jumping and throwing (Branković & Bubanj, R., 1997). Particularly, it is required in technical gestures like take off and landing in vertical jumping (Bubanj, S. et al., 2010). Since performance in majority sports activities is dependent on the athlete's ability to rapidly produce muscular force (Newton & Kraemer, 1994), and since most athletes and coaches strive for an improvement in performance, vertical-jump testing is being used to measure the effectiveness of various training programs in the development of explosive strength (Klavora, 2000). Enhanced work and efficiency in the stretch-shortening cycle, during the Countermovement Jump (CMJ), is partly being explained by the use of the elastic energy, stored in the muscles and tendons (Ingen-Schenau, Bobbert, & De Haan, 1997; Komi, & Bosco, 1978). Bencke et al. (2002) stated that genetics may be an important factor for the performance in the aforementioned anaerobic task, i.e., the vertical jump. According to MacDougall, & Wenger (1991), factors which influence an athlete's performance, in addition to genetic endowment, are training and favorable health status. According to Marković (2007) plyometric training provides a statistically significant and practically relevant improvement in vertical jump height in healthy individuals, with the mean effects ranging from 4.7% in the Squat Jump and Drop Jump, over 7.5% in CMJ with the arm swing, to 8.7% in CMJ without the arm swing. Smilios, Pilianidis, Sotiropoulos, Antonakis, & Tokmakidis (2005) suggested that the CMJ performance is enhanced when vertical jump sets are alternated with loaded jump squats or half squat sets are performed with low to moderate loads from within the power training zone i.e., 30–60% of 1 repetition maximum. In relation to gender, Fuster, Jerez, & Ortega (1998) suggested that for males, vertical jump appears to be related more closely to longitudinal dimensions than for females, while static strength has more to do with body mass (weight) than with body size (height). Schiltz et al. (2009) mentioned that even though relative peak torque values in eccentric knee flexion exerted by m. quadriceps cannot discriminate between professional and junior basketball players, higher absolute force production in taller and heavier athletes does contribute to their competitive advantage over junior players. The aims of the current research were to determine the difference in the explosive strength of the lower extremities between: 1) athletes and non-athletes; 2) the participants in relation to gender; 3) athletes in relation to their sports activity.

THE METHOD

The sample of participants consisted of 240 individuals (120 athletes and 120 non-athletes), chosen from the population of high-school students. Among them, there were

106 male and 134 female participants, with a body height of 173,52+8,91 in cm, body weight of 64,13+11,02 in kg, aged 16,76+3,46 years (Mean±Std.Dev). One half of the participants, 120, were professionally engaged in different sport activities (combat sports, N=19; soccer, N=22; handball, N=9; basketball, N=12; volleyball, N=21; water sports [swimming, N=7; water polo, N=2]; dance, N=12; body building, N=7; parkour, N=1; tennis, N=4; table tennis, N=4). The participants voluntarily agreed to participate in the study which was conducted in accordance with the Helsinki Declaration. First of all, the participants took part in a warming protocol consisting of 800m of smooth run, 4x30m skip ahead, 4x30m lateral skipping and 4x30m back skipping. During the vertical jump protocol, the participants carried a Velcro belt around their lower trunk, with a wireless device Myotest (Sion, Switzerland) safely attached to a belt. The Myotest is a valid (Bampouras, Relph, Orme, & Esformes, 2010) and reliable (Bubanj et al., 2010) device. All of the participants performed five CMJ without the arm swing. The sample of variables, processed and analyzed by the Myotest device included: Height (expressed in cm); Power (expressed in W/kg); Force (expressed in N/kg) and Velocity (expressed in cm/s). For the statistical analysis and interpretation of the results, the statistical package SPSS 13.0 was used. The results were expressed by descriptive statistics, while in order to calculate the statistically significant difference in the explosive strength of the lower extremities between the participants in relation to their sport activity and gender, the T-test, ANOVA method and POST HOC (LSD) test were used (Pallant, 2007).

RESULTS AND DISCUSSION

According to the descriptive statistics (Figure 1), the best results for the variables Height, Power, and Velocity were achieved by basketball players, while the best results for the variable Force were, surprisingly, achieved by non-athletes.

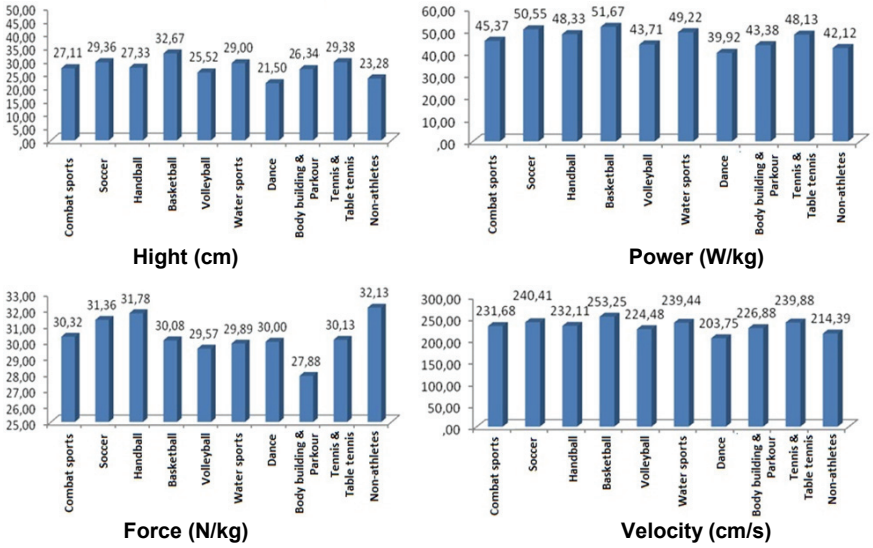

Fig. 1. Descriptive statistics of the explosive strength of the participants (N=240).

In general, athletes and male participants performed better on the functional test than non-athletes and female participants, respectively. The statistically significant differences were determined based on variables Height, Power, and Velocity, by using the t-test (Table 1). The parameters of Height, Force, Power and Velocity, for which the participants of the current research were assessed, jointly contribute to the overall performance in CMJ. The performance in the variable Force for all the participants was low. That fact, particularly for athletes, could negatively influence their sport success. In that sense, a well-designed plyometric program is needed for athletes.

Table 1. Differences between athletes-non-athletes and male-female participants determined by using the t-test.

	Athlete	N	Mean	Std. Deviation	Sig.	Sex	N	Mean	Std. Deviation	Sig.
Height (in cm)	no	120	23.28	6.197	*0.000	f	134	21.27	4.049	*0.000
	yes	120	27.50	6.182		m	106	30.60	5.209	
Power (in W/kg)	no	120	42.12	8.447	*0.000	f	134	39.60	5.632	*0.000
	yes	120	46.68	8.179		m	106	50.45	7.877	
Force (in N/kg)	no	120	32.13	26.629	0.440	f	134	31.78	25.205	0.578
	yes	120	30.23	3.747		m	106	30.41	3.978	
Velocity (in cm/s)	no	120	214.39	26.453	*0.000	f	134	205.68	18.634	*0.000
	yes	120	232.23	26.722		m	106	245.59	21.124	

*statistically significant difference $p < 0.05$

By using the ANOVA method (Table 2), statistically significant differences were determined between the groups of athletes for all the variables, except for the variable Force.

Table 2. Differences between the groups of athletes determined by the ANOVA method.

		Sum of Squares	df	Mean Square	F	Sig.
Height (in cm)	Between Groups	2038.702	9	226.522	6.396	*.000
	Within Groups	8145.206	230	35.414		
	Total	10183.908	239			
Power (in W/kg)	Between Groups	2826.979	9	314.109	4.858	*.000
	Within Groups	14870.417	230	64.654		
	Total	17697.396	239			
Force (in N/kg)	Between Groups	322.075	9	35.786	.096	1.000
	Within Groups	85948.575	230	373.689		
	Total	86270.650	239			
Velocity (in cm/s)	Between Groups	38022.569	9	4224.730	6.508	*.000
	Within Groups	149302.614	230	649.142		
	Total	187325.183	239			

*statistically significant difference ($p < 0.05$)

Basketball players, who achieved the best results for the variables Height, Power, and Velocity, as mentioned earlier in the text, differed in a statistically significant manner in

relation to athletes of combat sports, volleyball players, dancers and non-athletes (Table 3). Statistically significant differences were determined by using the POST HOC (LSD test). However, the fact is that among the basketball players (N=12), the majority of the participants were males (N=11), unlike the volleyball players (N=21), dancers (N=12) and non-athletes (N=120), where male participants were the minority (N=6, N=1, N=38, respectively), while only among the athletes of combat sports (N=19) was the majority of the participants male (N=13).

On the other hand, we need to stress that basketball players achieved better results than from e.g. soccer players (N=22), or body builders (N=7). In Serbia, soccer and body building are considered 'male' sport disciplines. In the current research, almost 100% of the participants who participated in soccer and body building were of the male sex.

Table 3. Differences between athletes and non-athletes for the variables Height, Power and Velocity, determined by the usage of POST HOC (LSD test).

Height / Power/ Velocity	Combat sports	Soccer	Handball	Basketball	Volley ball	Water sports	Dance	Body building & Parkour	Tennis & Table tennis
Soccer	.23/*.04 /.28								
Handball	.93/.36 /.97	.39/.49 /.41							
Basketball	*.01/*.04 /*.02	.12/.70 /.16	*.04/.35 /.06						
Volleyball	.40/.52 /.37	*.04/*.01 /*.04	.45/.15 /*.00	*.00/*.01 /*.00					
Water sports	.43/.24 /.45	.88/.68 /.92	.55/.82 /.22	.16/.49 /.14	.14/.09 /.14				
Dance	*.01/.07 /*.00	*.00/*.00 /*.00	*.03/*.02 /*.00	*.00/*.00 /*.03	.06/.19 /*.00	*.01/*.01 /*.00			
Body building & Parkour	.76/.56 /.66	.22/.03 /.20	.73 /.21/.02	*.02/.03 /.82	.74/.92 /.31	.36/.14 /*.05	.08/.35 /*.05		
Tennis & Table tennis	.37/.42 /.45	.10/.47 /.96	.48/.96 /.25	.23/.34 /.15	.12/.19 /.97	.90/.78/ *.00	*.00/*.03 /.31	.31/.24 /.31	
Non-athletes	*.01/.10 /*.01	*.00/*.00 /*.00	*.05/*.03 /*.00	*.00/*.00 /.01	.11/.40 /*.01	*.01/*.01 /.17	.32/.37 /.18	.16/.67 /*.01	*.01/*.04 /*.01

*statistically significant difference ($p < 0.05$)

Studies dealing with similar objectives can be found, but not many are comparable due to different methodology, cohort, type of muscle action, testing conditions, etc. (Gašić et al., 2011). Mayhew and Salm (1990) determined a significant difference in jumping performances, i.e., explosive strength of the lower extremities between 181 untrained participants of both sexes. Holloway and Baechle (1990) stated that women and men respond to strength training in very similar ways based on their individual pretraining baselines. According to the aforementioned authors there is no evidence that women should train differently than men. However, training programs should be tailored for each

individual. Cronin and Hansen (2005) conducted a study with aim of examining the importance of the strength and power measures on sprint performance in 26 professional rugby league players (mean age 23.2 years). Maximal strength (3 repetitions maximum), power (30 kg jump squat, countermovement, and drop jump), isokinetic strength measures (hamstring and quadriceps peak torques and ratios) and 5 m, 10 m, and 30 m sprint times were measured. A correlational approach and a comparison between means of the fastest and slowest players were used. The squat jump and CMJ heights as well as the squat jump relative power output were the only variables found to be significantly greater in the fast players. It was suggested that improving the power to weight ratio as well as plyometric training involving countermovement and loaded jump-squat training may be more effective for enhancing sport speed in elite players.

CONCLUSION

It should be stressed that the obtained results can only give insight into the differences in manifested explosive strength, but cannot explain their causes in depth. It can be supposed that a yearlong basketball practice represents a good basis for the development of superior jumping abilities in basketball players, in comparison to the other athletes in the current research. In general, the same applies when the athletes and non-athletes, who participated in the current research, are compared: certain sport activities contribute to the difference in explosive strength of lower extremities.

REFERENCES

Bampouras, T.M., Relph, N., Orme, D., & Esformes, J.I. (2010). Validity and reliability of the Myotest Pro wireless accelerometer. *British Journal of Sports Medicine,* Doi:10.1136/Bjsm.2010.078972.59i9

Bencke, J., Damsgaard, R., Saekmose, A., Jørgensen, P., Jørgensen, K., & Klausen, K. (2002). Anaerobic power and muscle strength characteristics of 11 years old elite and non-elite boys and girls from gymnastics, team handball, tennis and swimming. *Scandinavian Journal of Medicine & Science in Sports*, 12, 171-178. doi: 10.1034/j.1600-0838.2002.01128.x

Branković, M., & Bubanj, R. (1997). Atletika-tehnika i metodika (Athletics-Techniques and methodology). Niš: Self edition of author. In Serbian.

Bubanj, S., Stanković, R., Bubanj, R., Bojić, I., Đinđić, B., & Dimić, A. (2010). Reliability of myotest tested by a countermovement jump. *Acta Kinesiologica*, 4 (2), 46-48.

Cronin, J.B., & Hansen, K.T. (2005). Strength and power predictors of sports speed. *Journal of Strength and Conditioning Research*, 19 (2), 349-357.

Fuster, V., Jerez, A., & Ortega, A. (1998). Anthropometry and strength relationship: Male-female differences. *Anthropologischer Anzeiger*, 56 (1), 49-56.

Gašić, T., Bubanj, S., Živković, M., Stanković, R., Bubanj, R., & Obradović, B. (2011). Difference in the explosive strength of upper extremities between athletes in relation to their sport activity, type of engagement in sport and gender. *Sport Science*, 4 (1), 63-67.

Holloway, J.B., & Baechle, T.R. (1990). Strength training for female athletes: A review of selected aspects. *Sports Medicine*, 9 (4), 216-228.

Ingen-Schenau, G. J. Van, Bobbert, M.F., & De Haan, A. (1997). Does elastic energy enhance work and efficiency in the stretch-shortening cycle? *Journal of Applied Biomechanics*, 13, 389-415.

Klavora, P. (2000). Vertical-jump tests: A critical review. *Strength and Conditioning Journal*, 22 (5), 70-76.

Komi, P.V., & Bosco, C. (1978). Utilization of stored elastic energy in leg extensor muscles by men and women. *Medicine and Science in Sports and Exercise*, 10, 261-265.

MacDougall, J.D., & Wenger, H.A. (1991). The purpose of physiological testing. In: MacDougall, J.D., Wenger, H.A., & Green, H.J. (Eds.) *Physiological testing of the elite athlete*. Canadian Association of Sport Sciences, Ontario.

Mayhew, J.L., & Salm, P. C. (1990). Gender differences in anaerobic power tests. *European Journal of Applied Physiology and Occupational Physiology*. 60 (2), 133-138.

Marković, G. (2007). Does plyometric training improve vertical jump height? A meta-analytical review. *British Journal of Sports Medicine*, 41, 349-355. doi:10.1136/bjsm.2007.035113

Newton, R.U., & Kraemer, W.J. (1994). Developing explosive muscular power: Implications for mixed methods training strategy. *Strength and Conditioning*, 16, 20-31.

Pallant, J. (2007*). SPSS Survival Manual*. Third Edition, Allen & Unwin.

Schiltz, M., Lehance, C., Maquet, D., Bury, T., Crielaard, J.M., & Croisier, J.L. (2009). Explosive strength imbalances in professional basketball players. *Journal of Athletic Training*, 44 (1), 39-47.

Smilios, I., Pilianidis, T., Sotiropoulos, K., Antonakis, M., & Tokmakidis, S. (2005). Short-term effects of selected exercise and load in contrast training on vertical jump performance. *Journal of Strength and Conditioning Research*, 19 (1), 135–139.

RAZLIKE U EKSPLOZIVNOJ SNAZI DONJIH EKSTREMITETA IZMEĐU SPORTISTA I NESPORTISTA: PRELIMINARNO ISTRAŽIVANJE

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Sa biomehaničkog aspekta eksplozivna snaga je neophodna u atletskim disciplinama poput skoka u dalj, skoka u vis i bacanja. Naročito, neophodna je u elementima tehnike kao što su odskok i doskok u vertikalnim skokovima. Ciljevi aktuelnog istraživanja bili su da se utvrdi razlika u eksplozivnoj snazi donjih ekstremiteta između: 1) sportista i nesportista; 2) ispitanika u odnosu na pol; 3) sportista u odnosu na njihovu sportsku aktivnost. Uzorak ispitanika sačinjavalo je 240 ispitanika (120 sportista i 120 nesportista, tj., 106 ispitanika muškog i 134 ispitanika ženskog pola, tim redosledom), odabranih iz srednjoškolske populacije učenika. Svi ispitanici su izveli pet skokova sa počučnjem bez zamaha ruku, sa ciljem da se utvrde, upotrebom uređaja Myotest (Sion, Švajcarska), sledeće varijable eksplozivne snage: Visina (izražena u cm); Snaga (izražena u W/kg); Sila (izražena u N/kg) i Brzina (izražena u cm/s). Za statističku analizu i pretstavljanje rezultata korišćen je statistički paket SPSS 13.0. Rezultati su izraženi deskriptivnom statistikom, dok su u cilju utvrđivanja statistički značajne razlike u eksplozivnoj snazi donjih ekstremiteta između ispitanika, u odnosu na njihovu sportsku aktivnost i pol, korišćeni t-test, metod ANOVA-e i POST HOC (LSD) test. Najbolje rezultate u varijablama Visina, Snaga i Brzina, postigli su košarkaši, dok su najbolji rezultat u varijabli Sila postigli nesportisti. Uopšte uzev, sportisti i ispitanici muškog pola su funkcionalni test sproveli bolje od nesportista i ispitanika ženskog pola, respektivno. Statistički značajne razlike su utvrđene između grupa sportista u svim varijablama, osim u varijabli Sila. U odnosu na aktuelno istraživanje može se pretpostaviti da višegodišnje bavljenje košarkom predstavlja dobru osnovu za razvoj skakačkih sposobnosti košarkaša u poređenju sa drugim sportistima. Uopšteno, isto važi i kod poređenja sportista i nesportista koji su učestvovali u aktuelnom istraživanju: određene sportske aktivnosti doprinose razlici u eksplozivnoj snazi donjih ekstremiteta.

Ključne reči: *eksplozivna snaga, skok sa počučnjem, sportisti, nesportisti, pol, razlike.*