DIFFERENCES IN MORPHOLOGICAL SPACE OF THROWERS FINALISTS OF THE BEIJING OLYMPICS

Ratko Pavlović[1], Ilona Mihajlović[2], Kemal Idrizović[3], Martin Pupiš[4], Aleksandar Raković[5] and Goran Bošnjak[6]

[1] Faculty of Physical Education and Sports, University of East Sarajevo, Bosnia and Herzegovina
[2] Faculty of Sport and Physical Education, University of Novi Sad, Serbia
[3] Faculty of Sports and Physical Education, University of Nikšić, Montenegro
[4] Department of Physical Education and Sport, Matej Bel University Banska Bystrica, Slovakia
[5] Faculty of Sport and Physical Education, University of Niš, Serbia
[6] Faculty of Physical Education and Sports, University of Banja Luka, Bosnia and Herzegovina

Original scientific paper

Abstract
Morphological space is very important and primary in the selection, targeting and achieving results in sport. This is particularly apparent in professional sport where remarkable results are achieved. Depending on the sport, sport discipline it depend also of the participation and influence of human space, or its segments to the total score. When describing and defining specific populations of athletes, their morphological status, the most common parameters that are taken are body height, body weight, body mass index, and very often the age of the respondents. These parameters are very reliable and give a true picture of the morphological area of the studied population. This paper analyzes the differences in the segments of human space of throwers, the finalists of the Beijing Olympics. The sample included 24 competitors in three disciplines (shot, discus, hammer). Differences in body height, body weight, BMI and age were analysed. For data processing t-test has been for small independent samples that confirmed the presence of statistically significant differences between throwers. Discus throwers and shot putters differ statistically significant in BMI values (p<0.05), discus throwers and hammer throwers in body height (p<0.05). The most statistically significant differences were recorded between the shot putters and hammer throwers in body weight (p<0,01) and BMI values (p<0,05).

Key words: *morphological status, throwing disciplines, differences, Olympic games*

Introduction

Anthropological space is very important and primary in the selection, targeting and achieving results in sport. Depending on the sport, sport discipline it depends also the participation and influence of human space, or its segments to the total score. In the structural and biomechanical analysis of athletic disciplines, in addition to the relevant kinematic and kinetic parameters to be analyzed, a very important place occupies also the analysis of body height, body weight and Body Mass Index (BMI). On the basis of some numerical indicators there can be seen the dominant somatotypes specific to certain athletic disciplines (mesoendomorf, mesoectomorf, ectoendomorf,…).

So we have indications that the endomorph component ranges from 3.25 to 3.75 for disk throwers to 3.75 for ball throwers, ectomorf from 2.00 for ball throwers and disk to 2.25 for hammer throwers and mesomorphic from 5.50 for hammer throwers to 6.25 for the disk throwers (Pavlović, 2012). A very common question that arises in the throwing events, is about the body height, body weight, BMI and often the age of throwers competitors. Each of the four throwing events has its own characteristics in terms of techniques, rules of performing and weight of the device. Summing all throwing events, at first glance, the similarities are observed in the three events (ball throw, discus and hammer throw).

For competitors of these disciplines can be said to have an almost identical morphological status (height, weight, BMI), while the javelin throwers significantly differ (Amour & Elliot, 1989). Javelin is structurally and biomechanically different from other throwing disciplines, especially in terms of weight of the equipment, so the body height, body weight, BMI does not play an important role in achieving results. However, it cannot be said for the ball throw, discus and hammer throw which in achieving of results limits first the space for throwing (diameter of circular segment) and then shape and weight of the equipment. Compared to jumping disciplines, pitchers have much less space for maneuver space for the start-up phase of run-up and in a relatively small space frame they must exercise to the maximum their psycho-physical and technical qualities (Pavlović, 2010). Also, throwing disciplines require a high level of output power in a very short period of time. Because of these characteristics, the performance result is, in addition to technical performance and motor skills, subordinated to the morphological status of athlete pitcher (height, weight, BMI). Result in the throwing events, in addition to morphological size and sex (Alexander et al., 1996a), is defined also with the ejection parameters (speed, height, angle), aerodynamic characteristics of device, the influence of the environment (wind, air density), ground reaction force (Mc Coy et al., 1985; Tončev, 2001; Rasmussen, 2005; Jovović, 2006; Idrizović, 2010).

The height ejection is extremely important for shot putters and disc with correctly used the technique. To throw a good length, height ejections must be as large as possible, and with the other parameters to be at the appropriate level (angle and speed of ejection). In the discus throw angle must be adjusted to the pitcher capabilities, making it easy for less experienced pitchers to range from 40 º -45 º, and for those more mature from 34 º -38 º (Mc Coy et al. 1985, Knicker, 1999). Studies have shown that the angle of experienced pitchers, ranges from 27º-40º (Bukhatsov, 1988; Idrizović, 2010; Stefanović, 1992; Linthorne, 2001). In the shot put, the height of pitcher as well as body mass affects the shot further, because here is manifested the acting of absolute power that is the greater mass (pitchers body) to lower mass of the device, where aerodynamics of the device has no effect on the length of the throw. The situation is similar with the hammer throw where the initial acceleration phase to the hammer gives in phase of throw-out and entering the turn, and more weight and power of pitcher is required to counter the effects of high centrifugal forces. Centrifugal force is extremely high, and it prevents movement of pitcher from the back to the front part of the circular segment and thus to keep the pitcher on his way into the site throw, closer to an imaginary vertical projection and to perform the throw-out. In this position, the pitcher is tilted rearward closing angle of 70º-80º to the vertical (Pavlović, 2010). Alexander conducted research in 1996 on the finalists of throwing disciplines at the Olympics in Barcelona in order to compare the biomechanical performances of male and female athletes. He got the results that there are certain differences and they are result of muscle strength, flexibility and explosive strength in male and female athletes. Harasin and Milanović (2005) in a sample of top pitchers conducted research with the aim of determining the differences between the best Olympic and world results in the throwing disciplines from Montreal in 1976 to Athens in 2004. By applying t-test they determined the trend of growth and differences in each event individually. For the success of result, in addition to motor skills a significant proportion has also achieved the morphological status of each competitor. The results are more relevant and needed to practice if it is the case of a sample of top athletes-thrower participants of a major competition such as the Olympic Games. The subject of this study is timely focused on the analysis of the Beijing Olympics that is the finalists in the throwing disciplines in order to identify differences in terms of the anthropological status of the pitcher.

Methods

The study sample consisted of 24 top athletes in the three throwing events (shot, discus, hammer) who participated in the final of the Beijing Olympics in 2008. Variables that were taken in the analysis are those that define the anthropological space of competitors: *Body Height-cm, Body Mass-kg, Body Mass Index -kg/m² and Age.* In order to get relevant results on the basis of which one can get answers, basic statistical parameters were applied, and in terms of identifying the differences the analysis has been performed by using T-test for independent small samples.

Results and discussion

Athletic throwing events are acyclic motion (shot put and disc) and cyclic-acyclic motion (javelin and hammer throw) where the main goal is maximum throwing of device for as long as possible distance in accordance with the prescribed rules of the discipline (Jovović 2006; Čoh, 2002; Mihajlović, 2010; Smajlović, 2010; Raković & Stanković, 2011). If we would like to generally describe the pitchers then we could say the following: pitchers are of the large body height and corresponding large body mass. They possess absolute power that manifests itself during ejection of device when the larger mass of the pitcher acts on lower mass of device.

Table 1. Anthropological parameters of finalists

SHOT PUT	GOD	AVIS	AMAS	BMI
Christian Cantwell (SAD)	28	196	150	39,05
Tomaš Majewski (POL)	27	204	140	33,64
Ralf Bartles (GER)	30	186	125	36,13
Reess Hoffa (SAD)	31	182	133	40,15
Adam Nelson (SAD)	33	183	115	34,34
Pavel Lizhin (BLR)	27	189	110	30,79
Andrey Miknevič (BLR)	32	202	127	31,12
Miroslav Vodovnik (SLO)	31	197	160	41,23
DISCUS				
Gerd Kanter (EST)	29	196	125	32,55
Piotr Malachowski (POL)	25	192	122	33,15
Virgilijus Alekna (LAT)	36	200	130	32,50
Robert Harting (GER)	24	201	130	32,17
Jennifer F.Casanas (ESP)	30	184	101	29,81
Bogdan Pishchalnikov (RUS)	26	197	111	28,60
Rutger Smith (HOL)	27	197	130	33,50
Robert Fazekas (HUN)	33	193	114	30,64
HAMMER				
Primoz Kozmus (SLO)	29	188	112	31,72
Vladimir Devyatovsky (BLR)	31	192	115	31,25
Ivan Tsikhan (BLR)	32	186	110	31,88
Krisztian Pars (HUN)	26	188	113	32,01
Koji Murofushi (JAP)	34	187	96	27,50
Olli-Pekka Karjalainen (FIN)	28	194	120	31,91
Szyimon Ziolkowski (POL)	32	192	120	32,60
Libor Charfreitag (SLK)	31	191	115	31,59

Table 2 Differences between the discus throw (D) and shot put (SP)

	Mean		SD	t-value	p
Age	D	28,75	4,13	-,53	,608
	SP	29,63	2,26		
Body Height	D	195,00	5,40	,74	,474
	SP	192,38	8,53		
Body Mass	D	120,38	10,73	-1,71	,110
	SP	132,50	16,98		
BMI	D	31,62	1,74	-2,71	,017*
	SP	35,81	4,02		

(Mean-standard deviation, SD-standard deviation; t-value-test p-level of significance * Sig. /p <0.05/)

By the height and body mass leaders are the ball throwers and disc throwers in relation to pitchers, while for the hammer throwers it can be said that they are of less body height but larger body mass. It has been observed that a larger body weight is in those pitchers in which the device for throwing is of larger weight. Limbs are in most of pitchers long and with strong muscles (Pavlović, 2010; Idrizović, 2010). In addition to these observations, it is known that athletic throwing belongs to the group of ballistic movements where the throwing athletic devices are thrown into space in order to achieve the greatest possible range shots. Throws are initiated by explosive agonist muscle activation, followed by a period of their relaxation and ending with the period of deceleration by the action of the antagonist muscles or passive stretching of the connective tissue.

Table 3 Differences between the discus throw (D) and hammer throwers (H)

		Mean	SD	t-value	p
Age	D	28,75	4,13	-,95	,360
	H	30,38	2,56		
Body Height	D	195,00	5,40	2,43	,029*
	H	189,75	2,87		
Body Mass	D	120,38	10,73	1,67	,118
	H	112,63	7,60		
BMI	D	31,62	1,74	,37	,717
	H	31,31	1,59		

(Mean-standard deviation, SD-standard deviation; t-value-test p-level of significance * Sig. /p <0.05/)

Table 4 Differences between the shot put (SP) and hammer throwers (H)

		Mean	SD	t-value	p
Age	SP	29,88	2,30	-,41	,687
	H	30,38	2,56		
Body Height	SP	192,38	8,53	,82	,423
	H	189,75	2,87		
Body Mass	SP	132,50	16,98	3,02	,009**
	H	112,63	7,60		
BMI	SP	35,81	4,02	2,95	,011*
	H	31,31	1,59		

(Mean-standard deviation, SD-standard deviation; t-value-test p-level of significance * Sig. /p <0.05/; **Sig. /p<0.01/)

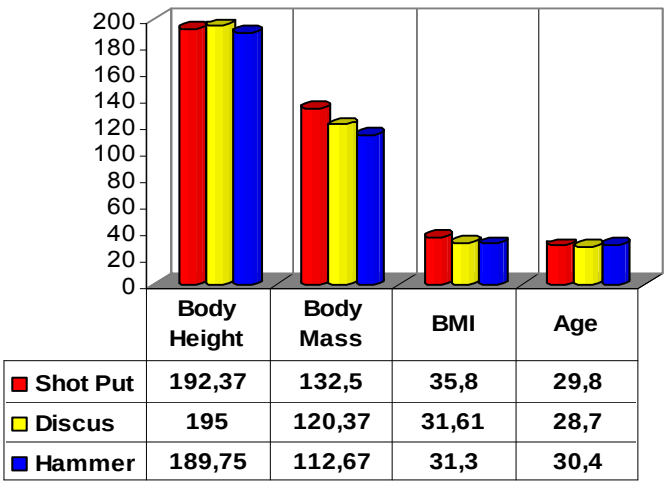

Figure 1. Mean values of anthropometric parameters

Most researchers who conducted research in the area of morphological characteristics (Morrow et al., 1982; Nelson et al., 1991; Wojtys & Huston, 1996; Rasmussen 2005 according to Idrizović, 2010) agree that pitchers have over other athletes a greater amount of muscle mass, and that by the classification of Sheldon they are closest to mesomorphic type (Milanović et al., 1986; Bowerman et al., 1998; Tončev, 2001; Čoh, 2001). Table 1 presents the parameters of athletes in each discipline individually. Tables 2-4 are the basic statistical parameters of the anthropological status of the study sample of athletes-throwers and the results of t-test. By the review and analysis of mean differences of defined segments of the human space observed are the differences between the thrower of disc and shot putter in all measured variables (Table 2). However, these differences are statistically significant only in the parameter BMI in favor of shot putters (Mean = 35.81), that is they had a higher average BMI at the level ($p < 0,05$). Also, larger values shot putters expressed in body mass (Mean = 132.50 kg) and age (Mean = 29.63 years). Only where the pitchers were dominant is body height (Mean = 195cm), but this difference was not statistically significant. It is known that in discus and shot put, in addition to motor skills significant influence has both body height and body weight (Nelson et al. 1991). However, based on these results it can be concluded that in the discus throw body height was significant, due to greater height at the time of ejection of device, in order for aerodynamic disc to have better elevation angle during the ejection. This achieves a better parabolic flight through the air, as opposed to the ball that has not an aerodynamic shape, and the result depends on the mass of pitcher that is conveyed and transmitted to the device (Bartlett, 1992; Alexander et al., 1996b).

It was exactly that what was confirmed on the basis of BMI values in favor of the ball throwers who had higher body mass in relation to body height. Shot put and disc throw has similarity in view of the performing of technique, primarily is related to the rotational motion around the vertical axis in the horizontal plane and the ejection parameters. Normally, in both cases, motor skills play an important, if not the leading role in achieving results. Ejection height and trajectory on which is acted upon the ball are primarily defined by genetic factors, particularly physical height and arm length. Therefore taller pitchers have an advantage over the lower-pitchers in biomechanical sense as well (Idrizović, 2010). Anthropometric measures have a very strong influence on the movement of the ball, which starts from the initial position and ends in its ejection, whose height ejection of ball in the top pitchers is in the range of 220-255cm (Bartlett, 1992; Lanka, 2000). By the analysis of mean differences in the variables of anthropological status obvious differences are also in all observed variables between the disc throwers and hammer throwers (Table 3).

But as in the previous case, the differences were statistically significant only in the parameter of height, in favor of the disc thrower (Mean = 195cm), that is they were on average taller than the hammer thrower (Mean = 189.75 cm) at the level of ($p < 0,05$). Also, greater values disc throwers expressed in body mass (Mean = 120.38 kg) and BMI (Mean = 31.62), unlike the hammer throwers with an average height of 189.75 cm and the average weight of 112.63 kg. Only the hammer throwers were on average older, with an average of 30.38 years, but this difference did not achieve statistical significance. Discus and hammer throwing as acyclic disciplines have similar rotational movement around the vertical axis, also in the horizontal plane. However, because of the much larger weight of the hammer, in phase of performing the turn, strong action of centrifugal force is felt, which increases the weight of device in each turn, trying to throw pitcher from his trajectory movement (Bartonietz et al., 1997). To prevent this hammer thrower makes compensatory movement, taking characteristic position of cover, and trying to move away his center of gravity from vertical axis that is passing between the pitchers body and device (Pavlović, 2010; Mihajlović, 2010).

In order to successfully perform that the pitcher opposes with the strength of the extensor muscle of the back and body weight. In this case the height of the body doesn't play an important role because of the stable support in the phase of turn, where the center of gravity of the body is on as much as possible shorter distance from the surface of the support, ensuring pitchers considerable stability. The most important factor of the length of shot is ejection velocity (Vo = 26-30m / s) and it is a factor that can be improved by pitcher's motion, if other, technical, morphological and physical factors have optimal values (McCoy et al., 1984, Knicker, 1999; Konz, 2006). By the review and analysis of mean differences of anthropological status of shot putters and hammer throwers the differences in all measured variables are observed (Table 4). In three of the four parameters, the differences are in favor of shot putters. They had higher values of body height (Mean = 192.38 cm), body weight (Mean = 132.50 kg) and BMI (Mean = 35.81). Even in two measures those differences achieved statistical significance and those are in the body weight at level ($p < 0.01$) and BMI at level ($p < 0.05$), as was expected. Only the hammer throwers, on average, had a greater number of years. Shot put and hammer throw are athletic disciplines that have common characteristics in terms of weight of device (7,257 kg), space for throw (2,135 m). Both disciplines report complex rotational movement around the vertical axis and overtaking of device in the horizontal plane. However, in the shot put is much more important the pitchers body weight with which the pitcher acts on the lower mass of ball and ejection height from which the ball is ejected. In the hammer throw the height of ejection is not as crucial (ejection height in Y. Sedykha was 166cm) as speed of turn which aims to report as much as possible action of centrifugal force which will manifest itself during the hammer ejection. Also the success of result in the shot put in addition to morphological features (Kyriazis et al., 2010) influence the power, with all its manifestations as well as speed of performing technique (Stojanović and Radić, 2003; Kyriazis et al., 2009; Pavlović, 2010). In some studies as an important factor of success in the shot put is the level of activation of certain muscle groups, before all m.quadriceps vastus lateralis, m.gastrocnemius internus, m.pectoralis major and triceps brachii (Tesch and Karlsson, 1985; Terzis et al., 2007), also ejection speed, angular displacement and momentum during ejections (Mayhew et al., 1993; Harasin, Milanović and Čoh, 2010). Differences in human space segments, among pitchers finalists Beijing Olympics 2008th are evident even if it is not achieved in all parameters statistically significant difference at level $p < 0.01$ and $p < 0.05$. However, the existing differences are still an indication of different anthropological dimensions of individual pitchers and their laws that are valid separately for each event (Figure 1).

Conclusion

Based on the obtained and presented results of research in human space of finalists in throwing events at the Beijing Olympics in 2008. it can be concluded that the pitchers in the three disciplines are of quite similar anthropological status. Differences that were recorded confirm previous findings about the possible similarities and differences in the throwing events. Of the total number of finalists pitchers (total of 24) differences in body height (AVIS), body weight (AMAS), Body Mass Index (BMI) and age (years) were recorded. However, in terms of statistical significance, it was confirmed only in four parameters at the level of ($p<0.05$) ($p<0,01$). Discus throwers and shot putters differ statistically significant in BMI values (0.017*), discus throwers and hammer throwers in body height (0.029*). The most statistically significant differences were recorded between the shot putters and hammer throwers in body weight (0.009**) and BMI values(0.011*). The results of this study can serve as a starting point and a realistic basis and framework for further research of this issue in athletic disciplines.

References

Amour, J., & Elliott, B. (1989,). Three dimensional cinematographic analvsis of throwing. *Paper presented at the International Biomechanics in Sports*, Melbourne, Australia, (pp. 205-217).

Alexander, M.J.L., Lindner, K.J., & Whalen, M. T. (1996a). Structural and biomechanical factors differentiating between male and female shot put athletes. *J Hum Move Studies*. *30*, 103-146.

Alexander, M. (1997). Comparison of biomechanical aspects of performance in male and female athletes. Ed. Wilkerson, Ludwig, & Zimmermann. *15 International Symposium on Biomehanics in Sport,* (pp. 25-44). Denton, Texas.

Bartlett, R.M. (1992). The biomechanics of the discus throw: a review. *J Swort Sci*. *10*, 467-510.

Bartonietz, K.E., Barclay, L., & Gathercole, D. (1997). Characteristics of top performances in the women's hammer throw: Basics and technique of the world's best athletes. *New Studies in Athletics*, *12*(2-3), 101-109.

Bowerman, W., Freeman, W., & Gambetta, A. (1998). *Atletika-Trening jačine i snage*. [Athletics-Training volume and strength, In Croatian]. Zagreb: Gopal.

Čoh. M. (2002). *Atletika* [Athletics. In Slovenian]. Ljubljana: Univerza v Ljubljani Fakulteta za šport.

Huston, L.J., & Wojtys, E.M. (1996). Neuromuscular performance characteristics in elite female athletes. *Am J Sports Med*, *24*(4), 427-436.

Jovović, V. (2006). *Atletika biomehanika-tehnika i metodika* [Athletics-biomechanics techniques and method. In Serbian]. Nikšić: Filozofski fakultet.

Knicker, A. (1999). Biomechanical Analysis of the Throwing Events-Discus Throw. *Biomechanical Research Project Athens*, (pp.161-174).

Konz, S,M. (2006). Technique and performance level comparsions of male and female hammer throwers. /*Doctoral Dissertation*/. Brigham: Brigham Young University.

Kyriazis, T.A., Terzis, G., Boudolos, K., & Georgiadis, G. (2009). Muscular Power, Neuromuscular Activation, and Performance in Shot Put Athletes At Preseason and at Competition Period. *Journal of Strength & Conditioning Research*, *23*(6), 1773-1779.

Kyriazis, T., Terzis, G., Karampatsos, G., Kavouras, S., & Georgiadis, G. (2010). Body composition and performance in shot put athletes at preseason and at competition. *Int J Sports Physiol Perform*, *5*(3), 417-421.

Harasin, D., Milanović, D., & Čoh, M. (2010). 3D kinematics of the swing arm in the second double-support phase of rotational shot put – elite vs sub-elite athletes. *Kinesiology,* 42(2), 169-174.

Harasin, D., & Milanović, D. (2005). Differences between the best Olympic results and the World's best results achieved in the Olympic years in throwing events in athletics. *Kinesiologia Slovenica, 11*(1), 31-42.

Linthorne, N.P. (2001). Optimum relese angle in shot-put. *Journal of Sports Science*, *19*, 359-372.

Lanka, J. (2000). Shot-putting. In: *Biomechanics in Sport (ed.Vladimir Zatsiorsky).* NY: Blackwell Science Ltd. (pp. 435-457).

McCoy, R.W., Gregor, R.J., Whiting, W.C., Rich, R.G., & Ward, P.E. (1984). Kinematic analysis of elite shot putters. *Track Technique*, *90*, 2868-2872.

McCoy, R.W., Gregor, R.J., Whiting, W.C., Rich, R.G., & Ward, P.E. (1985). Kinematic analysis of discus throwers. *Track Technique*, *91*, 2902-2905.

Morrow, J.R., Disch, J.G., Ward, P.E., Donovan, T.J., & Katch, V.L. (1982). Anthropometric, strength and performance characteristics of American world class throwers. *Journal of Sport Medicine and Physical Fitness*, *22*(1), 73-79.

Milanović, D., Hofman, E., Puhanić, V., & Šnajder, V. (1986). *Atletika-znanstvene osnove* [Athletics-scientific basis. In Croatian.]. Zagreb: Fakultet za fizičku kulturu.

Mihajlović, I. (2010). *Atletika* [Athletics. In Serbian.]. Novi Sad: Fakultet sporta i fizičkog vaspitanja.

Nelson, K.R., Thomas, J.R., & Nelson, J.K. (1991). Longitudinal change in throwing performance: gender differences. *Res Ouart Exerc Sport*, *62*, 105-108.

Pavlović, R. (2010a). *Atletika* [Athletics. In Serbian.]. East Sarajevo: Fakultet fizičkog vaspitanja i sporta.

Pavlović, R. (2010). Motoričke sposobnosti kao faktori uspjeha u atletici [Motor skills as factors of success in athletics. In Serbian.]. *Sport i zdravlje, 5*(2)*,* 96-103.

Pavlović, R., Radinović, Z., & Janković, M. (2012). The morphological status of the finalist in throwers disciplines at the Beijing Olympics. *Sport mont, 10*(34-36), 447-455.

Stanković, D., & Raković, A. (2011). *Atletika* [Athletisc. In Serbain.]. Niš: Faculty of sports and P.E.

Stefanović, Đ. (1992). *Atletika 2-tehnika* [Athletics 2-tehniques. In Serbian.]. Beograd: SIA.

Smajlović, N (2010). *Atletika* [Athletics. In Bosnian.]. Sarajevo: Fakultet sporta i tjelesnog odgoja.

Tesch, P.A., & Karlsson, J. (1985). Muscle fiber types and size in trained and untrained muscles of elite athletes. *Journal of Applied Physiology, 59*(6), 1716-1720.

Terzis, G., Karampatsos, G., & Georgiadis, G. (2007). Neuromuscular control and performance in shot-put athletes. *Journal of Sports Medicine and Physical Fitness*, *47*(3), 284-290.

Tončev, I. (2001). *Atletika tehnika i obučavanje* [Athletics-techniques and training. In Serbian.]. Novi Sad: FFK-e.

Idrizović, K. (2010). *Atletika I i II*. [Athletics I and II. In Serbian.]. Podgorica: Univerzitetska riječ.

*** (2013). http://www.iaaf.org/statistics/toplists/index.html.

*** (2013). http:/www. iaaf.org- Home of World Athletics.

RAZLIKE U MORFOLOŠKOM PROSTORU BACAČA FINALISTA NA OLIMPIJSKIM IGRAMA U BEIJINGU

Sažetak

Morfološki prostor je jako važan i to prije svega u selekciji, pripremi i postizanju rezultata u sportu. Ovo je posebno značajno u profesionalnom sportu gdje se očekuju posebni rezultati. U ovisnosti o sportu, tj. o sportskoj discipline, također ovisi i o sudjelovanju i utjecaju prostora čovjeka ili njegovih segmenata, na konačni rezultat. Kad se opisuje i definira specifična populacija sportaša i njihov morfološki status, najčešći zajednički parametri koji se uzimaju su visina, težina, indeks tjelesne mase, a često i uzrast ispitanika. Ovi parametric su dosta realni i daju istinitu sliku morfološkog prostora istraživane piopulacije. Ovaj članak bavi se razlikama u segment humanog prostora bacača, finalist na Olimpijskim igrama u Beijingu. Uzorak je uključivao 24 natjecatelja u tri discipline (kugla, disk, kladivo). Analizirane su razlike u visini tijela, težini, BMi indeksu i uzrastu. Za analizu podataka primjenjen je t-test za male nezavisne uzorke koji potvrđuje prisustvo statistički značajnih razlika među bacačima. Bacači diska i kugle značajno se razlikuju u vriejdnosti BMI indeksa ($p<0.05$), a bacači diska i kladiva u visini tijela ($p<0.05$). Statistički najznačajnije razlike su zabilježene između bacača kugle i kladiva u težini ($p<0.01$) i vrijednosti BMI indeksa ($p<0.05$).

Ključne riječi: *morfološki status, bacačke discipline, razlike, Olimpijske igre*

Received: September 11, 2013
Accepted: December 20, 2013
Correspondence to:
Assoc.Prof.Ratko Pavlović, Ph.D.
University East Sarajevo
Faculty of Physical Education and Sport
Stambulčić bb, 71420 Pale, RS – Bosnia & Herzegovina
Phone: +389 2311 3654
E-mail: pavlovicratko@yahoo.com