A STUDY ON THE DYNAMIC PROGRESS OF PERFORMANCES OF PROMINENT WORLD-CLASS ATHLETES IN SELECTED TRACK-AND-FIELD EVENTS

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Abstract:

The article presents the results of our studies on the dynamic progress of performances in track-and-field athletes in sprint, throwing and jumping. Prominent world-class athletes were followed and their performance developments in some events were analyzed and compared. In these groups some athletes were also investigated who had recently retired from competitive athletics. The investigation disclosed differences between sprinters, throwers and jumpers from the point of view of the beginning of specialized training, of the age in which they attained their top performances, and of the number of years of specialized training they needed in order to attain their top personal performances. It was also discovered that the sprinters started their specialized training as a rule at the age of 16 years and they attained their top performances between the ages of 24 - 25 years. In the case of throwers their beginning of specialized training was also at the age of 17 and their top performance came at 26 - 27 years; in the case of jumpers it was all a little earlier – beginning at 14 - 15 years of age and the top of performance between 23 - 24 years of age.

Key words: *dynamics of performances, track-and-field, top world-class performances*

UNTERSUCHUNG DES DYNAMISCHEN LEISTUNGSFORTSCHRITTS BEI DEN SPITZENLEICHTATHLETEN IN AUSGEWÄHLTEN LEICHTATHLETIKDISZIPLINEN

Zusammenfassung:

Diese Arbeit stellt die Ergebnisse unserer Untersuchung des dynamischen Leistungsfortschritts der Leichtathleten in Sprintläufen, Wurf- und Sprungdisziplinen dar. Die Spitzensportler aus ganzer Welt wurden beobachtet und ihre Leistungsentwicklung in einigen Disziplinen analysiert und verglichen. In diesen Gruppen wurden einige Sportler untersucht, die sich seit kurzem nicht mehr an Wettkämpfen beteiligen. Die Untersuchung zeigte die Unterschiede zwischen Kurzstreckenläufern, Werfern und Springern in Bezug auf den Beginn mit einem speziellen Trainingsprogramm, das Alter in dem sie ihre Spitzenleistungen erzielten und die Anzahl von Jahren des spezialisierten Trainings, die sie brauchte, um ihre persönlichen Spitzenleistungen zu erzielen.

Es wurde festgestellt, dass die Kurzstreckenläufer mit ihren gesonderten Trainingsprogrammen in der Regel im Alter von 16 Jahre beginnen und dass sie ihre Spitzenleistung im Alter zwischen 24 - 25 Jahren erzielen. Was die Werfer betrifft, fangen sie mit dem speziellem Trainingsprogramm auch im Alter von 17 Jahre an und erreichen ihre Spitzenleistung mit 26-27 Jahren, während die Springer mit dem speziellen Trainingsprogramm etwas früher anfangen – das heißt, mit 14 - 15 Jahren - und ihre Spitzenleistung mit 23-24 Jahren erreichen.

Schlüsselwörter: *Dynamik der Leistungen, Leichtathletik, Spitzenleistung*

Introduction

The study on the dynamics of performances and their regularities has a significant meaning for the assessment and comparison of athletes' performances at the beginning and at peak of their careers. Our study included an investigation of both individuals and groups. A mathematical expression found in general theory which helps to describe the dynamics of the sport is well known. Basically there are three periods in an athlete's career - the early stage when there is a fast increase in performance, the middle stage with only a little change in performance, and the third stage with a slow decrease in performance followed by termination of competitive activity.

To our previous works (Tilinger & Wudy, 1993; Tilinger, 2004) and to the studies of Wazny (1976), Matvejev (1966), etc., we have attempted to introduce certain new information concerning the rate of increase (both predicted and actual) of the performances in some track-and-field events. The purpose of the study was to offer information also for the selection of talented youth.

Methods

The sample of subjects consisted of 16 world prominent 100 m and 200 m sprinters, 20 world prominent high jumpers, 15 world prominent long jumpers, 19 world prominent discus throwers, 12 world prominent shot putters and 20 world prominent pole vaulters in the analysed groups. The athletes in these groups were those who had either ended their competitive careers or who have passed their prime and were in decline. The basic characteristics of the observed athletes are presented in Table 1.

Our basic goal was to develop a nomogram - a model which could be used as a predictive instrument in talent selection at an early age. To develop this nomogram we first outlined the graphical curves which modelled most accurately the performance paths - from the beginning to the end of competitive activity - of different athletes. Our experience indicates that the most appropriate curve is the one suggested by Matvejev (1966), i.e. $y = a + bx + cx^2$, where y is the performance in year x, and a, b, c are the equation coefficients.

For the calculation of theoretical trends in individual athletes and group performances a computer using the relevant applications was employed. The calculation included statistical means, and standard deviation, but also the equation coefficients and other parameters. The resulting data were used for the analyses of the dynamics of performances.

The work embraced the following activities:
1. Development of the database; sufficient number of data concerning the athlete's career performances;
2. Calculation of theoretical trends; the theoretical performances were calculated from the athlete's actual best annual performances;
3. Calculation of the group performances, obtained from mean modified trends; these trends were added to parallel curves which created nomograms of performances which contained bands (strips) of the dynamics of performance, from low (-1, 0) to high (6, 7) performance level.

Results

The analysis of the actual performance development and its theoretical trend disclosed that the groups of world sprinters, jumpers and throwers were quite homogeneous, and that is why the theoretical trends, regarding the groups of sprinters, jumpers and throwers, became a basis for the theoretical models for the predictive calculation of the dynamics of the other athletes' performances. The graphical representation of the group actual performance closely approximates the graphical indication by the equations, specific for each event.

Table 1. Basic characteristic of the observed athletes

Events	100 m	200 m	High Jump	Long Jump	Pole Vault	Shot Put	Discus Throw
The group means performance (s, cm, m)	10.02	20.09	226.3	815.7	553.5	21.11	67.24
Age at what the best performance was reached (years)	25.3	24.6	23.5	24.5	25.6	26.5	27.8
The first performance was recorded at the age (years)	16	16.2	14.5	15.5	15.3	17.1	17.8
The number of training years before reaching the performance maximum (years)	9.3	8.4	9.0	9.0	10.3	9.4	10
The best performance in the group (x_{max}), (s, cm, m)	9.92	19.72	235	845	572	21.71	71.16
The worst performance in the group (x_{min}), (s, cm, m)	10.14	20.49	221	798	525	20.28	64.48

The graphical record of this theoretical trend was modified for practical use since the theory predicted a decrease in performance in the middle stage, and in practice there was little or no decrease. The theory was very accurate in predicting the development during the first stage but not during the second stage. Thus in the nomogram the data *x = top of performance* was preserved for future use. These graphs of parallel lines developed via theory and practice are nomograms, with each band representing approximately standard deviation differences (Figures 1, 2). Individual bands define different levels of increases of performance from low rate (strips -1, 0) to average rate (strips 3 – 4) to high rate (6, 7). The investigation showed that low level at the beginning of the career (especially the situation at the second to fourth years of specialized training) is usually connected with low dynamics of performance and lower peak personal performance. Similarly, higher performance level at the beginning of the career of the athlete (high number of the bands, where it is possible to find the annual best performances of the athlete at second to fourth years of specialized training), are usually connected with higher dynamics of performance and in higher maximal personal performance (Figures 1, 2).

Discussion and conclusions

Comparison of all the athletes' groups shows that the theoretical trends are practically parallel, slightly approaching each other except for the results of the analyses of sprint events. The noticeable flatness of the curves seen in the sprint events indicates relatively little development in the performance. It means that the participants' improvement is small and after reaching their maximum after about 7 - 9 years their performances in the following years remain rather constant (Figures 3, 4).

The pattern of characteristics of the dynamics of performance is almost the same in all events with the exception of the sprint. The fact that the sprinters achieve more than 91 % of their maximum performance after only the first year of specialized training, and that they achieve more than 95 % after 3 years of training, and the remaining 5 % is achieved between 4 - 8 years of specialized training is an interesting discovery. This probably indicates the special need for a suitable genetic disposition in pursuing this event successfully.

The pattern characteristics of the observed athletes are to be found in Tables 2, 3 and 4.

To conclude, this study of the dynamics of performance belongs in the category of prerequisites
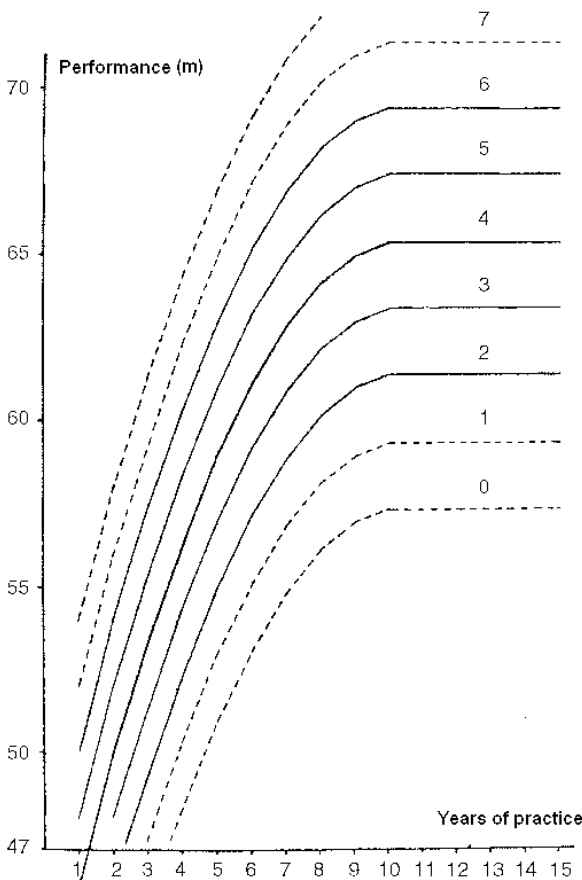

Figure 1. Nomogram of the dynamics of performance development – discus throw, men. The curves describe the bands (strips) with low (0, 1), average (3, 4) and high (6, 7) level of dynamics of performance in the followed group of athletes.
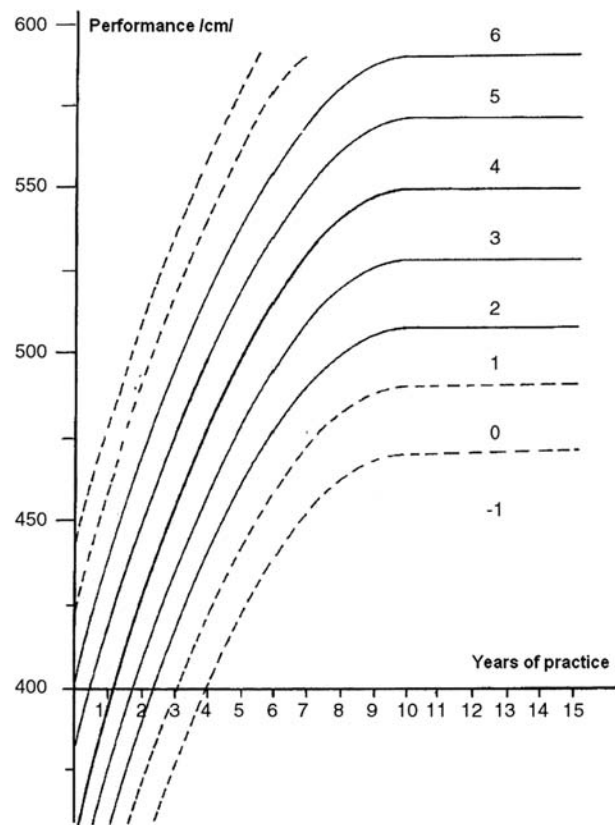

Figure 2. Nomogram of the dynamics of performance development – pole vault, men. The curves describe the bands (strips) with low (-1, 0), average (3, 4) and high (6) level of dynamics of performance in the followed group of athletes.
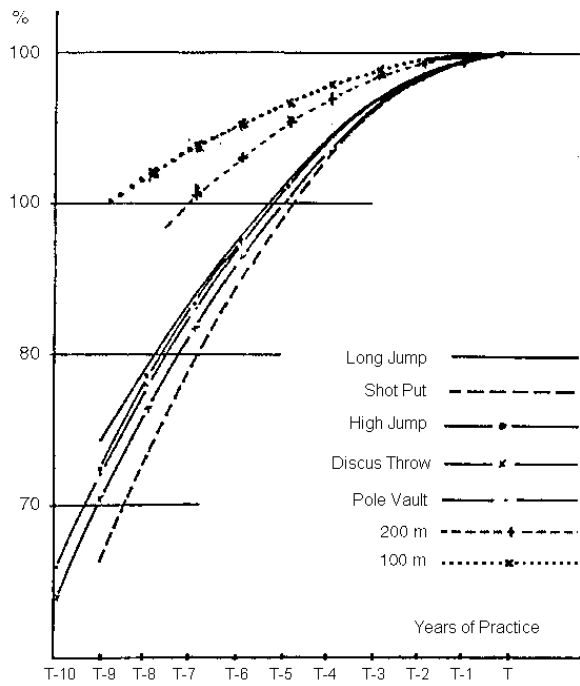
Figure 3. Model characteristics of the dynamics of performance in some athletics events. Relationships between years of practice and performance (expressed in the percentage of the peak performance) T – The year when athletes reached the top of personal performance.
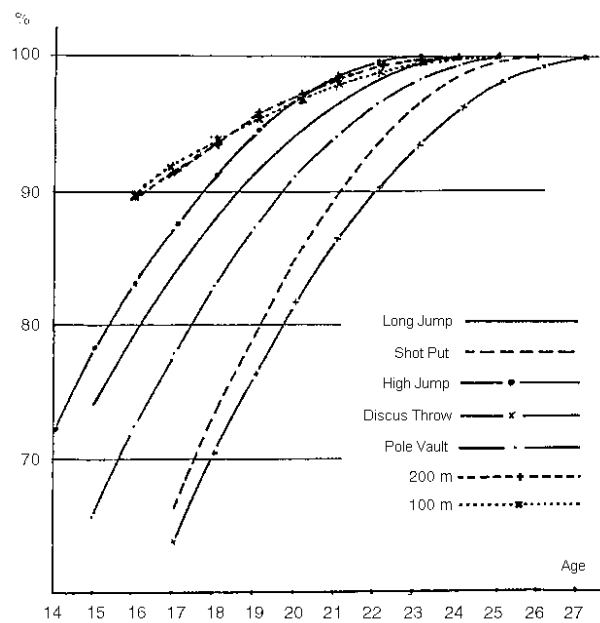

Figure 4. Model characteristics of the dynamics of performance in some athletics events. Relationships between age of the athlete and performance (expressed in the percentage of the maximum).

for quality practice in the process of development. For this reason we attempted to examine the tasks associated with the dynamics of sport perform-ance regularities with respect to sprints, jumps and throws. We have used a database developed from data that were normally inaccessible, on ath-letes who have either passed their prime and are in

decline or who were prominent world athletes in the past decade and are now retired.

Although it is not possible to extrapolate or generalize on the results mentioned above, it may be assumed that these results will be valid in most other cases of intense training of high-performance athletes. Further research is needed to substantiate such an assumption.

Table 2. The pattern characteristic of the performance dynamics - sprinters (100 m: n = 16, 200 m: n = 16)

Years of Training	100 m			200 m		
	Age	Performance (s)	% Max.of Perform.	Age	Performance (s)	% Max.of Perform.
	16	11.32	89.40	16	22.71	89.40
1	17	10.99	92.08	17	22.15	91.69
2	18	10.78	93.88	18	21.66	93.17
3	19	10.61	95.38	19	21.24	95.62
4	20	10.46	96.75	20	20.90	97.18
5	21	10.33	97.97	21	20.64	98.40
6	22	10.24	98.83	22	20.45	99.32
7	23	10.17	99.51	23	20.34	99.85
8	24	10.13	99.90	24	20.31	100
9	25	10.12	100			

Table 3. The pattern characteristic of the performance dynamics - throwers (shot put: n = 12, discus: n = 19)

Years of training	Shot Put			Discus Throw		
	Age	Performance	% Max. of Perform.	Age	Performance	% Max. of Perform.
	17	13.83	66.27	17	41.64	63.73
1	18	15.32	73.41	18	45.97	70.36
2	19	16.55	79.30	19	49.87	76.32
3	20	17.72	84.91	20	53.33	81.62
4	21	18.70	89.60	21	56.35	86.24
5	22	19.50	93.44	22	58.94	90.20
6	23	20.12	96.41	23	61.09	93.50
7	24	20.56	98.51	24	62.81	96.13
8	25	20.81	99.71	25	64.09	98.09
9	26	20.87	100	26	64.93	99.37
10				27	65.34	100

Table 4. The pattern characteristic of the performance dynamics - jumpers (high jump: n = 20, long jump: n = 15, pole vault: n = 20)

Years of training	High Jump			Long Jump			Pole Vault		
	age	Perfor-mance	% Max. Perfor.	age	Perfor-mance	% Max. Perfor.	age	Perfor-mance	% Max. Perfor.
	14	161.3	71.69	15	598	74.10	15	362	65.82
1	15	175.6	78.04	16	640	79.31	16	397	72.18
2	16	186.7	82.98	17	677	83.89	17	428	77.82
3	17	196.9	87.51	18	709	87.86	18	456	82.71
4	18	205.6	91.38	19	737	91.33	19	480	87.27
5	19	212.7	94.53	20	760	94.18	20	501	91.09
6	20	218.1	96.93	21	779	96.53	21	518	94.18
7	21	222	98.67	22	793	98.26	22	531	96.55
8	22	224.2	99.64	23	802	99.38	23	541	98.36
9	23	225	100	24	807	100	24	547	99.45
10							25	550	100

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STUDIJA O DINAMICI RAZVOJA REZULTATA TIJEKOM KARIJERE SVJETSKIH ATLETIČARA IZ ODABRANIH ATLETSKIH DISCIPLINA

Sažetak

Uvod

Članak predstavlja rezultate istraživanja o dinamici razvoja rezultata u tijekom sportske karijere atletičara sprintera, bacača i skakača. Istraživanje je obuhvatilo svjetski uglednih atletičare koji su se nedavno oprostili od natjecateljskog sporta, a analiziran je razvoj rezultata tijekom njihovih sportskih karijera.

Proučavanje dinamike razvoja rezultata i njenih zakonitosti vrlo je važno za procjenu i usporedbu atletskih rezultata na početku sportaševe karijere i na njenom vrhu. U osnovi, postoje tri razdoblja u sportaševoj karijeri: rana faza, u kojoj rezultati brzo rastu, srednja faza, u kojoj su rezultati na najvišoj razini i malo se mijenjaju, i treća faza s blagim padom rezultatom koji prati prestanak aktivne natjecateljske karijere.

Cilj je rada pokazati neke nove informacije o brzini rasta (predviđenoga i stvarnoga) rezultata u nekim atletskim disciplinama. Te bi informacije trebale pomoći u selekciji mladih talentiranih atletičara.

Metode

Uzorak ispitanika sastojao se od svjetski poznatih atletičara: 16 sprintera na 100 m i 200 m, 20 skakača u vis, 15 skakača u dalj, 19 bacača diska, 12 bacača kugle i 20 skakača s motkom. Atletičari su ili nedavno završili svoju natjecateljsku karijeru ili su već prošli rezultatski vrh svojih karijera. Osnovne karakteristike uzorka ispitanika prikazane su u tablici 1.

Osnovni je cilj istraživanja bio načiniti nomogram – model koji bi mogao poslužiti kao prognostički instrument u ranoj selekciji talenata. Za stvaranja nomograma prvo smo iscrtali krivulje kojima je modeliran tijek razvoja rezultata od početka do kraja natjecateljske karijere svakog ispitanika. Na temelju iskustva autori smatraju da je najprikladnija krivulja koju je prdložio Matvejev (1966), tj. $y = a + bx + cx^2$, gdje je y rezultat u godini x, a a, b i c su koeficijenti jednadžbe.

Za izračunavanje teorijskih trendova rezultata pojedinih atletičara, ali i skupina po pojedinoj atletskoj disciplini, koristili smo se srednjom vrijednošću i standardnom devijacijom, ali i koeficijentima jednadžbe i drugim parametrima. Dobiveni podaci korišteni su u analizama dinamike rezultata.

Provedene su sljedeće istraživačke aktivnosti:

1. Razvoj baze podataka; 2. Izračun teorijskih trendova rezultata iz stvarnih najboljih godišnjih rezultata pojedinog atletičara; 3. Izračun rezultata grupe dobiven iz prosječnih vrijednosti modifi-

ciranih trendova. Nomogrami rezultata sastoje se od dobro definiranih linija dinamike razvoja rezultata od niske razine (-1, 0) do visoke (6, 7) razine razvoja rezultata.

Rezultati

Skupine sprintera, skakača i bacača bile vrlo homogene stoga su teorijski trendovi koji se odnose na specifične skupine atletičara postali osnova za izradu teorijskih modela za prognostički izračun dinamike razvoja rezultata drugih atletičara. Grafički prikaz grupnih stvarnih rezultata vrlo se približio grafičkim pokazateljima dobivenima jednadžbom specifičnom za svaku atletsku disciplinu.

Grafički prikaz teorijskih trendova modificiran je za praktičnu uporabu zato što se teorijskom modelom predvidjelo sniženje rezultata u srednjem stadiju, a u praksi je sniženje rezultata bilo vrlo malo ili ga uopće nije bilo. Teorijski model omogućio je je vrlo točno predviđanje razvoja rezultata u prvoj fazi, ali ne i u drugoj fazi razvoja sportske karijere. Istraživanje je pokazalo da je niska razina rezultata na početku karijere (osobito onih nakon 2. do 4. godine specijaliziranog treninga) uobičajeno povezana sa slabom dinamikom razvoja rezultata i nižim osobnim rekordima. I obrnuto, visoka razina rezultata na početku karijere (gdje se godišnji najbolji rezultati javljaju između 2. i 4. godine specijaliziranog treninga) obično je povezana s visokom dinamikom razvoja rezultata i s višim osobnim rekordima (slike 1 i 2).

Rasprava i zaključak

Usporedba svih skupina otkriva da su teorijski trendovi gotovo paralelni te da se neznatno približavaju jedni drugima osim rezultata sprintera. Uočljiva položenost krivulja u sprinterskim disciplinama upućuje na vrlo slab razvoj rezultata. To znači da su atletičari napredovali neznatno te da su im rezultati, nakon što su dosegnuli svoj maksimum nakon otprilike 7 do 9 godina, sljedećih godina ostajali nepromijenjeni (slike 3 i 4).

Obrazac karakteristika dinamike razvoja rezultata gotovo da je identičan za sve discipline, osim za sprintere. Vrlo je zanimljivo otkriće da su sprinteri postizali više od 91 % svojih najboljih rezultata nakon samo godine dana specijaliziranog treninga te da su više od 95 % svojih najboljih rezultata postizali nakon 3 godine specijaliziranog treninga, a da su preostalih 5 % postizali između 4. i 8. godine specijaliziranog treninga. Ovo bi moglo biti upozorenje da, žele li sprinteri biti uspješni u svojoj disciplini, valja u postupcima selekcije pokloniti puno veću pažnju njihovim genetičkim predispozicijama.

Obrasci karakteristika promatranih atletičara prikazani su u tablicama 2, 3 i 4. Ovo istraživanje

dinamike razvoja rezultata predstavlja preduvjet za kvalitetan rad s atletičarima u pojedinim fazama sportskog razvoja. Istraživanje je otkrilo razlike među sprinterima, bacačima i skakačima s obzirom na dob u kojoj su započeli specijalizirani trening, dob u kojoj su ostvarili svoje vrhunske rezultate i broj godina specijaliziranog treninga koje su trebali da bi ostvarili svoje osobne najbolje rezultate.

Sprinteri su započinjali specijalizirani trening, u pravilu, u šesnaestoj godini, a najbolje rezultate su postizali u dobi od 24 do 25 godine. Bacači su počinjali sa specijaliziranim treningom također u sedamnaestoj godini, a vrhunske rezultate su postizali u 26. – 27. godini. Skakači su sa specijaliziranim treningom počinjali nešto ranije, u 14. – 15. godini, a vrhunske rezultate su postizali u 23. – 24. godini.

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