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AN EXPERT MODEL FOR DETERMINING SUCCESS IN MIDDLE-DISTANCE RUNNING

EKSPERTNI MODEL USPEŠNOSTI ZA TEKE NA SREDNJE PROGE

Abstract

Middle- and long- distance running success is affected by the level and appropriate combination of the various dimensions of a runner's biological status. The purpose of this article is to show the model for assessing a runner's level of competence and, at the same time, to discover the link between the potential success determined by the model and the runner's actual competitive success. In the given reduced potential model for determining success in middle-distance running, we have only focused on the runner's most important potential dimensions in the morphological, motor and functional spaces. The Pearson correlation coefficient was used to assess the correlation between actual competitive success and potential success. The correlation between the runners' actual competitive success and potential success is statistically significant (0,66) ($p<0,01$). The runners' actual competitive success was correlated with each subspace as follows: morphological subspace $r=0.54$ ($p<0.01$), motor subspace $r=0.52$ ($p<0.01$) and functional subspace $r=0.44$ ($p<0.01$).

Keywords: middle-distance running, model, expert modelling, success

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Povzetek

Za uspešnost v tekih na srednje in dolge proge sta pomembni tako raven kot ustrezna kombinacija različnih dimenzij antropološkega statusa tekača. Namen prispevka je predstavitev modela za oceno uspešnosti tekačev na srednje proge in hkrati ugotoviti povezanost med potencialnim modelom uspešnosti in dejansko uspešnostjo spremljanih tekačev. V predstavljenem reduciranem potencialnem modelu uspešnosti v tekih na srednje proge smo se osredotočili samo na najpomembnejše potencialne dimenzije tekača v morfološkem, motoričnem in funkcionalnem prostoru. Povezanost med dejansko tekmovalno uspešnostjo tekačev in potencialno uspešnostjo reduciranega potencialnega modela uspešnosti je bila 0,66 ($p < 0,01$). Dejanska tekmovalna uspešnost tekačev pa je bila s posameznimi podprostori povezana takole: z morfološkim prostorom $r= 0,54$ ($p < 0,01$), z motoričnim $r= 0,52$ ($p < 0,01$), in funkcionalnim $r= 0,44$ ($p < 0,01$).

Ključne besede: tek na srednje proge, model, ekspertno modeliranje, uspešnost

INTRODUCTION

One of the most typical characteristics of today's competitive sport is its selectivity. Essentially, peak performance requires talent and hard work under expert guidance. There are few talented individuals who are capable of maintaining motivation over a long period of time and fewer even who effectively respond to endurance training in a way that causes adaptive changes leading to elite performance. Therefore, it makes sense (considering various aspects such as coaching expertise, finances and – above all – the ethical aspect of sport) to identify potentially successful individuals early in their development and provide them with suitable working conditions to further develop their talent.

Success in middle- and long-distance running depends on a large number of very different dimensions of the runner's biological status. The level of the athlete's motor and functional abilities, personality features, anthropometric measurements and their structured combination are all vital to success. The coach must know which abilities, features and characteristics are vital to performance and what their order of importance is, i.e. what weight of influence each element carries. Only then does the knowledge of developing and modulating individual dimensions become meaningful and useful.

This is the main reason why talent identification, selection and development must be well thought out and dealt with in a truly professional way. These procedures must be based on as complex and as holistic scientific criteria as possible. There are different talent identification models applied in sports science and practice, e.g. TIPS – Talent, Intelligence, Personality, Skill or TABS – Technique, Attitude, Balance, Speed (Williams & Reilly, 2000; Bompa, 1994; Brewer, Balson & Davies, 1995; Kluka, 1999) to assess the most suitable candidates for different sports. However, the accuracy and reliability of all these models is still a problem to overcome.

Recently, expert models have been used for a more accurate talent assessment and prediction of potential competitive success; they are based on artificial intelligence methods and offer researchers a more complex approach to the problem (Ulaga, Čoh & Jošt, 2006; Leskošek, Bohanec, Rajkovič & Šturm, 1992; Tomažin, Čoh & Škof, 2001). In the article, we want to show an expert model for the prediction of middle-distance runners' competitive success and at the same time to establish the relationship between the given potential model of success (assessment of expert modelling) and the athlete's competitive performance (criterion variable).

METHOD

Expert modelling method

An expert model of the reduced potential model of a successful middle-distance runner was built with the help of elementary level variables (leaves of a tree) and variables at derived level (tree knots) (Table 1). We focused our attention on three areas of the runners' biological status: morphological, motor (neuromuscular) and functional. Dimensions in these segments represent only a small but very important aspect of the whole model of success in middle-distance running.

Determining middle-distance runners' success encompassed 17 independent (predicted) variables. For example, five morphological variables were included in the morphological area of RPM at elementary level *(leaves of a tree)* (Table 1): body weight (AT), relative weight (ATAV), body height (AV), fat content (AMASPP) and muscle-mass content (AMISP). At higher levels, the variables were combined in nodes *(tree knots):* body weight (masa), longitudinal measures of the body (dolraz), body volume (volum) and final score of the morphological area (MORFO) (Table 1).

The reduced model of *morphological dimensions* was built primarily on three morphological dimensions that are vitally important for middle-distance running success (Table 1): body weight, longitudinal measures of the body and body volume. As middle-distance running is a weight bearing endurance activity, body mass (via gravitational force) represents a very important influence in running success. A number of research papers (Shepard & Astrand, 1992; Škof, Kropej & Milić, 2002) show that percentage of body fat correlates negatively with running performance as it represents dead weight. The role of active lean muscle mass depends on the length of the running distance. More muscle mass can result in greater muscle force and power, and despite greater gravitational force this can be beneficial over shorter distances (e. g. 800m). However, with distances longer over 10km, excess muscle mass becomes a disadvantage. It is well documented that the longer the running event, the lighter the successful runners tend to be (Tittel & Wutscherk, 1992).

Running performance is influenced by the runner's body height in two ways: directly and indirectly. Taller runners with longer legs have longer levers through which they apply muscle force. Muscle force applied through a longer lever allows a greater range of movement; in running, this means a longer stride which brings about higher velocity. Being taller means having greater overall body mass and also greater lean muscle mass, which in turn means an improved ability to develop force. Due to enhanced biomechanical (a more favourable stride length/frequency ratio) and muscular efficiency (force production), taller runners may have an advantage over shorter ones in shorter distances (Tittel & Wutscherk, 1992). Also, analysis of data obtained from the 1972 Olympic Games showed that taller runners most frequently prevail in short and middle-distance events (Schmolinsky, 1993).

With regard to *functional characteristics,* we believe that in middle-distance running both aerobic and anaerobic abilities are vital for success (Table 1). Middle- and long-distance running require high level of aerobic endurance. Several earlier studies (Morgan, Baldini, Martin & Kohrt, 1989; Powers, Dodd, Deason, Byrd & McKnight, 1983) have shown that maximum oxygen uptake (VO_2max), running velocity at lactate threshold and running economy at high velocity correlate significantly with running success. However, we know that very few elite runners possess high levels of all three variables.

Coaches also know that, despite high aerobic ability, some runners do not compete as well as they should. Middle-distance runners (800m to 3/5km) especially must be able to maintain a relatively high running velocity over the whole race distance. This fact emphasises the role and significance of other running parameters, too – motor abilities which are based on neuromuscular mechanisms (voluntary and reflex muscle activation, muscle force, elasticity of musculo-tendinous structures, running economy at high velocity) and the runner's anaerobic lactate capacity.

Paavolainen, Nummela & Rusko, (1999) and Šturm, Ušaj (1985) have shown that, in addition to aerobic power and running economy, neuromuscular parameters such as contact time, maximum running velocity, the magnitude of take-off force etc. also play an important role in the success of well-trained five-km runners. Similarly, Noakes (1988) states that a runner's performance is not limited by "central" parameters alone (by "central," he refers to aerobic capacity) but also by factors such as muscular power which combine athletes' neuromuscular and anaerobic abilities.

The role of aerobic and anaerobic capacities or the contribution of aerobic and anaerobic energy sources in a running event depends on the intensity and duration of running (Škof, Kropej & Milić, 2002). This is why in the modelling of a *reduced model of motor dimensions* we have chosen the available parameters that have thus far proved to be the most reliable predictors of competitive running success.

We have combined individual variables into a hierarchical tree, where the final success of a middle-distance runner was determined on the basis of a criterion function (normalizers) and tree ponders (weights) (Table 1) (Ulaga, Jošt & Čoh, 2006; Ulaga, 1999; Leskošek, 2000).

Apart from numerical grading, normalizers were also graded into five-step intervals with attributive marks (excellent (exc.), very good (v.g.), good, satisfactory (satisf.), unsatisfactory (unsatisf.)). In the case of body fat content, which is a falling function (AMASPP, Table 1), the highest mark, excellent, numerically representing the upper limit 5,0, was given to the subjects with fat content (fat mass/body weight in %) 5, very good (4.0) to one whose fat content was 7, good (3.0) to the subject whose fat content was 9 etc. Intermediate results are thus calculated with numerical marks (e.g. fat content 6 gives a numerical mark of 4.5). Normalizers were set to the senior age group, taking into account the values that are regarded as peak performance in middle-distance running. This is especially important from the point of view of longitudinal monitoring of an athlete's development. To determine the weights of the tree, we used the method of dependent weights assignment (Ulaga, Jošt & Čoh, 2006). In this method, weights are assigned with regard to the relative share of an individual variable, also in determining the values of derived criteria. The method of dependent weight determination originates from the principle that the sum of all elementary variables in a model of success must be 100. On the assumption of the linear connection between criteria, the weights of the derived criteria equal the sum of the weights of directly subordinated criteria. Directly subordinated criteria can either be basic criteria, which originate in given derived criterion, or the derived criteria themselves, which originate in other derived criteria regardless of their level in the tree of the success model (Ulaga, Jošt & Čoh, 2006; Ulaga, 1999).

To work out the scores by means of a reduced potential model of success, we used the SMMS computer programme (Leskošek, 2000).

Subjects

47 Slovene middle-distance runners participated in the study. The subjects were taken from four age groups: senior (6 subjects), junior (14), youth (14), and boys (12). They were tested in the period between the beginning of January and the end of March, from 2001 to 2003. On the day of their testing, all the participants were injury-free and healthy.

Experimental procedure

The subjects first performed a maximum velocity test. Then, dynamic parameters of their technique were measured, followed by anthropometric measurements and speed and power tests; after a few hours' rest, their maximal aerobic power (VO_2max) was measured on a treadmill.

Description of testing protocol and dependent variables

A sample of dependent variables was chosen so that it covers a large portion of the middle-distance runners' motor and functional space, and determines middle-distance running success to the highest possible degree (Table 1).

Measuring maximum velocity was estimated by a 30m-flying start time which was measured with a Brower Timing System (USA), and top speed was calculated (MMAXV). Sprint stride length and frequency, contact and flight times were measured with contact mats (Globus, Italy). We used these parameters to compute Index Activity (TACTIV-the ratio between contact time and flight time).

Table 1: Reduced potential model of success in middle-distance running

Code	*Code name*	*Unit*	*Weight*	*Normalizers*
Competition performance			100	
MORFO			***26***	
masa	*body mass*		*11*	
AT	body weight	kg	5	45:0, 53:1, 57:2, 62:3, 65:4, 67.5:5, 69:4, 72:3, 74:2, 75:1, 80:0
ATAV	relative weight	kg/cm	6	0.29:1, 0.32:2, 0.34:3, 0.35:4, 0.365:5, 0.38:4, 0.39:3, 0.4:2, 0.41:1
dolraz	*longitudinal measures*		*3*	
AV	body height	cm	3	160:1, 170:2, 173:3, 175:4, 180:5, 185:4, 187:3, 190:2, 200:1
volum	*body volume*		*12*	
AMASPP	fat content (Matiegka)	%	8	5:5, 7:4, 9:3, 10:2, 11:1, 13:0
AMISP	muscle-mass content (Matiegka)	%	4	47:1, 49:2, 50.5:3, 52:4, 54:5, 56:4, 57.5:3, 59:2, 60:1
MOTOR			***37***	
MOČ	*strength*		*12*	
ZCMJVOD	countermovement jump height CMJ	cm	8	27:0, 30:1, 34:2, 38:3, 45:4, 50:5
ZSJVOD	vertical jump height SJ	cm	2	23:0, 26:1, 30:2, 34:3, 40:4, 45:5
CMJ/SJ(%	CMJ : SJ ratio	%	2	107:1, 109:2, 112:3, 115:4, 118:5
HITROST	*speed*		*13*	
MMAXV	maximum velocity	m/s	9	8:0, 8.5:1, 8.9:2, 9.2:3, 9.4:4, 9.6:5
TACTIV	activation index		4	0.55:1, 0.6:2, 0.65:3, 0.7:4, 0.75:5, 0.8:4, 0.85:3, 0.9:2, 0.95:1
VZDRZLJ	*endurance*		*12*	
DVLT	LP velocity	km/h	3	10.5:1, 11,5:2, 13:3, 15:4, 16:5
DVKON	test's terminal velocity	km/h	9	14:1, 15.5:2, 17:3, 18.5:4, 20.5:5
FUNKCIO			***37***	
aerobni	*aerobic*		*21*	
DVO2MAX	max oxygen uptake -REL	ml/kg/mi	7	54:1, 60:2, 65:3, 73:4, 78:5
VO2AMAX	max oxygen uptake -ABS	ml	11	2900:0, 3400:1, 3900:2, 4400:3, 4900:4, 5500:5
DVO2LT	oxygen uptake at LP	ml/kg/mi	3	40:1, 44:2, 49:3, 52:4, 56:5
anaerobni	*anaerobic*		*16*	
DLAMAX	lactate at VO2max	mmol/l	9	4:0, 6:1, 8:2, 10:3, 11.5:4, 12.5:5
DRQMAX	respiratory quotient at VO2max		7	1:1, 1.07:2, 1.12:3, 1.15:4, 1.18:5

Measuring speed strength was estimated by a vertical squat jump (ZSJVOD) and countermovement jump (ZCMJVOD) which were measured on a force platform (Kistler, 9278, Winterthur). A parallel squat jump was performed vertically from a mid-position (thighs parallel to ground, right angles at the knees), back straight, arms at sides. The subject performed the jump without countermovement. The countermovement jump was begun with the subject standing straight and with arms at sides, then lowering the body with a downward movement (as low as 90° at the knees) and immediate vertical jump. The CMJ/SJ ratio enabled us to assess a runner's muscle system elastic efficiency.

Anthropometric measurements were used (International Biological Programme (IBP, Weiner & Lourie, 1969) to compute each subject's body weight/body height ratio (ATAV) and body composition: the contributions of lean muscle tissue (AMISP) and fat tissue (AMASPP). Fractionation of body mass for the estimation of body composition was done by Matiegka's method (1921) (Cattrysse, 2002). We measured joint diameters, joint circumferences and skin folds. To do this we used the following anthropometric instruments: a pair of compasses, calliper, metric tape and skin-fold calliper. Body weight (AT) was measured with Tanita TBF-105 body fat monitor scales (Japanese manufacturer) with accuracy up to 0.1kg. Body height was measured with a standard anthropometer (Swiss manufacturer, GPM, Siber Hagner & Co., Ltd.) Results are measured with accuracy up to 0.5 cm.

Functional and biochemical parameters were estimated by an incremental test to exhaustion, performed on a treadmill. After a six-minute warm up at 5 and 6 km·h^{-1}, the running velocity increased by 1km·h^{-1} every two minutes at constant 2% incline. Initial velocity was 8 km·h^{-1}. Aerobic capacities ((maximum oxygen uptake – VO$_2$max, its absolute (DVO2AMAX) and relative values (DVO2MAX)), and this run's velocity at VO$_2$max (VKON), oxygen uptake at lactate threshold (DVO2LT), velocity at lactate threshold (DVLT) and the runners' respiratory quotient at VO$_2$max (DRQMAX) were assessed on the basis of spirometric parameters obtained with a Cosmed K4b2 (Rome, Italy) spirometric system (McLaughlin, 2001). Heart rate was measured with Polar heart rate monitors (Oulu, Finland). Lactate measurements before (Lamir) and after exercise (DLAMAX) were obtained from a blood micro-sample taken from the runners' earlobe (Eppendorf Ebio+).

Criterion variable

Criterion (dependent) variable was calculated from the runners' best performances at 800, 1000 and 1500m. Results were converted into IAAF tables points (Spiriev, 1998).The points average represented the final criterion variable (TMT_avrg). The highest score indicates the best performance.

Data processing methods

Correlation between criterion variable, competitive success (TMT avrg) and variables at elementary (leaves) and derived levels (knots) were determined by means of Pearson correlation coefficient.

RESULTS

At the level of elementary variables (Table 2) in the morphological space, all variables (except body height, AV) correlate statistically significantly with the criterion variable. The strongest

Table 2: An example of two runners' results in the same age group, using the method of expert modelling (i); correlation between competitors' raw results in individual variables and competitive success (ii); correlation between potential success assessment and competitive success (criterion variable (TMT_avrg)) (iii).

			(i)				*(ii)*	*(iii)*
	competitor	A-17 years		competitor	B-18 years		varia/TMT_avrg	score/TMT_avrg
		Score			Score			
Code	Res.	f(x)	Mark	Res.	f(x)	Mark		
Final score		3.22	v.g..		2.24	good		0.658**
MORFO		3.88	v.g.		2.43	good		0.536**
masa		4.73	exc.		2.25	good		0.400**
AT	67	4.8	exc.	72.9	2.55	good	0.383**	0.380**
ATAV	0.37	4.67	exc.	0.4	2	good	0.364**	0.359*
dolraz		4.6	exc.		4.26	exc.		0.202
AV	182	4.6	exc.	184	4.26	exc.	0.286	0.202
volum		2.93	good		2.13	good		0.522**
AMASPP	8.2	3.4	v.g.	9.9	2.1	good	-0.453**	0.424**
AMISP	49	2	good	49.3	2.2	good	0.476**	0.441**
MOTOR		2.93	good		1.03	satisf.		0.518**
MOČ		2.32	good		1.34	satisf.		0.139
CMJVOD	36	2.5	good	30.9	1.22	satisf.	0.235	0.215
ZSJVOD	33.8	2.95	good	28.6	1.65	satisf.	0.285	0.283
CMJ/SJ(%)	107	1	satisf.	108	1.5	satisf.	-0.132	-0.108
HITROST		2.28	good		0.74	unsatisf.		0.364*
MMAXV	9.22	3.1	v.g.	8.37	0.74	unsatisf.	0.547**	0.502**
TACTIV	0.979	0.42	unsatisf.				-0.042	0.009
VZDRZLJ		4.25	exc.					0.682**
DVLT							0.359	0.286
DVKON	19	4.25	exc.				0.725**	0.709**
FUNKCIO		3.03	v.g.		3.33	v.g.		0.436**
aerobni		4.18	exc.		3.4	v.g.		0.660**
DVO2MAX	74.3	4.26	exc.	68.2	3.4	v.g.	0.567**	0.561**
DVO2AMAX	4980	4.13	exc.				0.685**	0.700**
DVO2LT							0.345	0.298
anaerobni		1.53	satisf.		3.23	v.g.		-0.113
DLAMAX	6	1	satisf.	7.7	1.85	satisf.	0.075	0.064
DRQMAX	1.08	2.2	good	1.18	5	exc.	-0.227	-0.226
TMT_avrg		848			722			

Legend: *p < 0,05, ** p < 0,01

correlation of an individual variable with criterion variable (TMT_avrg) is reflected in two variables: proportion of fat (AMASPP, r= - 0.453) and lean muscle mass (AMISP, r=0.476). Within the motor subspace describing velocity (HITROST), we ascribed the greatest importance to the ability of the athlete to develop maximum velocity (MMAXV), which is also reflected in the high correlation of this variable with the criterion variable (MMAXV, r=0,547). Within the motor subspace that describes endurance (VZDRZLJ), the highest correlation of all in the whole tree is with the velocity at VO_2max (DVKON, r=0.725) and much less significant with velocity at lactate threshold (DVLT, r=0.359). In the framework of correlations within the functional subspace of the variables with the criterion variable, it is easy to observe a strong correlation with aerobic capacities, especially with the maximum (absolute) oxygen uptake (DVO2AMAX, r=0.685) variable. Again, it is noticeable that the correlation with the variable related to lactate threshold values is weaker (oxygen uptake at LT, DVO2LT, r=0.345).

Correlation between individual spaces and their final assessment with actual success (Table 2) reveals statistical significance with a 1% risk level in all spaces; specifically: morphological (r=0.536), motor (r=0.518) and functional space (r=0.436). The final assessment correlation with the actual success is r=0.658, which is statistically significant at a 1% risk level.

DISCUSSION

The most important finding of this research is that the designed reduced model of chosen parameters and their weights suitably predicts runners' competitive success. The correlation of the model (the final assessment of the individual runner) with the runners' competitive success is 0.66. The correlation of individual sets of variables with competitive running success is also relatively high, while correlation of individual variables with competitive running success ranges from low and statistically insignificant to very high.

In the space of morphological dimensions, a hypothesis was confirmed that body fat mass has a negative influence while lean muscle mass has a positive influence on competitive middle-distance running performance. The negative role of fatty tissue in running and other endurance athletes has been confirmed in numerous studies (Shephard & Astrand, 1992; Škof, Kropej & Milić, 2002). Runners combining 800 and 400m are as successful as those who combine 800 and 1,500m. It is therefore not surprising that runners who tend toward mesomorph are well suited to these events (Tittel & Wutscherk, 1992). The longer the distance, the lower the body mass of successful runners. Data on Olympic finalists' body weight in middle-distance events from 800m to 10, 000m supports this completely (800m: 69.6kg; 1500: 63kg; 5km: 62.9kg: 10km: 61.6kg) (Tittel & Wutscherk, 1992).

Body height in our model is only moderately correlated with competitive running success. The average body height of our sample of runners was 178.8cm ± 5.2cm, which is 2cm short of a ideal value when we defined normaliser intervals. The interval was chosen according to available data from earlier publications: 800m – 184.4cm; 1,500m – 178.6cm; 5km – 176.6cm in 10km – 174.8cm (Tittel & Wutscherk, 1992). A very low standard deviation of body height in our sample may be one reason for lower correlation, the other one being the fact that perhaps our interval of ideal body height was set a little too high.

In line with the results of other studies (Morgan, Baldini, Martin & Kohrt, 1989; Dodd, Deason, Byrd & McKnight, 1983; Noakes, 1988) and our expectations, aerobic capacities play a key role in our model of success. Our model shows a particularly high correlation between competitive success and maximum (absolute) oxygen uptake (DVO2AMAX). Middle-distance events (800 and 1,500m) require the activation of all aerobic potentials – they are run at an intensity of 100-120% or more VO_2max velocity – and at the same time, due to the importance of speed, require a relatively mesomorph type of a runner (with a somewhat higher proportion of muscle mass). This is also the reason why the correlation of middle-distance runners' success with speed and oxygen uptake at lactate threshold is much lower than the correlation between runners' competitive success and maximum oxygen uptake values. Correlations with values at lactate threshold are more significant in long-distance running.

On the basis of earlier research, we predicted that the values to determine anaerobic capacities would be interconnected, but the two tests that we chose to prove this, i.e. lactate content at maximum oxygen uptake (DLAMAX) and respiratory quotient at maximum oxygen uptake (DRQMAX), did not satisfactorily show that. None of the chosen tests is significantly correlated with the criterion variable. Runners were tested at the beginning and in the middle of the preparation period (between December and March), when their training was not yet geared towards anaerobic lactate capacity. This is why their blood lactate values were low. Another reason may be the fact that incremental treadmill test protocol is not a very specific anaerobic lactate capacity test. Despite these two likely reasons, the fact is that research (Vučetič, 2007; Šentija, Vučetič & Marković, 2007) actually shows that in this test middle-distance runners record blood lactate levels of up to 15 mmol/L while long distance runners reach values of around 12 mmol/L. The values also depend on the test protocol (Vučetič, 2007).

To improve the model, it would be reasonable to introduce another variable to better represent runners' anaerobic lactate capacities. We could thus enrich the battery of tests for runners with one of the anaerobic tests: MART (maximal anaerobic running test, Paavolainen et al, 1999), 400m test with maximum blood lactate at the end of the test or even Wingate test (less suitable for runners).

Our model confirms that for elite performances in middle-distance running, the ability to develop very high running speed and maintaining a relatively high speed over the whole distance is as important as high aerobic capacity. Maximum sprinting velocity (MMAXV) and maximum velocity reached during the incremental test protocol on the treadmill (DVKON) were among the model's strongest predictors of competitive success. The correlation between MMAXV and middle-distance running success was 0.55, which is a little lower than the one recorded by Paavolainen et al (1999), 0.63, in their research into the correlation between 5km performance and maximum speed (20m flying start) of orienteerers.

Lower than expected and lower than the findings of earlier research were the correlations between middle-distance competitive success and variables representing the ability to develop force at speed (ZSJVOD and ZCMJVOD), the ability to use elastic muscle potential (CMJ/SJ) and Index Activity (TACTIV).Their role was most probably combined in the maximum velocity test, as sprinting speed is closely correlated with both power (ZSJVOD (r=0,561), ZVMJVOD (r=0,537)) and the ability to use muscle's elastic component (TACTIV) (r= -0,36).

Two runner case study is presented in table 2. By analysing the results of each individual's expert system, we can determine that while competitors A and B were similar in their functional abilities, competitor B had a lower score in morphological space due to his higher body fat percentage and overall body weight. In the motor space, competitor B's score was lower because of his lower maximum velocity. In this way, the model we created allows us to individually evaluate the chosen dimensions that influence the subject's success. In our case, normalisers were set to senior age group (universal model) with regard to the values achieved by elite performers. We must, therefore, take into account that subjects in younger age groups do not achieve scores as high as they would if normalizers were set to the corresponding age group. We have nevertheless decided to apply a universal model that facilitates longitudinal monitoring of a competitor's success and the development of his individual characteristics.

CONCLUSION

It is certainly true that running research has been wide and varied. There is an enormous body of information; however, studies usually give consideration to one particular aspect at a time. Thus, the need arises to develop a model which would describe and combine into a whole only the factors playing the most influential role in middle-distance running success. In real life situations, this would enable researchers to identify advantages and disadvantages of each individual, which has been demonstrated in the case studies of competitors A and B (Table 2). Being aware of an individual's advantages and disadvantages is of key importance to further modifying the training process, and can lead to better competitive success. This research study has certainly contributed to the theory of success in middle-distance running.

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