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An Attempt at the Identification of Anthropometric Conditioning of Sport Results in 400-Metre Men's Hurdles

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Key words: *somatic build, sprinters, hurdles.*

Abstract

Background: *The purpose of this work is to verify the opinions concerning the preferred somatic build and to define current parameters of the model of the sports-master in 400-metre hurdles.*

Material/Methods: *Data about the height and the body mass of the best world competitors in 400-metre hurdles have been used in the research. Results were divided into three levels: below 48 s; 48.00–48.99 s and 49.00–49.99 s. For all groups the following indexes were defined: Rohrer's, Quetelet I and Quetelet II. The dependence between the sports level and the somatic parameters were rated by means of the coefficient of Pearson's correlation. The differentiation between the somatic features in each group of proficiency, was evaluated by means of the t-Student test.*

Results: *In 2006, statistically important relations between the sports result of best hurdlers and the value of Quetelet's II factor (0.03) was obtained. Then in 2007, the essential positive dependence (0.009) between the result and the value of Rohrer's factor was observed. None of the analysed parameters was found to be statistically important in every of the chosen years.*

Conclusions: *Body height in the group of best hurdlers in most cases was located in values between 182.5–183.5 cm while the body mass between about 72–73 kgs. Besides, the hurdlers are characterized with the slender somatic build, which is proven by convincing values of slenderness indicators: Rohrer's (ca. 1.20), Quetelet's I (ca. 400) and Quetelet's II (ca. 22). Rohrer's factor is particularly valuable in this case.*

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Introduction

The somatic build is one of basic criteria of selection [1]. On the one hand, it gives extensive possibilities of choosing people whose physical conditions predestine them to attaining high sports results; on the other hand, however, the question arises whether this really is a necessary factor.

Athletics is a many-sided discipline using forms of the movement natural to man, such as running, jumping and throwing. This versatility makes training and attaining high results possible by men of considerably diverse somatotypes. Nevertheless, it seems that there are indispensable parameters conditioning high sports results.

400-metre hurdles forces competitors, while running the course, to clear 10 hurdles of the height of one yard (91.44 cm). This, in turn, produces requirements of suitable motor (speed, power, endurance, agility) and technique preparation. Simultaneously, however, the question appears whether physical conditions are not a parameter which, into the essential manner, affects (or even limits) the efficiency of the realization of this motor task. For years there has been an opinion that a hurdler must be tall, because it not only makes the clearing of hurdles easy to him, but it also allows him to minimalize the number of steps at the distance, and, first of all, at interhurdle distances. The results of the conducted analyses suggest that this parameter can have an essential meaning for the sports result. Affirmative dependences of the number of steps at the distance, for leading female hurdlers of the world, were obtained by Letzelter [2,3].

The connection of the step rhythm with the result of men's 400-metre hurdles is supplied with much better documentary evidence. Confirmatory thesis of positive correlations between the number of steps and the result was, for instance, in the work of Kostial [4] or Iskra [5]. The skill of the maintenance of the rhythm of the course, the number of steps at the last interhurdle distance and the slight fall in the speed of the run in the second half of the distance, those are the key elements for attaining high results in running [5].

It appears, however, that the claim that height and, what is more, the minimum number of steps at the distance is the most important factor, is an oversimplification. Superb results attained by shorter competitors contradict it. The leading hurdlers of recent years have been departing from the accepted model of the champion many times. Bershawn Jackson – 173 cm tall (the world champion of 2005, the Olympic bronze medallist of 2008), Dai Tamesue – 170 cm tall (the bronze medallist of the world championships in 2001 and 2005), Wintrop Graham – 178 cm tall (the Olympic vice-champion of 1992, silver medallist in 1991 and bronze medallist of the world championships in 1993) or Fabrizio Mori – 175 cm tall (the world champion of 1999, the vice-champion of 2001) can be a few good examples of that. What is even more interesting is the fact that among Polish leaders in this event there have also been competitors of a rather shorter build (Paweł Januszewski – 178 cm, Ryszard Szparak – 178 cm, Jerzy Hewelt – 175 cm, Ryszard Stoch – 180 cm and Tadeusz Kulczycki – 180 cm).

The matter of body mass of the 400-metre hurdlers seems to be a similarly controversial one, to be more precise, the matter of correlation between the body mass and the body height. A generally prevalent opinion, classifying 400-metre hurdles to the group of events of high-speed training character, seems to support the need for the properly developed muscular mass. Of course, it would be difficult to suppose that hurdlers would be characterized with athletism of the body comparable even to sprinters. Yet compared to runners at the distance of 800 metres this would probably be a distinguishing factor. Analysing the physique of best competitors in history – we do not find many examples of competitors about the considerable musculature. Samuel Matete (the world champion of 1991 and the silver medallist of 1993 and 1995) or James Carter (the silver medallist of the world championships of 2005, the Olympic vice-champion of 1996) can be of example. But we speak here rather about "the impression" which is exerted by the competitor with one's own build and not data supported by the conducted analyses. What is interesting, however, is the fact that the tendency to increase the height and the mass of the body of Olympic finalists already existed in years 1976–1988 [6].

The present look at the leading competitors induces us rather to opinions that most of them are characterized with a rather slender somatic build (eg. Kevin Young – the world champion, Edwin Moses – two-time Olympic champion, Amadou Dia Ba – the Olympic vice-champion, Bershawn Jackson – the world champion).

A suitable height of the body is considered to be the most desirable feature of the master-class hurdler's build. Yet it is not a decisive factor itself. There is no point for a hurdler in possessing parameters proper rather for the volley-ball player or the basketball player. As Gralka says [7]: "(…) Tallness does not at all predestine to achieving good results in hurdling. Proper proportions of the body are of importance. A long trunk and a neck add several centimetres of the height indeed, yet they do not make clearing the hurdle easier at all". Such an opinion is also shared by Puzio [8]. The height of the position of the gravity centre of a body is not decisive either. A too strongly muscled trunk, with relation to legs, and a heavy head raise the centre of gravity considerably; nonetheless, this does not help with hurdling".

The situation in which the competition was played had an influence on the earlier opinions emphasizing parameters of the competitors' body build (most of all the height). The rivalry on the slag-pavement was on the agenda at the end of the sixties. The synthetic track, which was introduced during the Olympics in Mexico in 1968 – the superb world record set by David Hemery 48.12 s [9] – changed a little the requirements for hurdlers. The greater elasticity by which it is characterized permits competitors to compensate a (possible) shorter height of the body with the procurance of a greater speed of the run and, what is more, easier realization of rhythm foundations. That is, one can venture saying that the present meaning of the height is decreasing. A common use of synthetic tracks prefers quick competitors too. That is why one can suppose that nowadays training leads to a greater development of the musculature of the 400-metre hurdlers.

The aim of this work is to verify the opinions, concerning the preferred somatic build and to define current parameters of the model of the sports master in 400-metre hurdles. This information should determine the essential premise in the process of the sport selection and also guide the planning of the sports training.

Material and methods

Data about the height and the weight of the best world competitors in 400-metre hurdles have been used in the research. The range of the analysis embraced 100 best results in years 2006-2008. The data were introduced for three following years so that the obtained results could depict the current and constant state of affairs.

To define whether there are differences among competitors of a different sports level – the competitors were divided into three different levels within the framework of 100 best results:

- I – competitors who obtained results below 48 s,
- II - competitors who obtained results in the section 48.00–48.99 s,
- III - competitors who obtained results in the section 49.00–49.99 s.

On the basis of the gathered information there are three qualified coefficients of the slenderness: Rohrer's, Quetelet's I and Quetelet's II, known also as the BMI (Body Mass Index). Those coefficients were enumerated according to the following examples [10]:

ROHRER'S FACTOR = (body mass [g] x 100) / (body height [cm])3
QUETELET I FACTOR = body mass [g] / body height [cm]
QUETELET II FACTOR = body mass [kg] / (body height [m])2

The result and height-weight data of competitors were determined on the basis of the latest statistical publications of the International Association of Athletics Federations (IAAF) [9,11,12], the European Athletic Association (EAA) [13,14], the International Association of Athletics Federations

(ATSF) [15,16,17], and also official publishers of the world championships in the track and field [18] and the European championships in the track and field [19]. In addition, these data have been supplemented, when needed, with some information from official IAAF Internet sites [20] and the EAA statistics [21].

The studied data were presented by arithmetical averages ($\bar{x}$) with regard to standard deviations (SD).

The attempt to define the dependence between the sports level (the result of 400 m hurdles) and the parameters of the somatic build was rated by means of the coefficient of Pearson's correlation. The differentiation between the parameters in each group of proficiency and each year was evaluated by means of the t-Student test.

Calculations were performed with the computer technique using Statistica (v. 7.1) and Microsoft Excel software.

Results

In the first part of the analysis one marked average values for each parameter in the successive seasons. These data were presented in Tables 1–3.

In the analysed years one did not note down any considerable changes in the average of one hundred best results in the world (Tab. 1–3). The best result average was noted in the year of the World Championships in Osaca in 2007 (Tab. 2), the same year the hundredth result in the world was the best one over three years (2006 – 50.37 s; 2007 – 50.28 s; 2008 – 50.29 s). The number of results submarginal of 50 seconds can also be an indication of the level change. In 2006 one noted 70 such results, in the following year there were 80 of them; however, in 2008 there were 67. It seems that the average level of leading hurdlers of the world was imperceptibly higher in 2007, though there was no essential statistical difference in the average of 100 best results in the world.

The average height of one hundred best hurdlers in years 2006–2008 was put in the section of almost 1 cm (181.81–182.82 cm), the size of this parameter did not yield any significant changes (Tab. 1–3). It occurs that the results can show the current tendency among the best.

Tab. 1. Analysed parameters in the group of 100 best hurdlers of the world and of each level of proficiency in 2006

Result (s)	Body height (cm)	Body mass (kg)	Quetelet I factor	Quetelet II factor	Rohrer's factor
Average for results 47.00 – 47.99 s (n=4)					
47.66 ±0.26	**182.75** ±6.65	**73.25** ±7.80	**400.51** ±34.98	**21.92** ±1.79	**1.20** ±0.11
Average for results 48.00 – 48.99 s (n=17)					
48.63 ±0.30	**183.53** ±5.19	**74.53** ±5.45	**405.83** ±22.64	**22.11** ±1.11	**1.21** ±0.07
Average for results 49.00 – 49.99 s (n=49)					
49.52 ±0.28	**182.22** ±4.87	**73.44** ±4.80	**403.10** ±25.45	**22.14** ±1.58	**1.22** ±0.11
Average "100"					
49.50 ±0.69	**182.52** ±5.70	**73.30** ±5.27	**401.48** ±24.04	**22.01*** ±1.40	**1.21** ±0.10

** relevance at the level of 0.05*

Analysing the average of the body height at various result levels, one can notice no significant differences. The indicators obtained for the best result group (results below 48 s) in 2007 and 2008 (Tab. 2–3) are the exception here. Yet it is hardly a trend, because the number of competitors who fulfil the criteria of the classification to this group is low. It is difficult to draw a univocal conclusion on the basis of just two results in these years (altogether there were three competitors).

Tab. 2. Analysed parameters in the group of 100 best hurdlers of the world and of each level of proficiency in 2007

Result (s)	Body height (cm)	Body mass (kg)	Quetelet I factor	Quetelet II factor	Rohrer's factor
Average for results 47.00 – 47.99 s (n=2)					
47.67 ±0.08	**187.00**[A, B] ±1.41	**80.50** ±4.95	**430.39** ±23.21	**23.01** ±1.07	**1.23** ±0.05
Average for results 48.00 – 48.99 s (n=21)					
48.46 ±0.31	**182.61** ±6.25	**73.72** ±5.36	**403.49** ±21.65	**22.11** ±1.18	**1.21** ±0.09
Average for results 49.00 – 49.99 s (n=57)					
49.54 ±0.29	**181.13** ±5.51	**72.17** ±5.29	**398.33** ±25.34	**22.01** ±1.49	**1.22** ±0.10
Average "100"					
49.40 ±0.67	**181.81** ±5.49	**72.76** ±5.31	**400.06** ±24.48	**22.02** ±1.39	**1.21*** ±0.10

** relevance at the level of 0.05; A – significant difference in the reference to group of 48.00–48.99 s results*
B – significant difference in the reference to group of 49.00–49.99 s results

Tab. 3. Analysed parameters in the group of 100 best hurdlers of the world and of each level of proficiency in 2008

Result (s)	Body height (cm)	Body mass (kg)	Quetelet I factor	Quetelet II factor	Rohrer's factor
Average for results 47.00 – 47.99 s (n=2)					
47.52 ±0.38	**188.00** [A, B] ±0,00	**80.50** ±4.95	**428.19** ±26.33	**22.78** ±1.40	**1.21** ±0.07
Average for results 48.00 – 48.99 s (n=19)					
48.61 ±0.6	**183.25** ±6.51	**72.92** ±4.40	**397.90** ±19.26	**21.74** ±1.28	**1.19** ±0.10
Average for results 49.00 – 49.99 s (n=46)					
49.57 ±0.28	**181.77** ±5.36	**71.81** ±6.32	**394.88** ±30.79	**21.73** ±1.70	**1.20** ±0.11
Average "100"					
49.54 ±0.65	**182.82** ±5.64	**72.78** ±5.99	**397.93** ±28.25	**21.78** ±1.56	**1.19** ±0.10

A – significant difference in the reference to group of 48.00–48.99 s results
B – significant difference in the reference to group of 49.00–49.99 s results

A similar dependence can be noticed in the body mass: a clearly greater value of this parameter refers only to the least numerous group of competitors achieving results below 48 s. In the case of the body mass, it is also the information about the competitor's body. The results prove a large spread of the body mass of leading competitors; however, the extreme results belong to exceptions (apart from two runners of very low body mass – below 60 kgs). In the light of these gathered data, we can, however, conclude that, at present, competitors of high body mass (according to the official information, there is a lack of competitors above 90 kgs) do not belong to the world advance party. So it seems legitimate to state that the present tendency of the advance party are hurdlers of the average somatic build and of the height imperceptibly exceeding 180 cm.

The essential information of the somatic build is delivered by the indicators of mass proportion and the body height. The comparatively least informative from them is Quetelet's II coefficient, also known as BMI (abbreviation). Yet one points out the fact that this is not a fully adequate tool for estimating the somatotype of sportsmen. Due to a low content of fatty tissues, the BMI value can be extortionated at them and can suggest the overweight which in fact is a rather surreal effect (particularly at record-seeking sportsmen representing the highest world level). With relation to values obtained in years 2006 and 2007, the size of the BMI decreased slightly in 2008 – all the time, however, being within the limits nearing 22.

The Quetelet's I coefficient seems to be a more reliable factor. With the exception of the situation in the best result group in years 2007 and 2008, this parameter is nearing in all the remaining groups and years to 400, though results only for the year 2006 in all result sections are above 400. Such a value suggests the hurdlers' slender somatic build. In all the analysed years, hurdlers obtaining results in the section 49.00–49.99 s produced evidence of the imperceptibly more slender physique than those whose results were situated in the section 48.00-48.99 s. Those, in turn, (with the exception of year 2006) were averagely more slender than the group of the best competitors. Due to a limited number of hurdlers in the best group (results below 48.00 s), which was mentioned before, it is hard to treat this as binding. One ought to notice, however, that all differences within the range of Quetelet's I factor described above were slight and one did not show essential statistically differences among them.

Last from the qualified parameters was Rohrer's coefficient. It is proper to notice that values for the II and III result groups and also for all of "100" results were identical in the year 2006 and 2007 (respectively 1.21; 1.22 and 1.21). In the Olympic year (2008) best hurdlers proved to be of slightly more slender body build than in the previous two years. However, statistically significant differences among each result group in each year have not been shown. The size of Rohrer's factor for the best 400-metre hurdlers of years 2006-2008 reached values nearing to 1.20.

One did not find essential differences among average values of the analysed parameters for 100 best results in years 2006–2008. One did not show essential differences in the result of the analysed parameters among groups of proficiency in the year 2006 either. In 2007, an essential difference in the body height in the group of competitors who obtained the result below 48 s and others was proven. However, one ought to pay attention to the fact that in the group of the best competitors only two results have been noted; therefore, the results are hardly representative. An identical situation occured in 2008, when two essential differences of the body height between the best group (below 48 s) and the others was noted – yet again in the group of the fastest ones only two results were marked.

In 2006, the statistically important correlation between the sports result of the best hurdlers and the value of Quetelet's II factor (0.03) was obtained. Then in 2007, an essential positive dependence (0.009) between the result and the value of Rohrer's factor was obtained. However, essential dependences for the analysed parameters were not revealed in 2008 .

The formula of analysis in the three successive seasons undertaken in this paper permitted seizing the current state and also observing a possible trend of changes of chosen somatic build parameters. On the other hand, an analysis of parameters in three years treated as one group was given up, because some competitors could belong to the world's top in the analysed period in every year, which could upset the gathered results. The applied solution allowed avoiding fortuities which often accompany single analyses. An analysis accomplished this way analysis illustrates the latest data about somatotypes of world class hurdlers.

Discussion

The continuous increase in the level of rivalry in sport and the research on solutions leading to the maximization of sports results is not without significance either. It influences the process of selection and sport selection itself. The somatic [1] build is one of basic criteria indeed. This occurrence also influences the rotation parameters of "the model of a sports champion".

Hurdlers' somatic build became a subject of interest for researchers in 1960s. The opinion that the height is a factor requisite and basic for a hurdler reigned universally for years. One of the first Polish coaches specializing in hurdler racing affirmed that the longer the stride length, the smaller the number of steps in the course and eventually the better result at the finish line. Simultaneously, however, he pointed out that the height itself was not a decisive factor, and the height position of the pubic joint has the key-meaning here – because it allows a competitor to clear a hurdle [7]. As

the calculation method of a desirable relation of the body length to the height of the position of the pubic joint for runners on the distance of the 400m hurdles, he proposed the formula:

A : S < 1.95 where:

A = the height of the body,

S = the height of the position of the pubic joint

For organisational reasons, there is no possibility to measure all world's best hurdlers. Although this is not a scientific indicator, it can play an auxiliary part in the coaching (selection) of the 400-metre hurdlers.

A little earlier the height (178.03 cm) and the mass of the body (72.88 kgs) among best (n=16) Polish hurdlers was qualified by Janusz [22]. A similarly numerous group of juniors (n=17) was an object of Skibińska's research [23]. Then a dissertation concerning the somatic build of best hurdlers in the world was written by Ważny [24]. He focused on participants of the Olympics from years 1960 (n=35) and 1964 (n=41). The results obtained by him proved increasing of both the height and the body mass in successive years (178.5 cm and 69.4 kgs and 180.6 cm and 73 kgs respectively). Interestingly, this tendency was confirmed by Ważny and Sozański's following research concerning the finalists of the Olympics in Moscow in 1980 (181,7 cm and 71,1 kgs) [25] and also the following elaboration by Sozański and co-authors [6] concerning the finalists of the Olympic Games in Montreal (in 1976 – 184.5 cm and 75.2 kgs) and Seoul (in 1988 – 183.8 cm and 78.3 kgs). Albeit in the case of the finalists from Seoul there was a slight decrease in the average of the body height followed by a considerable increase in the average of the body mass. Within these parameters obtained by other authors data suggested constant and systematical incrementing of basic parameters of the somatic build among the best competitors in the world.

With an analysis containing the height and mass of the body of Olympic finalists in years 1960–1996, Iskra [26] showed a comparatively little differentiation of the height (182.2–185.9 cm) with considerably greater differences of the average mass of the body of those competitors (74.5–81.6 kgs).

The somatic build of 400m hurdlers was also an object of research in the 1970s. It did not, however, refer to competitors of the world advance party and authors were rather concentrated on national competitors. Erdmann [27] published a lengthy thesis about the possibility of using morphological parameters as the criterion of selection in the 400 m hurdles among Polish competitors. The parameters defined for twenty leading competitors in the country were equal to 179.87 cm and 72.74 kgs. Therefore, they differed from the world tendencies. Another work concerning the somatic build of best hurdlers of Czechoslovakia starting in various age categories (youngsters, juniors, seniors) was published by Kostial and Matusek [4]. It is proper to pay attention to the fact that the results of the height of the body imperceptibly differentiated best juniors (180.1 cm and 67.9 kgs) and seniors (181.3 cm and 72.3 kgs) at this distance. Intelligibly, they were more characterized by the body mass. What is also interesting, the parameters obtained by them were comparable to the results of this analysis, which perhaps suggests the constant value of these parameters for many years. The body mass of academic hurdlers in the USA was defined by Pipes [28]. Yet due to the limited number of the examined (n=3), it is hardly representative either.

In the 1980s, apart from authors mentioned above, there were others who analysed the somatotypes of sprinters and hurdlers. For instance, there was Thorland with the team [29] – however, among the defined parameters there were only those concerning fat deposition. Next, Withers and co-authors [30] dealt with not so numerous a group of competitors (n=5).

In the 1990s, Socha [31], examining the somatic build of Polish male and female athletes, obtained average values of 184.96 cm and 77.58 kgs for 12 leading hurdlers in the country.

Over the recent years, Iskra [5,26,32] has been the one who analysed this topic. Seeking factors determining the result of 400 m hurdles among twenty leading Polish hurdlers of the 1990s, he pointed out the average height of the body 183.8 cm and the mass of the body 73.43 kgs. At the

same time, he admitted that these parameters did not show an essential correlation with the sports result [32]. Additionally, he defined Rohrer's factor as the coefficient, setting it for the examined group at 1.18. Iskra, in a lengthy monograph examining the conditions of results in hurdles, investigated the height and weight parameters of thirty Polish hurdlers at the distance of 400 metres (representing the level from the masterly international class to II sports class) and enumerated average parameters for this group: 183.49 cm and 74.43 kgs and the value 1.21 of Rohrer's factor. It is worth mentioning that those are values comparable to the results obtained in this research [33].

Once again, the height-weight data of the best hurdlers in the world (73 competitors from years 1968–2000) appear in Iskra's elaboration in 2003 [5]. Although the principle aim of this research was a definition of the influence of chosen elements of the hurdler rhythm on the sports result, yet the body height (184.63 cm), the body mass (75.56 kgs) and Rohrer's factor (1.20) appear among the parameters calculated by the author. Iskra did not obtain a statistically significant correlation with the result for any of these parameters. The fact that these data, though sectional (they refer to top hurdlers from 30 years), do not show considerable differences with relation to results obtained in this research should be noteworthy. Once again, it suggests there has not been a great variability of the somatic build indicators among the best 400 m hurdlers over the years.

So what kind of image of a hurdler does the above research and analyses of the accessible literature depict? Doubtlessly, we know that the height and the body mass themselves are not the only parameters decisive about the success, because the proper proportions of the body are extremely important. Milicerowa [34] affirms, for example, that in 400 m hurdles a slender structure of the shin is desirable. Iskra in his research [26,33] proves: the height of the body, the length of the foot, the width of the chest, a high value of mass of the active tissues and muscular ones as well as a low level of the adipose tissues are the parameters strongly correlated with the attained performance. It is advisable to put emphasis on the fact that the complex anthropometrical test run on a large group of best competitors (from many countries) is, in principle, impossible, hence the need of the research of simpler parameters perceptible in a easier way. These ones would give an important tool in selection and could also be used as parameters "of the model of the champion". They would be a specific sign-post in the process of the best 400 m hurdlers training.

One ought to perceive that in 400 m hurdles success is achieved by competitors of a dissimilar somatic build [5,33], so the fact that some competitors do not fulfil the criteria given above does not cross out their chances of achieving high results. Motor preparation of hurdlers seems to be the key element here. Wanting to mark "border values" we notice that nowadays there are not too many competitors below 178 cm in the advanced party, or above 190 cm too. There are also few of them of a very muscular body.

The chosen research methodology of course does not exhaust the topic; however,one should realize that a more accurate anthropometric examining of such a large group of competitors from the entire world is organizationally impossible on account of their availability. Parameters taken for analysis are in this situation model for the characterization of the somatic build of the world's best 400 metres hurdlers.

Conclusions

The obtained results, in the light of existing research in this direction, prove that the meaning of the height of body is less significant at present than it was a dozen or a few dozen years ago. Concluding, one should state that the gathered values should be used as a selection criteria in 400m hurdles run. The average body height in the group of best hurdlers amounts to 182.5–183.5 cm at the body mass of about 72–73kgs and these parameters do not diversify competitors' different sport levels.

Widening the research by slenderness factors is also legitimate and the values characteristic of the best hurdlers should be:

- Rohrer's (ca. 1.20),
- Quetelet's I (ca. 400),
- Quetelet's II (ca. 22).

Rohrer's factor is particularly valuable in this case. These values work well with most of the analysed leading competitors of the world and apart from the indicators of the motor preparation this can be helpful information while choosing the specialization.

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