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ATHLETIC DECATHLON: ARE THERE DIFFERENCES BETWEEN THE RESULTS OF DECATHLON RECORD-HOLDERS AND THEIR BEST PERSONAL RESULTS?

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ABSTRACT

Athletic decathlon is psychophysically very challenging athletic competition that takes place over two consecutive days. Decathlon athletes are usually said to be the most dexterous and versatile athletes because they have to be good in all disciplines. It is the only competition where the athlete is struggling with themselves, as all disciplines are scored, and the winner is the one who has the most points (Pts) after the last discipline. This survey included five top 10 decathlon world record holders for the period from 1984 to 2016 and their results. Those five athletes are- Daley Thompson, Dan O'Brien, Thomas Dvorak, Roman Sebrle, and Ashton Eaton. The main objective of the research was to analyze and determine the differences between the results of the record results in the decathlon and their best personal results. A t-test for small independent samples was applied to obtain the necessary information. The results obtained confirmed statistically significant differences in 50% of the disciplines for both levels of significance. Differences were evident in disciplines like - high jump (t=-4,440; p<0.011), 110m hurdles (t=-3,769; p<0,020), discus (t=-3,958; p<0.017), pole vault (t=-4,706; p<0.009) and 1500m (t=-2,903; p<0.044). On the basis of the point distribution, the so-called dominance is noticeable in the so called motor disciplines versus technical and power disciplines.
***Keywords:** Athletic decathlon, technical mastery, motor skills, differences.*

1. INTRODUCTION

Even in ancient times, at the 18th Olympic Games in the year of 708 AD, the ancient Greeks sought to express their skills by introducing an ancient pentathlon. This pentathlon contained a total of five disciplines (one-stage running, long jump, discus, javelin, wrestling). After more than a millennium, now as far back as the year of 1885, American athletes founded and modeled the All Around Championship on the ancient pentathlon, where competitions in several disciplines were held within five hours. As early as 1904, at the modern Olympic Games in St. Louis, multi-athlon competitions in the form of pentathlon and decathlon were introduced into the program of the games.

Today's modern decathlon is formed out of the need to allow athletes to express themselves in multiple disciplines and thus find their place in athletic disciplines (Pavlović, 2013). Decathlon disciplines are psychologically and physically the most difficult disciplines, where the competition of athletes is often the strongest and where the maximum of human capabilities and abilities is demonstrated within two days. Decathlon athletes are usually said

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to be the most versatile and competent athletes because they must be good runners (100m, 400m, 110 hurdles, 1500m), jumpers (long jump, high jump, pole vault) and throwers (discus, shot-put, javelin), which Aristotle had argued much earlier (Pavlović, Pupiš, Simeonov, Borovčanin, & Curović, 2016).

According to athletic rules, there are 20-30 male competitors in decathlon, and the winner is the competitor who has the most cumulative points after the last discipline. Competitions are conducted in a specific order in two days. The interval between the completion of one discipline and the start of the next one shall not be less than 30 minutes for each individual competitor. Where possible, the distance between the completion of the last discipline on the first day and the start of the first discipline on the second day of the competition should not be less than 10 hours. The performance of each discipline is scored according to the IAAF scoring system. Decathlon is often divided into the racing, jumping and throwing categories of disciplines and decathlon competitors are classified as sprint or jumping-throwing type (Kenny, Sprevak, Sharp, & Boreham, 2005).

Some authors find that the current scoring method favors athletes who are specialists in racing disciplines (Cox & Dun, 2002; Wimmer, Fenske, Pyrka, & Fahrmeir, 2011). However, regardless of the type of decathlon competitor type, the fact is that all of them must have good performance, endurance and good mental energy (Pavlović & Idrizović, 2017). It is the only competition where it does not matter whether the athlete is first, second or last in the discipline, because only the total number of points is important, and each athlete competes against his or her own capabilities and standards. They all seek to improve their personal performance in those disciplines where they fall behind either by personal or general criteria. It can be said that decathlon athletes represent a compromise of the different types of athletes in the field, because only rare ones show excellent performance in all ten disciplines.

There is often talk about different types of decathlon athletes (type of runner or type of jumper, combined type of runner-jumper and combined type of runner-thrower). Although such terms are used in terms of training or competition, there is no accurate way of identifying the types of abilities for decathlon (Pavlović et al. 2016). Comparative analysis of five world records has revealed that disciplines with results which are more dependent on technical efficiency than basic motor skills are a key factor in top scores in decathlon (Bilić, Smajlović, & Balić, 2015) where speed, power and explosive power are vital, so the long-term planning of a combination of disciplines involves technique planning and refinement of strength, which would lead to some new model of decathlon competitors (Mandarić & Mandarić, 2016; Pavlović & Idrizović, 2017).

Decathlon and heptathlon were the subject of some statistical analysis that sought to define athletes' models, structures, and interconnections across disciplines, which would allow for easier selection of developmental training strategies to optimize the training process (Dawkins et al. 1994; Kenny et al. 2005). Since the decathlon is structured from three large groups of disciplines, the analysis of the results which were over 8000 points (period from 1966 to 2002) differentiated between several decathlon models and mainly models of the throwing type, jumping-racing type, jumping type, jumping type-throwing type (Cox & Dunn, 2002; Kenny et al., 2005).

The results of the study (Woolf, Ansley, & Bidgood, 2007), based on the results from 1986 to 2005 in athletic disciplines, in the first cluster confirmed sprint and long jump athletes, in the second cluster jump, pole vault, third cluster throwing disciplines, while 1500m is isolated as a racing stand-alone cluster (endurance factor). In this regard, Bilić (2015) considers that the key success factors in the decathlon are the technical efficiency and the efficiency of manifesting energy capacity and aerobic-anaerobic components (e.g. 1500m), which means that without explicit dominance of the sprinter disciplines (100, 110 hurdles, 400m) the result cannot be achieved at decathlon record levels (Fan, 2014; Gassmann et al., 2016). Pavlović, & Idrizović (2017) analyzed ten decathlon world record holders (from

1984 to 2016) with the aim of defining the factor structure. Factor analysis confirmed the existence of three factors (types of athletes) with a total of about 75% of the common variance system extracted. The first factor is defined as the type of "jumper-runner-runner", athlete the second factor as "runner-sprinter", and the third factor is the type of 'jumper" The results obtained support the previous statements, as they depict a combination of different types of athletes integrated into three different and partially independent factors (Mihajlović, 2010; Pavlović, 2014, 2017).

A study by Cox and Dunn (2002) confirmed that for decathlon participants, discus along with all throws always constituted one factor, and racing disciplines (except 1500m) integrated into a separate factor, identifying 3-cluster groups of decathlon disciplines. These groups were not defined by the three characteristics of running, jumping and throwing, although no explanation was proposed to allow rational grouping. Grouping disciplines within decathlon can, above all, have practical implications in terms of the benefits of athletes who are relatively better in disciplines in one cluster than those in another cluster, and decathlon data can be modeled as multivariate data, and cluster analysis can be used to identify and analyze groups that may exist across disciplines (Pavlović, 2017).

According to Wang and Lu (2007), key factors in the selection of decathlon competitors are body morphology, age, physical quality, high-load training and an emphasis on late-stage strength and technique. According to Pavlović (2013), there are a number of specific movements that enable the active integration of the elements of versatile competition and transformation into a single structure, which is one of the main characteristics of the training process, where on the basis of the so-called latent dimension (factor) would provide a pretty clear explanation of all ten disciplines.

Zatsiorsky and Godik (1962) performed a factor analysis (centroid method) of the performance of decathlon athletes who participated in the 1960 Olympics in order to determine the limited number of latent factors (motor skills) that define success in the decathlon and, as a consequence, to assist coaches and athletes in designing optimal training programs and its transfer. Individual disciplines as well as overall performance were analyzed (in the points awarded). The factor loadings of the first factor were the highest for the overall performance of the decathlon.

For individual disciplines, the workloads were almost identical to the magnitudes of their correlation coefficients with the total participation in the decathlon, so the factor was identified as "general level of athletic mastery" and therefore the intention of the research was not fully realized. Also, Park, & Zaciorski, (2011) analyzed the performance of athletes who competed in the 1988-2008 Olympic Games, where in the decathlon analysis, the first three major components explained 70% of the total variance. In the first major component (with 43.1% of the variance) it was extracted as a "sprinter performance" factor. The loadings of the second factor (15.3% of the variance) represented a combination of throws and jumps, and the third factor with 11.6% of the variance, was discipline 1500m.

Pavlović, Bonacin, and Radulović (2016), by factor analysis of athletic disciplines, defined a decathlon type of physical education and sports students, extracting two types (jumping type and throwing type), which confirmed the partial dominance of technical disciplines, which is consistent with results of some research (Bilić, Smajlović, & Balić, 2015).

From the foregoing it can be inferred that research on decathlon was mainly based on defining factors, clusters of disciplines, defining sports types in decathlon, and the participation of certain anthropological dimensions in performance. However, there has been no major research that has analyzed and studied the possible differences between the decathlon competitors' performance success, i.e. the best scores of decathlon record holders with their best personal results. Thus, this study was conducted with the main aim to research,

analyze and determine the possible differences between the results of the five top decathlon world record holders (from 1984 to 2016) and their best personal results.

2. METHODS AND MATERIALS

The research included a sample of five best decathlon athletes of all-time, starting from 1984 to 2016. Those five best athletes are: Ashton Eaton (USA), Roman Sebrle (CZE), Tomas Dvorak (CZE), Dan O'Brien (USA), and Daley Thompson (GBR). All results of the disciplines and the number of points in the decathlon are obtained from the IAAF official website. Basic central and dispersion parameters were calculated, and a t-test was observed to determine the difference between competitors.

Table 1: Decathlon records and the best personal result

	Decathlon records									
	Daley Thompson (born 30.07.1958)		**Dan O'Brayan** (born 18.07. 1966)		**Tomaš Dvoržak** (born 11.5.1972)		**Roman Šebrle** (born 26.11.1974)		**Ashton Eaton** (born 21.1.1988)	
	8-9.08. 84 LA		4-5.09.92 Talin		4.07.99 Prag		26-7.5.01. Gecis		28-29.08.15 Beijing	
Disciplines	Result	Pts	Result	Pts	Results	Pts	Result	Pts	Result	Pts
100m	10,44	989	10,43	992	10,54	966	10,64	942	10,23	1040
Long Jump	8,01	1063	8,08	1081	7,90	1035	8,11	1088	7,88	1030
Shot Put	15,72	834	16,69	894	16,78	899	15,43	816	14,52	760
High Jump	2,03	831	2,07	868	2,04	840	2,12	914	2,01	813
400m	46,97	960	48,51	885	48,08	905	47,79	918	45,00	1060
110m	14,33	932	13,98	977	13,73	1010	13,92	985	13,69	1015
Discus throw	46,56	799	48,56	840	48,33	836	47,92	826	43,34	733
Pole vault	5,00	910	5,00	910	4,90	880	4,80	849	5,20	972
Javelin throw	65,24	817	62,58	777	72,32	925	70,16	891	63,63	793
1500m	4:35,00	712	4:42,10	667	4:37,20	698	4:21,98	797	4:17,52	829
Total Points	**8847**		**8891**		**8894**		**9026**		**9045**	
	Best personal result									
	Daley Thompson		**Dan O'Brayan**		**Tomaš Dvoržak**		**Roman Šebrle**		**Ashton Eaton**	
Disciplines	Result	Pts	Result	Pts	Results	Pts	Result	Pts	Result	Pts
100m	10,26	1032	10,23	1040	10,54	966	10,64	942	10,21	1044
Long Jump	8,01	1063	8,08	1081	8,07	1079	8,11	1089	8,23	1120
Shot Put	15,73	835	16,69	894	16,88	906	16,47	880	15,40	814
High Jump	2,11	906	2,20	992	2,09	887	2,15	944	2,11	906
400m	46,86	965	46,53	982	47,56	931	47,76	921	45,00	1060
110m	14,04	969	13,47	1044	13,61	1025	13,79	1002	13,35	1060
Discus throw	47,62	821	52,71	927	50,28	876	49,46	859	47,36	816
Pole vault	5,25	988	5,20	972	5,00	910	5,20	972	5,40	1035
Javelin throw	65,38	819	66,90	842	72,32	925	71,18	907	66,64	838
1500m	4,23:71	786	4,36:53	702	4:27,63	760	4,21:98	798	4,14:48	850
Total Pts	**9184**		**9476**		**9265**		**9314**		**9543**	

3. RESULTS

Table 2 presents the descriptive statistics of the decathlon record holders and their best personal results. Based on the projections of the numerical values of the central and dispersion parameters, it can be concluded that the distribution of the results is within the normal distribution. When it comes to the average points of five world record players, in the decathlon (see Figure 1), the highest number of points is in long jump (1059.40pts), then in the 100m (985.80pts), hurdles 110mH (983.80pts), 400m (945.60pts), …., and at the back, with the lowest average points in the discipline, run 1500m (740.60pts). These values are an indicator that aerobic endurance was the weakest link among all five players in the overall scoring. Also, the analysis of maximum points reflects a nearly identical order of disciplines in the result (see Figure 3). Discipline long jump dominates with maximum number of points (1088pts), after that is hurdles 100m (1040pts), 400m (1060pts), hurdles 110mH (1015pts) and the last discipline is 1500m (829pts), a typical discipline of aerobic endurance. It can be concluded that there is a noticeable dominance of racing disciplines of anaerobic potential

(100m, 400m, 110mH) as opposed to the so-called technical (high jump, javelin, pole vault), and strong disciplines (shot-put, discus).

Table 2: Descriptive statistic all results decathlon men

Decathlon Results									
	Mean		Min.	Max.	Range	Std.Dev.	Skew.	Kurt.	CV%
100m	10,46	985,80	942	1040	98	36,39	,59	,89	3,69
Long Jump	7,99	1059,40	1030	1088	58	26,25	-,15	-2,77	2,47
Shot Put	15,83	840,60	760	899	139	57,89	-,40	-1,06	6,88
High Jump	2,05	853,20	813	914	101	39,37	1,02	,64	4,61
400m	47,27	945,60	885	1060	175	69,60	1,47	2,02	7,36
110mH	13,93	983,80	932	1015	83	33,13	-1,04	,94	3,37
Discus Throw	46,74	806,80	733	840	107	44,25	-1,61	2,35	5,48
Pole Vault	4,98	904,20	849	972	123	45,54	,57	,94	5,04
Javelin Throw	66,78	840,60	777	925	148	64,29	,55	-2,22	7,45
1500m	4:30,76	740,60	667	829	162	69,00	,47	-2,24	9,32
Best Results									**Total: 5,56**
	Mean		**Min.**	**Max.**	**Range**	**Std.Dev.**	**Skew.**	**Kurt.**	**CV% 4,70**
100m	10,38	1004,80	942	1044	102	47,34	-,72	-2,46	4,71
Long Jump	8,10	1086,40	1063	1120	57	21,02	1,10	2,11	1,93
Shot Put	16,23	865,80	814	906	92	39,51	-,53	-2,16	4,56
High Jump	2,13	927,00	887	992	105	41,82	1,12	,53	4,51
400m	37,83	971,80	921	1060	139	55,17	1,21	1,44	5,67
110mH	13,65	1020,00	969	1060	91	35,80	-,55	-,57	3,51
Discus Throw	49,49	859,80	816	927	111	45,28	,74	-,15	5,26
Pole Vault	5,21	975,40	910	1035	125	44,75	-,31	1,64	4,58
Javelin Throw	68,48	866,20	819	925	106	46,72	,53	-2,58	5,39
1500m	4:24,86	779,20	702	850	148	54,18	-,28	,84	6,95
									Total: 4,70

Abbreviation: Mean (average value), standard deviation (St.Dev), coefficient of variation (CV%)

The long jump is more of a motor than a technical discipline because the result is more subordinate to the speed of take off than to the technique of reflection, where the ratio of horizontal and vertical components is 2:1. This is especially evident in decathletes, so the long jump can be more integrated in racing than in technical disciplines. Also, the average scores of the top ten personal best scores are in the same order as they were when they reached the world record (see Figure 1). Long jump is first from the average (1086.40pts), followed by 100m (1004.80pts), 110mH (1020pts), 400m (971, 80pts), pole vault (975.40pts), and again at the frontend is running 1500m with the lowest number of points (779.20pts). As in the previous case, this discipline is an indicator of the lower aerobic endurance of the decathletes and is again the weakest link in the chain of the decathlon discipline. The maximum score provides a linear distribution identical to the average scores (see Figure 3). Long jump is the leading discipline with maximum points scored (1120pts), followed by 100m (1044pts), 400m and 110mH (1060pts) and 1500m (850pts). Here again it can be concluded that the dominance of racing disciplines is anaerobic potential (100m, 400m, 110mH, long jump), as opposed to the so-called technical and strength disciplines.

By inspection of Table 2, the analysis of results achieved in the athletic decathlon shows considerable homogeneity between disciplines where CV% ranges from 2.47% (long jump) to 9.32% (1500m). An analysis of the best personal results reflects even greater homogeneity across disciplines. Also, almost identical to the previous numerical parameters and in the best personal results, the greatest homogeneity of the results is recorded by the long jump (CV%=1.93) and the smallest in running 1500m (CV%=6.95) (see Table 2). Comparing cumulatively, of these two groups of results, greater homogeneity was observed in the personal scores of decathletes (CV%=4.70) than in the scores at the time of breaking the world records (CV%=5.56) (see Table 2).

Table 3: Differences of kinematic parameters finalists' men

Disciplines	Mean		Std.Dv.	Diff.	t	p<Sig. (2-tailed)
	Result	Pts				
100m (DR)	10,46	985,80	36,39	-19,00	-1,748	,155
100m (BR)	10,38	1004,80	47,34			
Long Jump (DR)	7,99	1059,40	26,25	-27,00	-1,510	,205
Long Jump (BR)	8,10	1086,40	21,02			
Shot Put (DR)	15,83	840,60	57,89	-25,20	-1,808	,145
Shot Put (BR)	16,23	865,80	39,51			
High Jump (DR)	2,05	853,20	39,37	-73,80	-4,440	,011*
High Jump (BR)	2,13	927,00	41,82			
400m (DR)	47,27	945,60	69,60	-26,20	-1,433	,225
400m (BR)	37,83	971,80	55,17			
110 Hurdles (DR)	13,93	983,80	33,13	-36,20	-3,769	,020*
110 Hurdles (BR)	13,65	1020,00	35,80			
Discus Throw (DR)	46,74	806,80	44,25	-53,00	-3,958	,017*
Discus Throw (BR)	49,49	859,80	45,28			
Pole Vault (DR)	4,98	904,20	45,54	-71,20	-4,706	,009**
Pole Vault (BR)	5,21	975,40	44,75			
Javelin Throw (DR)	66,78	840,60	64,29	-25,60	-2,013	,114
Javelin Throw (BR)	68,48	866,20	46,72			
1500m (DR)	4:30,76	740,60	69,00	-38,60	-2,903	,044*
1500m (BR)	4:24,86	779,20	54,18			

Abbreviation: DR - decathlon results; BR - best results; Mean (average value), standard deviation (St.Dev), coefficient of t-test value (T-value), significance level p (Sig. * p<0,05; Sig. **p<0,01)

Readings of the Table 3 shows that statistically significant differences were observed in the disciplines: high jump (t=-4,440; p<0.011), 110m hurdles (t=-3,769; p<0,020), discus (t=-3,958; p<0.017), pole vault (t=-4,706; p<0.009) and disciplines 1500m (t=-2,903; p<0.044); whereas no significant difference observed amongst the remaining disciplines of decathlon.

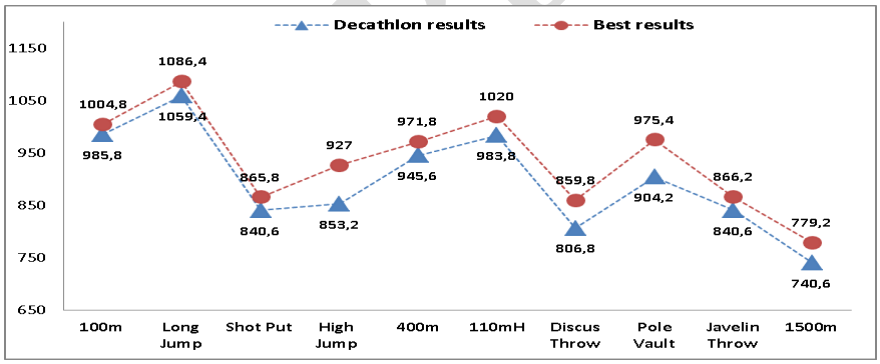

Figure 1: The frequency of athletes' average value

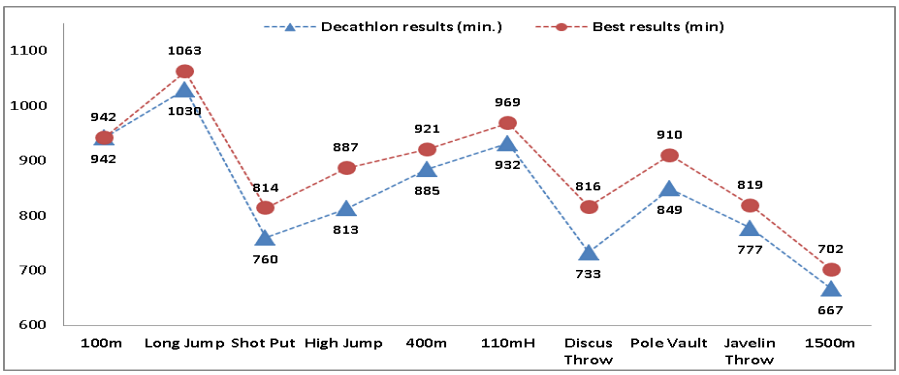

Figure 2: The frequency of athletes' minimum value

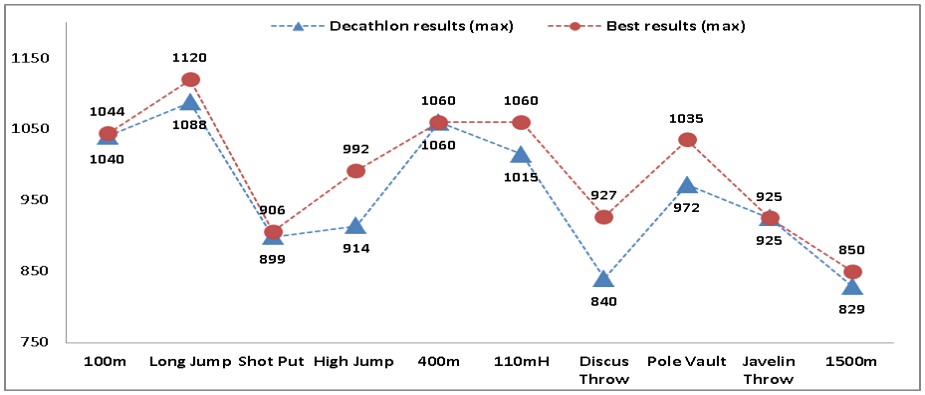

Figure 3: The frequency of athletes' maximum value

4. DISCUSSION

The current research has been carried out with the aim of identifying possible differences between the results of the record players achieved in the decathlon and their best personal results. The obtained results unambiguously confirmed the presence of significant differences according to the set criterion in all disciplines of decathlon, and in five disciplines (50%) the statistically significant differences of results were confirmed. Based on the results obtained, it is evident that the decathletes achieved on average lower scores (fewer points) at the time of reaching the world record than their best personal results. Statistically significant differences were observed in the disciplines like high jump, 110m hurdles, discus, pole-vault and 1500m. It is an indisputable fact that the differences are present in all three categories of disciplines (racing, jumping, and throwing) and in the so-called technical and motor disciplines. The results of the research confirmed that competing in disciplines separated from decathlon has advantages, in terms of better physical condition, better psycho-physical recovery, mental energy of the competitors, because nonetheless, a competition like decathlon that takes place in two consecutive days seriously draws physical, physiological and mental potentials of the athlete, and thus their results are slightly weaker than other competitions, which are not tied to the decathlon. It is evident that the modern decathlon requires uniformity in all disciplines, and it is an indisputable fact that a decathlon competitor does not have to be outstanding in any part of the competition to be a champion in all ten, but must be good in disciplines where one is weaker and excel in disciplines that are their specialty (Pavlović, et al. 2016). Since they have to be good in three races, three jumps, three throws and one endurance discipline, there is not much room to perfect just one discipline. Therefore, the decathlon contestants must compromise, and that is the very nature of the decathlon (Tidow, 2000).

Detecting the best profile of a decathlete with respect to the world-class performance level makes it possible to evaluate the matching of the most promising structures to reach the maximum potential in a decathlete. The decathlon space is characterized by a very wide range of disciplines and structures, the relationship between the presence of the versatile types of the very talented decathletes (Stemmler & Baumler, 2005), which is closely related to the study of the necessary conditions for full expression of the decathlon potential, based on a comparative analysis of the structure of the decathlon disciplines (Smajlović, 2000). In terms of saturation of motor skills, speed and power are vital in the decathlon, so requirements for mobility, skill, speed and explosive power of competitors prevail. Nowadays, the most commonly used is a combined system that involves practicing certain disciplines one after the other, at the same time perfecting all disciplines with an emphasis on exercises that are best suited for decathletes, depending on the mental and physical quality of the athletes, the health of individuals, the career period, the annual cycles. All competitors need to have a

consistently developed morphological-motor-functional space that is highly integrated into cognitive-conative potentials and will ensure that high competitive outcomes are achieved. The training of new disciplines involves the formation of new functional-motor structures that will enable the best possible way to achieve success, which is why decathletes always try to improve their results in those disciplines where they fall behind (Pavlović & Idrizović, 2017). Therefore, it is important to note that the process of training of decathletes is very demanding and during the 20th century it has undergone a major change, which is related to the overall methodology. Nowadays, the most commonly used is a combined system that involves the exercise of particular disciplines one after the other, while simultaneously educating all disciplines with an emphasis on exercises that are most appropriate for a decathlete. However, it depends on the mental and physical quality of the athletes, the health status of individuals, the period of their sports careers, the period of the annual cycle (Pavlović et al. 2016). What is very important in the coaching process is their process of transitioning from one discipline to another, which is a very complex task, when during this process dynamic stereotypes formed by training and practicing the previous discipline are initially suppressed. Today, better results in sprinting, long jump, pole vault can be observed, so that in the future we can expect progress in the decathlon, but also an opportunity to differentiate the new model in the decathlon (Mandarić & Mandarić, 2016), which the results of this research also confirm to some extent.

5. CONCLUSION

Based on the results of the research, it can be concluded that the differences between the results of the decathlon world record holders and their best achieved personal results are evident in 50% of disciplines with high statistical significance; high jump (t=-4,440; p<0,011), 110m hurdles (t=-3,769; p<0,020), discus (t=-3,958; p<0.017), pole vault (t=-4,706; p<0.009) and 1500m (t=-2.903; p<0.044). On the basis of the point distribution, the so-called dominance is noticeable in motor disciplines versus technical and powerful disciplines. These differences are compounded by the two-day decathlon program, which from the aspect of recovery is extremely difficult, the psycho-physical preparation of the competitors, the mental strength and some technical characteristics of the disciplines. Based on the 1500m discipline score, it was concluded that aerobic endurance was the weakest link in the decathlon space. It can be concluded that the decathlon training process should focus on improving performance in those disciplines where there are lower scores with an emphasis on aerobic endurance.

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