FACTOR ANALYSIS OF WORLD RECORD HOLDERS IN ATHLETIC DECATHLON

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Abstract

All-around competition is the only competition in which it does not matter whether the athlete is the first, the second or the last in a discipline. What matters is the total number of points, and a rounder competes against his/her personal capabilities and standards. Athletic all-around competitions are a series of consecutive athletic competitions divided in two days. Success is calculated by the sum score of all disciplines that are pointed due to the international athletic tables. The research included ten (10) is currently the world's best decathlete of all time until 2016. Aim of research was to carry out a factor analysis of the athletic decathlon world record holder in order to define factors (latent dimensions) that would determine the type of decathlon, or the so participation technical or motor discipline overall. Applying factor analysis in a defined area is extracted with a total of three factors explained about 75% of the common variance of. The first factor has exhausted 35.24% (pole vault, high jump, discus throw, 400m) and a set of common variance is defined as a type of jumper-thrower-runner. The second factor has exhausted 22.21% (100m; 110m hurdle) analyzed set and is defined as runners (sprinters) type athletes. The third factor has exhausted about 17% (long jump, 1500m) and is defined by a type of jumper-runner.

Key words: *decathlon, factors, athletic typology.*

Introduction

Decathlon is a competition which is held over two consecutive days and consists of ten track and field events. Usually around 20 to 30 male athletes participate at one competition. The winner is the athlete with the most cumulated points after the last event. The events are always tested in the following order: Day 1: 100m race, long jump, shot put, high jump, 400m race; Day 2: 110m hurdles, discus, pole vault, javelin, 1500m race. The procedure of measuring the performance depends on the event: For the track events, e.g., 100m, 400m, 110m hurdles, and 1500m, each athlete has one attempt in order to obtain a valid time. The remaining field events are further divided into two groups: In long jump, shot put, discus, and javelin, every athlete has three attempts and his best result in each discipline will be taken for the later scoring. In high jump and pole vault, each athlete tries to jump over a horizontal bar. If he succeeds, the bar will be raised by 3 and 10 centimeters, respectively. If he fails, the bar remains at the same height for the next try. After three consecutive misses an athlete will be eliminated and his best height will be taken for the later scoring. If an athlete does not manage to achieve a valid result in an event, he gains zero points in this event but is allowed to continue the decathlon. The performance of each event is converted into a points system developed by the International Association of Athletics Federations (IAAF) Woolf, Ansley, & Bidgood (2007). The principle of the scoring system is an attempt to reward performances of equal merit across the different disciplines with equal points. Simplistically the disciplines that make up the decathlon could be considered as providing three broad categories for grouping the disciplines: running (100m, 110mH, 400m and 1500m); jumping (LJ, HJ, PV); and throwing (SP, JT, DT). However, these categories are unlikely to represent the groupings based upon participants' performance in the disciplines; and indeed anecdotally decathletes are frequently classified by speed and skill levels as either a sprinter/jumper or a thrower/pole vaulter (Kenny, Sprevak, Sharp, & Boreham, 2005). Since 2001, the points have been calculated according to the IAAF. For each of the ten events the resulting points are rounded to zero decimal places. Theoretically, this points system should lead to an equal weighting of all ten track and field events. However, after an empirical analysis Cox, & Dun (2002) arrive at the conclusion that the current points system favors those athletes who do well at the field events (Wimmer, Fenske, Pyrka, & Fahrmeir (2011). Altogether, decathlon is a combination of ten track and field events which measure sprint, jumping, throwing and technical abilities of the athletes, as well as their endurance and mental strength. Thus, it is a complex task to investigate fundamental determinants of decathlon performance (Idrizović, 2010; Pavlović, 2013). Speed and strength (power) are of vital importance, and so it seems reasonable to conclude that successful combined event athletes must be fast and strong. The predominant requirements of the decathlete are mobility, skill, speed and explosive strength. The long term planning of combined events includes the planning of technique and strength conditioning. This concept is true for athletes of all ages - whereby technique is dovetailed with conditioning, but to varying degrees depending on ages.

For younger athletes (13 to 15) during the years of early training, athletes should work on the simple disciplines, ones that are more 'natural' to learn, such as sprinting, hurdling, long jump and high jump. Later training (15 to 18 years) should include more complex events such as shot, javelin and pole vault events that are more demanding. Today the most widely is used the combined system that includes training of individual disciplines one after another, simultaneous training of all disciplines with an emphasis on training disciplines that are most suitable for the rounder. However, it is depending on the mental and physical quality of the athletes, the health status of individuals, the period of sports career, the period of the annual cycle.

All competitors are necessary to have a consistently developed morphological-motoric-functional space that is highly integrated into the cognitive-conative potentials and will also ensure the achievement of high results of competitors. What is very important in the training process of rounders is their process of transition from one discipline to the other which is a very complex task. During this process, at the beginning there is a quenching of already formed dynamic stereotypes that were created by the training and training of the prior discipline.

New training of a new discipline involves the formation of new functional-motor structures that will enable the best possible way in achieving the success. Rounders always strive to improve their personal results in those disciplines in which they lag behind either by personal or general criteria. A large number of specific movements that allow the active connection of constituent elements of all-around competition and converting into a single structure is one of the main characteristics of the training process of rounders (Pavlović 2013). Key factors in selection of decathletes: Body shape, age, Physical quality, Training team management, Large load training, And emphasis on strength and technique in the late stage (Wang, & Lu, 2007).

It is an indisputable fact that the decathlon competitor does not have to be remarkable in any part of the competition to be a champion in all ten, but he must be good in the disciplines in which he is weaker and excels in disciplines that are his forte. Given that he must be good in three racing, three jumping, three throwing and one discipline in endurance, there's not much space to refine just one discipline. Therefore decathlon competitor must compromise, and therein lies the very nature of decathlon. This is a compromise in which the trade-offs must be made in the preparations in order to achieve maximum results (Tidow, 2000).

The comparative analysis of five world records it was found that discipline whose outcome is more dependent on technical efficiency performance than the level of basic motor abilities, are crucial determinants in top results in in the decathlon. At the present time, can be noted better results in sprint disciplines, long jump, pole vault, so that in the future we can expect progress in the decathlon

but also the opportunity of differentiating the new model of decathlon competitors (Mandarić, & Mandarić, 2016). Decathlon is the only competition in which it does not matter if the athlete is not the first, second or last in a discipline. What matters is the total number of points, and a rounder competes against own capabilities and standards. In consideration of efficiency of result achievements the most successful decathlon world 'score of different levels and ages determined the presence of a specific and different predictive contribution discipline decathlon total pointing score. A comparative analysis of the dominant predictor had found that disciplines whose outcome depends more on the technical efficiency performance than the level of training of basic motor abilities are the key determinant of the success of his score in the decathlon (Bilić, Smajlović, & Balić, 2015). At the present time, can be noted better results in sprint disciplines, long jump, pole vault, so that in the future we can expect progress in the decathlon but also the opportunity of differentiating the new model of decathlon competitors (Mandarić & Mandarić, 2016).

Because of these different contributions 'technical and motor discipline' to the overall success of his score in the decathlon would be of importance to analyze and determine the factor structure of the decathlon. On the basis of the so. latent dimensions (factors) would give a fair view of the explanation of the total variance discipline decathlon. On the basis of the results would have an insight into the size of the contribution of technical and motor discipline on the total placement in decathlon, ie. define a space or spaces kinesiology techniques as the primary structure decathlon. Zatsiorsky, & Godik, 1962. performed factor analysis (centroid method) of the decathlon performance in athletes participated in 1960 Olympic Games. The study was motivated by the desire to determine a limited number of latent factors ('motor abilities') that define success in decathlon and, as a consequence, to help coaches and athletes in designing optimal training programs that take into consideration the inter-event similarity and possible transfer of training results.

The authors analyzed the individual events as well as the overall performance (in awarded point scores). The factor loadings on the first factor were the largest for the total decathlon performance. For the individual events the loadings were almost identical to the magnitudes of their coefficients of correlation with the overall performance in decathlon. The factor was identified as the 'general level of athletic mastership' and hence the intended purpose of the research was not fully achieved. Including the overall performance in the factor analysis most probably masked the existing 'factor structure' of the decathlon events. The performance results of the athletes competed in the 1988-2008 Olympic Games were analyzed (Park, & Zaciorski, 2011). In the principal component analysis, the first three principal components explained 70% of the total variance. In the 1st principal component

(with 43.1% of total variance explained) the largest factor loadings were for 100m (0.89), 400m (0.81), 110m hurdle run (0.76), and long jump (−0.72). This factor can be interpreted as the 'sprinting performance'.   The loadings on the 2nd factor (15.3% of the total variance) presented a counter-intuitive throwing-jumping combination: the highest loadings were for throwing events (javelin throwing 0.76; shot put 0.74; and discus throwing 0.73) and also for jumping events (high jump 0.62; pole vaulting 0.58). On the 3rd factor (11.6% of total variance), the largest loading was for 1500 m running (0.88); all other loadings were below 0.4.

The study (Pavlovic, Bonacin, & Radulovic, 2016) the use of factor analysis defined the space athletic decathlon students Faculty of Physical Education and Sport. The results have confirmed the dominance of two factors with high values of variance system over 75% and are defined as a type of runner-jumper in the first factor and the type of pitcher in the second factor. Here is a confirmed partial dominance motor of technical disciplines. Similar results when it comes to the

structure of athletic gymnasts women are getting Gassman, Fröhlich, & Emrich 2016. It is on the basis of A previous all of the facts about all-around athlete, specificities, the structure was conducted this study to encompass the best placed of the world all-around the tables IAAF from 1984 to 2016. The main objective of the research was to determine the factor structure of the athletic decathlon or define the factors on the basis of which to determine the dominance of latent dimensions, certain technical and motor disciplines in the all-around.

Methods

The research included a sample than ten, currently the best, decathlon all-time, starting from 1984 to 2016. These are: Ashton Eaton (USA), Roman Sebrle (CZE), Tomas Dvorak (CZE), Dan O'Brien (USA), Daley Thompson (GBR), Kevin Mayer (FRA), Jürgen Hings (GDR), Bryan Clay (USA), Erki Nool (EST), Uwe Freimuth (GDR). All results of the disciplines and the number of points in the decathlon are downloaded from the IAAF website.*

Table 1. Top ten World decathletes (1984.-2016.)

Decathlete Venue	1. Ashton Eaton USA Beijing, 2015		2. Roman Šebrle CZE Götzis, 2001		3. Tomaš Dvoržak CZE Prague, 1999		4. Dan O'Brayan USA Taline, 1992		5. Daley Thompson, GBR LA, 1984	
Disciplines	*Results*	*Points*	*Results*	*Points*	*Results*	*Points*	*Results*	*Points*	*Results*	*Points*
100m	10,23	1040	10,64	942	10,54	966	10,43	992	10,44	989
Long Jump	7,88	1030	8,11	1088	7,90	1035	8,08	1081	8,01	1063
Shot Put	14,52	760	15,43	816	16,78	899	16,69	894	15,72	834
High Jump	2,01	813	2,12	914	2,04	840	2,07	868	2,03	831
400m	45,00	1060	47,79	918	48,08	905	48,51	885	46,97	960
1 day	4703		4678		4645		4171		4677	
110m	13,69	1015	13,92	985	13,73	1010	13,98	977	14,33	932
Discus throw	43,34	733	47,92	826	48,33	836	48,56	840	46,56	799
Pole vault	5,20	972	4,80	849	4,90	880	5,00	910	5,00	910
Javelin throw	63,63	793	70,16	891	72,32	925	62,58	777	65,24	817
1500	4:17,52	829	4:21,98	797	4:37,20	698	4:42,10	667	4:35,00	712
2 day	4342		4348		4249		4720		4170	
Total Points	9045		9026		8894		8891		8847	
Decathlete Venue	6. Kevin Mayer FRA Rio de Janeiro, 2016		7. Jürgen Hingsen GDR Mannheim, 1984		8. Bryan Clay USA Eugene, 2008		9. Erki Nool EST Edmonton, 2001		10. Uwe Freimuth GDR Potsdam, 1984	
Disciplines	*Results*	*Points*	*Results*	*Points*	*Results*	*Points*	*Results*	*Points*	*Results*	*Points*
100m	10,81	903	10,70	929	10,39	1001	10,60	952	11,06	847
Long Jump	7,60	960	7,76	1000	7,39	908	7,63	967	7,79	1007
Shot Put	15,76	836	16,42	877	15,17	800	14,90	784	16,30	870
High Jump	2,04	840	2,07	868	2,08	878	2,03	831	2,03	831
400m	48,28	896	48,05	907	48,41	889	46,23	997	48,43	888
1 day	4435		4581		4476		4531		4443	
110m	14,02	972	14,07	965	13,75	1007	14,40	924	14,66	891
Discus throw	46,78	804	49,36	857	52,74	928	43,40	734	46,58	799
Pole vault	5,40	1035	4,90	880	5,00	910	5,40	1035	5,15	957
Javelin throw	65,04	814	59,86	736	70,55	898	67,01	844	72,42	926
1500	4.25,49	774	4.19,75	813	4.50,97	613	4.29,58	747	4.25,19	776
2 day	4399		4251		4356		4284		4349	
Total Points	8834		8832		8832		8815		8792	

* https://www.iaaf.org/disciplines/combined-events/decathlon

Results and discussion

Decathlon is one of the oldest events in athletics with high requests of human functions, is a comprehensive sports event that combines techniques, physical ability, intellectuals into one, whose competitive levels reflects a country athletics levels to some extent. In comparison to the profile and level of success of the most successful decathlon all the time, it was observed that the absence of the special quality of the expression of the maximum potential of decathlons impossible to achieve the highest level of success. Joining the results of other authors in the analysis of typological sets decathlon (Etcheverry, 1995; Lee,2001; Van Damme, et al., 2002; Stemmler, & Baumler, 2005), it can generally be divided into two distinct areas: the versatile types with 3 of the 4 factors (sprinting, jumping, throwing, and endurance) with excellent performances and types of specialists with 1 or 2 factors with average and below-average performances. For versatile types dominate pentathlons jumper sprint and sprint-type jumper in relation to the types of sprinter-thrower and jumper-thrower (Bilić, 2015).

What is important is that the factors of success in athletics are specified hierarchically, which means that in the series, at the beginning, there are the most important factors or dimensions and in the end less important. In connection with that the researchers who work in athletics are also required to use scientific methods to allocate hypothetical factors (skills and characteristics) that define the promising athlete and participation of each factor in achieving high results in a particular athletic discipline (Pavlović, Idrizović, Rakovic, et al. 2014). It is this research that represents a model which should be hierarchically specified in terms of athletic all-around competition and to identify certain dominant factors. Disciplines of all-around competition require an unprecedented level of development of morphological dimensions, motor and functional abilities (speed, strength, endurance) that are routed through training to optimal values. Simply put, male and female rounders must be complete athletes with very high levels of basic, specific-situational and technical-tactical preparedness in all disciplines individually, and in all-around competition in general. Each rounder has his own characteristics i.e. group of disciplines in which he achieves better results. Some of them are more of a racing type, others are more of jumpers and the third are more of a throwing type. Normally, their typology depends primarily on the domination of certain motor and functional abilities as well as the morphological status, i.e. type of constitution (Mihajlović, 2010; Pavlović, 2013). Being guided by the previously presented in the text, the aim of this study is to determine the factor structure of athletic decathlon disciplines of world record holders in the period from 1984 to 2016. or the results of athletic decathlon, first, the basic statistical central and dispersion parameters and correlation analysis were calculated. On the basis of the parameters, in accordance with the defined goal of the research, the appropriate multivariate methods were applied.

Table 2. Descriptive Statistics

	Mean	*Min.*	*Max.*	*Range*	*Std.Dev.*	*Skew.*	*Kurt.*
100m	956,10	847	1040	193	54,97	-,59	,60
Long Jump	1013,90	908	1088	180	57,42	-,45	-,41
Shot Put	837,00	760	899	139	47,54	-,18	-1,17
High Jump	851,40	813	914	101	30,11	,96	,63
400m	930,50	885	1060	175	57,94	1,55	1,75
110mH	967,80	891	1015	124	40,89	-,68	-,38
Discus Throw	815,60	733	928	195	57,38	,29	,78
Pole Vault	933,80	849	1035	186	64,26	,62	-,73
Javelin Throw	842,10	736	926	190	65,62	-,09	-1,23
1500m	742,60	613	829	216	69,07	-,63	-,40

By inspection of Table 2 it can be concluded that decathlon athletes on average had the highest score and thus achieved the highest number of points (over 900) in the following disciplines: Long jump (1013,90), running 110m with hurdles (967,80), running 100m (956,10), pole vault (933,80), running 400m (930,50). Weaker average placement was made in the following disciplines: high jump (851,40), javelin throw (842,10), shot put (837,00), discus throw (815,60) and as a result the weakest and the least number of points was achieved in the discipline M1500m (742,60), which is more functional than motor component (Pavlović, 2007). From the jumping disciplines, decathlon athletes were dominant in the long jump (1013,90) compared to pole vault (933,80) and high jump (851,40). From the throwing disciplines, they were the most successful in the javelin throw (842,10) and the lowest in the discus throw (815,60). From the group of racing disciplines, the highest scoring average was made in running with hurdles (967,80) compared to running 100m, 400m, and 1500m. In addition, in the maximum result the ranking by disciplines is almost identical, the most points were won in the discipline long jump (1088) and the lowest number of points in the 1500m running (829). In the analysis of the sum of average achieved points, in the first place were running disciplines (3587), then jumping disciplines (2799,10) and the lowest number of points was achieved in the throwing disciplines (2494,70). In terms of the range of decathlon results (Table 2), points range from 101 (high jump) to 216 (M1500). Within the range of disciplines in the same group, the values range from 124-216 (running disciplines), 101-186 (jumping disciplines), and

139-195 (throwing disciplines). In terms of the Gaussov distribution, there are no significant deviations from the normal distribution. It can be concluded that the athletes generally had lower scores in the technical disciplines than in running disciplines that are based on natural forms of movement and motor manifestation (speed, explosive power, endurance) and the result does not depend so much on the technical performance. Similar results, although on the other population,

have been confirmed in research conducted by Pavlović, Bonacin, & Radulović (2016). In comparison between the jumping and throwing disciplines decathlon athletes on average made more points in the jumping disciplines (2799,10) than in throwing disciplines (2494,70), i.e. in the disciplines in which in addition to technical performance, motor abilities (strength, speed, coordination) and the ability of the synergic action of the lifting device (pole vault) have a big impact.

Table 3. Correlations

	100m	Long Jump	Shot Put	High Jump	400m	110mH	Discus Throw	Pole Vault	Javelin Throw	1500m
100	1,00									
Long Jump	,14	1,00								
Shot Put	-,41	,32	1,00							
High Jump	-,04	,16	,16	1,00						
400m	,53	,09	-,74	-,54	1,00					
110mH	,67	,00	-,14	,28	,09	1,00				
Discus Throw	,00	-,24	,41	,65	-,77	,33	1,00			
Pole Vault	-,18	-,50	-,43	-,65	,37	-,33	-,60	1,00		
Javelin Throw	-,29	-,14	,02	,10	-,27	-,08	,17	-,12	1,00	
1500m	-,31	,24	-,21	-,18	,44	-,17	-,61	,18	-,30	1,00

In the correlation analysis of athletic disciplines (Table 3) was recorded a total of 55 correlations of which 26 (55%) on the level of medium and medium-high projections that are statistically significant. The best connection was established between M100-M110 (.67), while the largest inverse relationship was observed between the Discus Throw-M400m (-.77).

Table 4. Eigenvalues, Extraction: Principal components

	Eigenval	% total Variance	Cumul. Eigenval	Cumul. %
Factor 1	3,52	35,24	3,52	35,24
Factor 2	2,22	22,21	5,74	57,45
Factor 3	1,69	16,88	7,43	**74,33**

Table 5. Factor Loadings (Varimax normalized), Extraction: Principal components, (Marked Loadings: > ,70)

	Factor Unrotated			Varimax normalized			
	Factor 1	Factor.2	Factor 3	Factor 1	Factor 2	Factor 3	Com.
100m	-,15	,94	-,09	-,05	,95	-,11	,92
Long Jump	,08	,18	,89	,45	,01	-,79	,82
Shot Put	,64	-,39	,37	,68	-,49	-,01	,71
High Jump	,73	,21	,15	,75	,14	,14	,60
400m	-,87	,42	,08	-,70	,45	-,49	,94
110mH	,22	,82	-,12	,26	,81	,08	,73
Discus Throw	,91	,14	-,28	,73	,13	,61	,92
Pole Vault	-,73	-,35	-,45	-,88	-,22	,14	,85
Javelin Throw	,30	-,27	-,35	,09	-,22	,48	,29
1500m	-,55	-,19	,56	-,30	-,25	-,71	,65
Expl.Var	3,52	2,22	1,69	3,20	2,21	2,02	
Prp.Totl	,35	,22	,17	,32	,22	,20	

To obtain the necessary information defined by the aim of the research was applied the factor analysis (principal components-Varimax rotation). At Varimax rotation, the load variance is calculated for each column in particular, so the increased number of common factors is obtained. However, before the Varimax rotation, unrotated factor matrix was applied, which gives a preliminary number of factors for extraction. The rotation of factors achieves simpler and theoretically more important factor solutions. Re-specification of factor model is achieved by returning to the phase of extraction, by extracting the factors and their re-interpretation.

Effect of rotation of factor matrix is to redistribute the variance from the previous factors on later factors, in order to achieve a simpler theoretically more important factor matrix. The set of ten athletic disciplines is defined by the total explained variance of the system of about 75%, with three different vector load factors extracted (Table 4).

Table 6. Correlations between factors

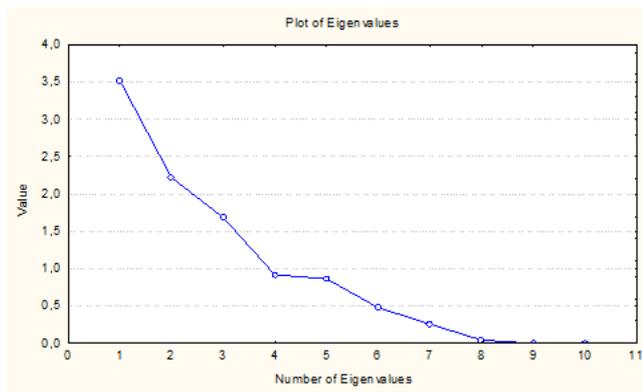|	Factor 1	Factor 2	Factor 3
Factor 1	1,00	-,01	
Factor 2	-,01	1,00	
Factor 3	,25	-,01	1,00

Figure 1. Factor stucture (Eigenvalues)

The first factor in the Varimax rotation is defined by the variables of all three spaces (running, jumping, throwing) that have made the greatest contribution to the total common variance with 35,24% with a significantly higher homogeneity of eventing disciplines. The eigenvalue of 3,52 is significantly greater than zero and reserves the right to extraction (table 4). Thus strong saturation of isolated vectors, although heterogeneous in terms of discipline group, provides the basis for the definition and extraction of the first factor, i.e. eventing type of athletes. As the main carriers of the first-factor extraction are jumping disciplines: pole vault (-.88) and high jump (.75), followed by discus throw (.73) and running M400 (-.70). Significantly strong vector saturation is manifested in the discipline shot put (.68), which defines the total variance of the first factor in five athletic disciplines. Their vector strengths are the backbone of a strong impact and independent extraction. The values of the factor strength i.e. the value of communality of the first factor are also with high projections (Com. 85-94). The first factor, in terms of defining, is heterogeneous because five disciplines with various motor, power and technical characteristics and features are isolated. Given the size of vector saturations which were demonstrated, we can conclude that it is an eventing type *jumper-thrower-runner*, i.e. a more technical profile of decathlon athlete. Thus, in terms of the phenomenological model, the first factor can be defined as the latent dimension of strength and speed or *anaerobic-aerobic endurance*.

The second factor in the Varimax rotation is defined by two disciplines of running, which showed a high homogeneity of the set, with the domination of the sprint 100m (.95) and a slightly lower vector intensity in the discipline of running 110m with hurdles (.81), with a lower projection which is smaller carrier of variability (Table 3). It is mostly about speed and technique, i.e. anaerobic type of decathlon athlete. Also in this factor, the discipline of running 400m manifested lower strength in saturation of the second factor. The second factor exhausted 22.21% of the common variance of the system with eigenvalue (eig. 2,22) that is greater than zero and reserves the right to self-extraction.

The values of the factor determination or the value of communality are with high projections (Com. 73-92). It can be seen that this set is positioned close to the largest number of manifest variables besides which its bundle passes (Table 4). This position in the coordinate system and the behavior of this factor as secondary, which in relation to the first, defines the measure of common variability of extracted factors (latent dimensions). In addition, the value of the factor coefficients is of high value. With regard that in the second factor are isolated variables that estimated sprint discipline, it can be defined as a type of *runners (sprinters).* If this factor is defined as energetic then it is an anaerobic type of motor-technical profile of decathlon athletes.

The last, third isolated factor exhausted 17% of the common variability of the analyzed system with significant eigenvalue (eig. 1,69), which allowed it to gain the ability for self-extraction and contributed to the overall common variance of the system. This factor is defined by the two disciplines which with their vector strengths contributed to independent extraction. The main carrier of third-factor variability is the discipline long jump (-.79) and running 1500m (-.71), i.e. jumping and racing (functional) discipline with the values of communality in the range of (.65-.82). The small contribution that is not statistically significant was exhibited in the discipline disc throw (.61) but due to its low vector saturation, it has not gained the opportunity to participate in defining the factor. This factor can be defined as eventing type *jumper-runner.* The motor equivalent would fit the type of speed-endurance, and functional equivalent of the anaerobic and aerobic type of decathlon athlete.

The correlation coefficient (Table 6) represents a very low correlation between the three isolated factors. The low positive correlation was demonstrated between the first and the third factor (.25), while others have zero correlations. This is also an indicator of independence of athletes in athletic eventing, where each result of a discipline is observed independently from the results of other disciplines.

Based on the factor analysis of the eventing discipline it can be concluded that at the current decathlon record holders are dominant three factors (types) of decathlon athletes. Given the number and severity of vector saturations in athletic disciplines in the first factor, the conclusion is that it is a type of decathlon athlete jumper-thrower. The second factor defines sprint type and the third factor defines eventing type of jumper-runner. In this case was confirmed the mix variant in the first factor, where jumping, throwing and running type of eventing athletes took part. The results support the allegations (Mihajlović, 2010; Idrizović, 2010; Pavlović, 2013) since they reflect a combination of different types of athletes. The reason for this redistribution lies in the period of time (over 30 years) that included world record holders as well as in the improvement of technical, motor and

functional parameters of ''newer'' eventing athletes in the individual disciplines. Sometimes the main points were won in jumping disciplines and sometimes in throwing, which depended on the constitutional type of that athlete and his/her specialty in terms of disciplines. In addition, the disciplines that have defined the first factor testify to the fact that most of the world's record holders were dominant in disciplines (discus throw, 400m, pole vault, high jump) on which could be defined their constitutional type. Next, the conclusion is that there has been no pure extraction of the dominant first factor and therefore no pure type of decathlon athlete (runner, a jumper, a thrower). Only in the second factor is the dominant race (sprint) type of decathlon athlete, while the third factor defines a combination of jumpers and runners. The results of this study are inconsistent with research conducted by Zaciorskij, & Godik 1962 who also got the three-factor model of eventing athletes but different vector saturations of factors, in terms of disciplines participation.

These results are in accordance the findings (Bilić, Smajlović, Balić, 2015). In consideration of efficiency of result achievements the most successful decathlon world 'score of different levels and ages determined the presence of a specific and different predictive contribution discipline decathlon total pointing score. A comparative analysis of the dominant predictor had found that disciplines whose outcome depends more on the technical efficiency performance than the level of training of basic motor abilities are the key determinant of the success of his score in the decathlon. (Mandarić, & Mandarić, 2015).

What is evident and attracts attention in all three factors is the position and saturation of racing disciplines (sprint and middle-distance). Based on their position and relationships it can be concluded that these are decathlon athletes with different anaerobic and aerobic power and their inverse relationship. It is sufficient to note that the predominance of fast muscle fibers allows the high intensity of muscular force for a short time which gives an advantage in the sprint (100m, 110mH), but because of its low energy component limits the good results in the 400m and 1500m. Also, the predominance of slow fibers prevents good results in jumping and throwing. There is also the influence of muscle mass which is inversely proportional to the relative aerobic power but significantly affects the results in the throwing disciplines, etc.

Today, decathlon athletes have slightly less mass, especially due to the advancement of training technology. Muscular force is less raised by increasing the cross-sectional muscle and more raised by activation of a higher percentage of motor units, and by increasing the so-called "gradient force", i.e. an increase in the intensity of the force for a short time. For example, the foot contact with the ground while sprinting is about 0.08s, while the time required to achieve maximum force in the extensor muscles of the foot is ten times higher. Therefore the muscle is "body built" less, and it affects more on the increasing of the movement efficiency by raising the gradient force. As a consequence, we have more gracious or stronger athletes. It can be said that the recent plethora of decathlon athletes precisely corresponds to more gracious but stronger athletes. The best example is the current world record holder Ashton Eaton (height 185cm, weight 84kg), who, probably due to his profile, significantly participated in the defining of the current factors in this research.

Conclusion

The study analyzed ten world record holders in the athletic eventing from 1984 to 2016. Its aim is to determine the number of factors and define their factor structure. Data were analyzed using factor analysis, which confirmed the existence of three factors (types of athletes) with a total of the extracted variance of about 75% of the combined system variables. The first factor is defined as eventing type of athlete "jumper-thrower-runner'' (Pole Vault, High Jump, Discus Throw, Shot Put, 400m), the second factor as eventing type ''runner-sprinter'' (100m, 110m Hurdle), and the third factor is the type of 'jumper-thrower" (Long Jump, 1500m). It should be noted that of the ten disciplines, javelin did not accomplish participation in extraction and factor defining because its vector strength was numerically insignificant. The obtained results support the allegations (Mihajlović, 2010; Pavlović, 2013) since they reflect a combination of different types of athletes integrated into three different and partially independent factors.

A possible reason for this factor reallocation and considerable heterogeneity of disciplines is in the covered time period (over 30 years), the differences of the morphological profile of decathlon athletes as well as improved technical, motor and functional parameters of ''younger'' eventing athletes in individual disciplines.

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**** https://www.iaaf.org/disciplines/combined-events/decathlon

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FAKTORSKA ANALIZA SVJETSKIH REKORDERA U ATLETSKOM DESETOBOJU

Sažetak

All-around natjecanje je jedino natjecanje u kojem nije bitno je li sportaš prvi, drugi ili posljednji u disciplini. Ono što je važno je ukupan broj bodova, a specijalist se natječe protiv njegovih / njenih osobnih sposobnosti i standarda. Atletska all-around natjecanja su niz uzastopnih sportskih natjecanja podijeljenih u dva dana. Uspjeh se izračunava zbrojem bodova svih disciplina koji su postignuti prema međunarodnim sportskim tablicama. Istraživanje je obuhvatilo deset (10) trenutno najboljih svjetskih desetobojaca svih vremena do 2016. Cilj istraživanja bio je provesti faktorsku analizu sportskog desetoboja svjetske rekorderke u cilju definiranja faktora (latentne dimenzije) koji će odrediti vrstu desetoboja, ili tako sudjelovanje tehničkih ili motornih disciplina u ukupnom poretku. Primjena faktorske analize u definiranom području izvedena je s ukupno tri faktora i objasnla je oko 75% zajedničke varijance. Prvi faktor iskazao je 35.24% (motkom, skok u vis, bacanje diska, 400m) i skup zajedničke varijance je definiran kao vrsta skakač-bacač-trkač. Drugi faktor iskazao je 22.21% (100 m, 110m prepreka) analiziranog seta i definira se kao trkači (sprinterski) tip sportaša. Treći faktor iskazao je oko 17% (dalj, 1500m) i definiran je tipom skakača-trkača.

Ključne riječi: *desetoboj, čimbenici, atletska tipologija.*