

# Discipline homogeneity based on the most successful decathlon scoring placement

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**Abstract.** Athletic Decathlon (all-around) is physically demanding athletic competition that is scored according to a special IAAF tables. and the winner is the competitor who wins the most points. However, some authors give different views on the contribution of individual disciplines total pointing result. or grouping similar disciplines. favoring those disciplines that are based on more motor potentials athletes creating homogeneous groups (clusters). This study analyzed ten world record holder in all-around athlete of the 1984th to 2016th Its aim is to determine the number of clusters. or the level of homogeneity between disciplines. Data were analyzed using hierarchical cluster analysis which confirmed the existence of nine clusters integrated into three major groups. In the first group defined with four clusters were distinguished discipline (100m-110m-400m-Pole Vault-LJ) that the representatives of the movement of sprint and high jump type (anaerobic capabilities). The second group of four clusters also have defined mainly all three throwing disciplines as primary (SP, DT, JT) and one rebounds as secondary (HJ) that defines the strong discipline of speed and explosive character. The third group is defined by discipline 1500m as the farthest point in the athletic decathlon. This is a confirmation that this is a typical aerobic ability. under the auspices of functional mechanisms. This score is confirmed some previous research on the number of clusters and partial homogeneity between disciplines that are under the umbrella of the same energy potential and possible benefits of sprint and jumping with respect to throwing disciplines.

**Keywords.** Cluster analysis, decathlon, homogeneity.

## Introduction

Decathlon and heptathlon were subject to many statistical analyses in the past. Dawkins et al. (1994) used cluster algorithms, regression trees and correspondence analysis to characterize leading athletes for 1992 Olympic heptathlon data. Cox & Dun (2002) clustered results from the world Athletic Championships from 1991 to 1999 in order to identify track and field events with big impact on the total points.

The Identifying relevant classification decathlete based on kinship interrelationship between disciplines get more

precise information about the presence and effects of various typical decathlete structure in relation to the level of performance, which facilitates the selection procedure for the individual development strategies and optimize the training process. Results from the most comprehensive study of this aspect of the decathlon (Stemmler & Bäumlner, 2005), showed that in reality present a very broad typological furniture. 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.

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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 et al., 2015; Pavlović et al., 2016).

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 (Pavlović & Idrizović, 2017).

The structure of the decathlon as disciplines consists of three large groups of disciplines; racing, jumping, throwing. By analyzing the results over 8000 points from 1966 to 2002 that are decathlonist exercised, differentiated several models compete in all events. Both models decathlon to 1980 were model throwers, jumpers and runners, followed by runner-

jumper, jumper-thrower and runner-throwers (Cox & Dunn, 2002; Kenny et al., 2005) while today a modern model decathlons requires uniformity in all disciplines.

Pavlović & Idrizović (2017) analyzed ten world record holders in the athletic events 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 events type of athlete "jumper-thrower-runner" (PV, HJ, DT, SP, 400m), the second factor as event type "runner-sprinter" (100m, 110H), and the third factor is the type of 'jumper-thrower' (LJ, 1500m). The obtained results support the allegations (Mihajlović, 2010; Pavlović, 2014) 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" event athletes in individual disciplines.

However, these simplistic characteristics may not represent the groupings defined by performances in the decathlon. The identification of groups may reveal a recondite advantage for athletes who excel in particular disciplines. The highest number of clusters common to all the methods was accepted as the solution. All six methods produced the same 3-cluster ([100m 400m 110H LJ PV HJ] [SP DT JT] [1500m]), 4-cluster ([100m 400m 110H LJ PV] [SP DT JT] [HJ] [1500m]) and 5-cluster ([100m 400m 110mH LJ] [SP DT JT] [PV] [HJ] [1500m]) solutions. Stability tests confirmed the consistency of all the solutions. The 10 disciplines of the decathlon form into five groupings, which can be adequately explained from a physiological perspective. The clustering suggests that athletes who perform better at the sprint/track disciplines may obtain an advantage in the decathlon (Gassmann et al., 2016).

From the analysis of five sets of World Championship decathlon data (1991 to 1999) Cox & Dunn (2002) commented that the discus throw and the shot-put throw were always grouped together while the running events (with the exception of the 1500 m) were often grouped together. They identified a 3-cluster grouping of the decathlon disciplines. Overall, these groupings were not defined by the three characteristics of running, jumping and throwing although no explanation was proffered to rationalize the groupings and the composition of the clusters were not consistent between sample sub-populations. In a subsequent analysis of decathlon data from the 1999, 2001 and 2003 World Championships and the 2000 and 2004 Olympic Games we found that better consistency of grouping and cluster content was obtained with a 5-cluster solution rather than a 3-cluster

solution (unpublished data). The clustering or grouping of the disciplines within the decathlon may have practical implications in terms of the advantages gained by athletes who are relatively better in the disciplines of one cluster than those disciplines contained within another cluster. Since decathlon data can be modelled as multivariate data, cluster analysis can be used to identify and analyze the groupings (or clusters) that may exist among the disciplines.

Exactly this variations in different groupings and the number of clusters in the decathlon was the reason for this research. The goal of the research is to determine the number of clusters, or homogeneity discipline ten best ranked decathlete from 1986 to 2016

## Methods

The research included a sample than ten, currently the best, decathlon all-time, starting from 1984, to 2016 year. 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), For data processing applied hierarchical cluster analysis.

All results of the disciplines and the number of points in the decathlon are downloaded from the IAAF website\* (Table 1).

## Results & Discussion

In order to obtain discipline homogeneity of top decathlon athletes (recorders) from 1986 to 2016 was applied the hierarchical cluster analysis and defined clusters. Structural analysis of the male decathlon gave empirical evidence of homogeneity and the existence of various groups presented in the form of various homogeneous clusters.

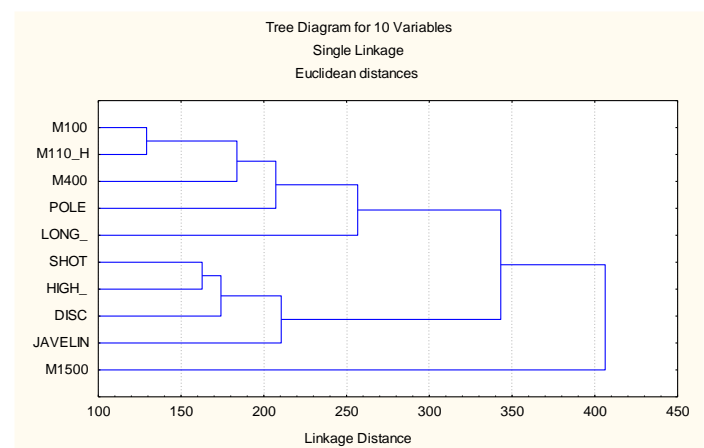


Figure 1. The dendrogram of cluster analysis.

**Table 1**Top ten of all time the decathlon (1984-2016; <https://www.iaaf.org/disciplines/combined-events/decathlon>).

Decathlete Venue	1. Ashton Eaton USA Beijing, 2015		2. Roman Šebrle CZE Götzis, 2001		3. Tomáš Dvoržák CZE Prague, 1999		4. Dan O'Brayan USA Taline, 1992		5. Daley Thompson. GBR LA, 1984	
	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	
	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	

**Table 2**

Euclidean distances.

Variables	100m	L J	S P	H J	400m	110 H	D T	P V	J T	1500m
100m	0									
Long Jump	287.	0								
Shot Put	457.	589.	0							
High Jump	382.	545.	163.	0						
400m	184.	352.	418.	343.	0					
110m Hurdles	129.	257.	460.	391.	235.	0				
Discus Throw	504.	683.	185.	174.	488.	512.	0			
Pole Vault	284.	405.	418.	369.	207.	282.	497.	0		
Javelin Throw	463.	611.	241.	211.	407.	464.	253.	411.	0	
1500m	740.	890.	406.	420.	628.	758.	412.	657.	453.	0

**Table 3**  
Means and standard deviations.

Variables	Mean	Std. Deviation
100m	956.10	54.97
Long Jump	1013.90	57.42
Shot Put	837.00	47.54
High Jump	851.40	30.11
400m	930.50	57.94
110m Hurdles	967.80	40.89
Discus Throw	815.60	57.38
Pole Vault	933.80	64.26
Javelin Throw	842.10	65.62
1500m	742.60	69.07

In athletic decathlon was extracted the total of 9 clusters. Of these nine clusters were defined three groups of disciplines, the certain larger Euclidean distance that is connected in the eighth cluster. The last, ninth cluster (in the third group) is defined as the most remote 1500m discipline in the athletic decathlon. This is yet another confirmation that the aerobic endurance is independent in the hypothetical area of the decathlon, i.e. under the auspices of the functional mechanisms.

In the first group defined with four clusters were distinguished disciplines (100m-110m-400m-Pole Vault-Long Jump), which are in the domain of racing and high jump type disciplines. Mostly it comes to connectivity and high homogeneity of the anaerobic type of movement, i.e. speed-explosive character. The minimum distance in the first cluster is between sprint disciplines 100m and 110m (Euclidean 129). The second cluster defines another racing discipline (400m), while the third and fourth the closest distance achieved the disciplines Pole vault and Long jump (Euclidean 405). The second group of four clusters defined mainly all three throwing disciplines (Shot Put, Discus Throw, and Javelin Throw) and one jumping discipline (High Jump). Minimum distance, i.e. good homogeneity was exhibited in disciplines Short Put - High Jump (163), and then Discus Throw – Javelin Throw. In terms of energy demands it can be said that the Shot Put and High Jump are of anaerobic potential, i.e. of strong and speed explosive characteristics of athletes.

If distances of clusters are analyzed individually, it can be concluded that the best homogeneity or the closest Euclidean distance is within the first cluster of racing disciplines 100 - 110m (129), followed by disciplines Shot Put - High Jump (163). Shot Put- High Jump - Discus Throw (174-185); 100m - 110m -400m (184-235). In the fifth cluster which defines the discipline of running and pole vault, the Euclidean distance is slightly larger 100 -110m - 400m - Pole Vault (207-284).

Almost the same numerical distance are the sixth, seventh and eighth cluster. Finally, the last, ninth cluster defined as endurance discipline (1500m), is at a very great distance from other disciplines (up to 890) and it is heterogeneous in the analyzed area. Analyzing the partial scoring record it can be seen that there is a good homogeneity within the five disciplines that defined the first group of four clusters. Mostly those are the racing events (100m, 110m, 400m) whose result depends on good motor skills (speed, explosive strength) and two jumping disciplines (Long Jump and Pole Vault). The average value of achieved points ranged from 930.50 (400m) to 1013.90 (Long Jump), in which was recorded the highest average score in the event competition. In the second group, considerable homogeneity was expressed for disciplines, mainly throwing type, with a lower number of points (815 Discus Throw - 851 High Jump).

The minimum number of points was achieved in the discipline of running 1500m (Mean = 742.60), which is an indication that this discipline is functionally and motorically very demanding and it was a problem for all in the sense of capturing a larger number of points. What characterizes this kind of cluster redistribution is the fact that at the world recorders (decathlon athletes), there was not homogeneity within a single group of disciplines (e.g. jumping, racing or throwing) which would eventually define only one pure athletic type, but it is a redistribution between all three groups of disciplines with a special extraction of 1500m discipline that is independent of all analyzed. This cluster distribution can be viewed from the aspect of different domination in certain disciplines of each of the ten recorders, which is also confirmed in the study performed by Kenny et al. (2005). However, there is an evident indication that most racing discipline of anaerobic potential demonstrated significant homogeneity along with Long jump and Pole vault, whose successful results have a high correlation with racing disciplines in terms of motor skills and techniques.

Also, homogeneity within the throwing disciplines is significant and presents an indication of the correlation in which, in addition to motor skills, a big impact has the technique of performing the discipline. The results of this research by cluster analysis produced 3 groups of clusters as a final solution which partially coincides with research performed by Woolf et al. (2007), so it can be adequately explained from a physiological perspective and cohesion within the racing disciplines on the basis of which certain benefits in the decathlon can be obtained. In this study, it is apparent the clustering of throwing disciplines (Shot Put, Discus Throw, Javelin Throw) which is also confirmed in the research by Cox & Dunn (2002) and is an indicator of significant correlation. However, the results of this study are partially in contradiction with the results of research conducted by Idrizović & Pavlović (2017) which defined the factor structure of the decathlon athletes by extracting the three factors that defined the common variables of decathlon athletes with about 75%. Such a structure has shown different homogenization of the first and third extracted factors, while the second factor in terms of homogeneity is the same as the cluster share in the current study because it is defined by racing disciplines (100m and 110m). Also, in the factor as well as in the cluster analysis the 1500m discipline had a special insulated contribution in defining the total variability, i.e. heterogeneity.

Partially observed, the results of the current study also show certain heterogeneity of disciplines at the world recorders, which can be caused by different factors, such as large time range that has defined the decathlon recorders (over 30 years), technical, motor and functional potential of individual athletes who have marked a certain period of time. In view of the high homogeneity, the common clusters defined only racing disciplines (100-110H) and Shot Put - High Jump which can be generally characterized by mostly anaerobic potential participating, i.e. speed-explosive properties which are diametrically different from the 1500m discipline, which is also isolated as a separate cluster and is an indicator of pure aerobic potential of athletes. This rearrangement may also be an indicator of various typologies of analyzed decathlon athletes, or domination of certain motor, functional and technical elements of each discipline separately. All the decathlon disciplines defined as different factors are interwoven, interacting, or restricted by some other performances. All these factors can be analyzed as separate parts of sports performances based on somatic, physical, technical, tactical and psychological aspects. In no other sports activities are not present so many different variations of techniques as a result of motor learning. 8-12 years of systematic training (Vinduškova & Ryaba, 2009). The perfect mastery of all technical disciplines in the decathlon is very demanding. Compared with experts in various disciplines the decathlon athletes lag behind in somatic characteristics in comparison to sprinters, jumpers, throwers and generally lag behind in endurance. Decathlon athletes

have much less time for exercise and improvement of individual disciplines, while the mastery of the technique of throwing disciplines in a limited number of attempts for throwing disciplines delivers maximum performance (Vinduškova & Špiláček, 2007). This research can be a guideline for similar research in competitions such as World. European Championships or the Olympic Games. The obtained results would be useful for the theory and practice of athletics in terms of defining and possibly different homogenization of athletic decathlon disciplines.

In conclusion, the study analyzed ten world record holders in athletic all-around competitions since 1984-2016. With the aim to determine the number of clusters, i.e. the level of homogeneity between the disciplines. Data were analyzed using Hierarchical cluster analysis which confirmed the existence of nine clusters integrated into three major groups. In the first group, defined with four clusters were distinguished disciplines (100m-110m 400m--PV-LJ) that are the representatives of racing and jumping type of disciplines (anaerobic capacity). The second group, also consisting of four clusters, defined mainly all three throwing disciplines (SP, DT, JT) and one jumping discipline (HJ) that defines the disciplines of strong and fast explosive character. The third group only defines the discipline 1500m as the distal point in the athletic decathlon, which confirms that this is a typical aerobic discipline under the auspices of the functional mechanisms. The results of this study are partially in accordance with the results of some previous studies (Cox & Dunn, 2002; Kenny et al., 2005; Woolf et al., 2007), confirming a certain correlation between the disciplines of the same energy potential and the possible advantages of racing and jumping disciplines compared to throwing discipline in the athletic decathlon.

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