Journal of Physical Education and Sport ® (JPES), 18(2), Art 98, pp. 670 - 676, 2018
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Morphofunctional markers of kinetic aptitude in a sport selection system

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Published online: June 30, 2018
(Accepted for publication May 05, 2018)
DOI:10.7752/jpes.2018.02098

Abstract:
In the article we study morphofunctional markers of sportsmen kinetic aptitude as one of the criteria for sport selection and sporting achievements prediction. The article contains various renderings of sport selection, shows its stages as a united system based on the hierarchy principle and targeted approach. It also extends different scientific views on the young people sporting aptitude detecting. The article reveals separate results of the diversified long-term researches (1965–2016) on the issues of physical and training load optimization in athletes of various sports taking into consideration their constitutional type (morphofunctional marker). Experimental materials are proved by high sporting achievements of Greco-Roman wrestlers and speed underwater swimmers. The study broadens the scientific knowledge about the opportunities of athlete perspective determination by means of morphofunctional criteria (markers) not only in a particular sport, but at the stage of his specialization.
Key words: morphofunctional markers, sport selection, model of an anthropometrical profile of the fighter.

Introduction

Physical In the growing sport competitive environment ultimate physical and psychological loads grow to the maximum as well. They place high requirements to athlete health, his behavioural reactions, and his ability to mobilize his resources during an important start. The success of a long-term sports training is possible if accompanied by physical loads optimization based on sport selection that has its own traits in every country, includes a number of connected stages and peculiarities depending on the sport. Professional literature reviews sport selection as a long-term multistage process, the efficiency of which determines the training optimization and the athlete training level. That is why the sport selection problem solution is one of the most important branches in the modern Sport Science.

The problem resides in the fact that a lot of sport selection tasks are solved by the coach instinctively, based on his own experience and application of simple motor proficiency tests. These tests mostly estimate the current physical state of a trainee, but not his genetic traits and natural abilities. The formation of a human body constitution is considerably stipulated by ancestral influences and can bear predictive significance for this or that sport. That is why it is important to determine the degree of the physiological age, i.e. the child's maturity level, his developmental level. The search for the ways to increase the sport selection efficiency, aimed at the research of kinetic aptitude morphofunctional markers is a promising direction in the sport selection system.

Material and Methods

The long-term experiment involved 80 speed underwater swimmers, among them 12 Merited Masters of Sports and 40 International Masters of Sports; 75 Greco-Roman wrestlers, among them 1 Merited Master of Sports, 18 International Masters of Sports and 56 Masters of Sports, whose morphometric characteristics are distributed according to their weight. Both categories are represented by the members of Krasnoyarskiy Krai select team and Russian national team.

To receive information about the level of morphofunctional characteristics we performed anthropometric measuring by means of common methods. The following anthropometric markers served as physical development criteria: body height, weight, body-weight ratio, chest circumference, vital capacity (VC), birth-death ratio, handgrip test.

We used a measuring tape to get body circumferences, the tape should tightly fit the measured body parts, but at the same time it should not squeeze soft tissues, there should not be any marks on the skin. Chest

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circumference is measured at maximal inspiration. The tape is placed on the back against the bottom of the bladebones with arms extended sidewards; on the front the tape is placed to the bottom segments of areolas. Waist circumference is measured strictly horizontally in the narrowest place, approximately mid-way between the 10th rib and the iliac crest. Pelvis width is the distance between the right and the left iliac crest points. Hip circumference is measured in the following position: legs stretched, feet at shoulder length, the body rests on both legs equally. The measuring tape is placed horizontally under the gluteal fold and closes on the outer surface of the hip. Minimal hip circumference is measured in the bottom third of the hip, about 7-8 cm above the knee-joint. Previously, we established centile rows (Moskovchenko & Shumakov, 2005) for each marker; according to them the estimation was done.

Estimation of the correlation between morphofunctional markers and weight categories was performed by means of correlation analysis. Statistical significance was determined with the help of multivariate statistics. Permitted values boundaries were determined by weighted coefficients of the main components.

The number of estimation tests was determined by Spearman-Brown safety coefficient:

$$r_{xy\,\wedge} = \frac{r_{xy}}{\sqrt{r_{xx} \cdot r_{yy}}},$$

with $r_{xy\,\wedge}$ - correlation between true values x and y; r_{xy} – correlation between empiric data; r_{xx} and r_{yy} – safety estimation of x and y. The values of r from 0.85 to 0.99 are taken as high safety. We determined the indices objectivity by these values. Rather strict estimation criteria allowed describing the correlation between the indices under study at a quite accurate level.

One of the tasks of the experiment was directed at the choice of methods to determine biomedical and pedagogical selection criteria with the aim to predict sport aptitude and perspectivity of an athlete, analysis of morphofunctional parameters dynamic pattern in highly skilled Greco-Roman wrestlers and underwater swimmers for morphofunctional markers determination.

Results

As revealed by the experiment, to get high sporting achievements two conditions must be combined: presence of the correspondent natural abilities stipulated by heredity and creation of circumstances for their maximal realization during the training process. These two conditions are inseparable and they basically determine the sporting orientation and selection. There is no united system of children athletic aptitude definition in all the regions of Russia. There exists intuitive selection in the regions: the coach bases on his experience and standards, he does not consider natural abilities and skills.

The authors understand by natural abilities morphologic and functional peculiarities of the constitution of brain, sense and movement organs that serve as natural premises for abilities development, including sporting abilities. Markers denote the so called tracers that reflect genetic premises for kinetic aptitude (Moskovchenko, 2004; Tkachuk & Dyusenova, 2015). Morphological markers characterize physical development, represent one of the criteria of a human health, showing at the same time changes of a body's biological forms and functions in the process of genetic programmes realization (Ashkenazi et al, 1993, p. 1252; Bartels et al, 2002, p. 240; Gorsky, 2005, p. 54; Kholodov et al, 2009, p. 416; Moskovchenko, 2012, p. 1094; 2016, p 36; Vasilkov, 2008, p. 210).

The studies found that athletes, who had advantages at the second stage of selection during the period of training group recruitment, make the best progress. Their initial level of natural abilities for kinetic aptitude development remained further at all the stages of preparation. This fact proves that the skills formation is based on the abilities, and their high development level results in sporting talent. Most researchers paid attention to athlete morphofunctional peculiarities in various sports. Studies by Bulgakova (1986), Platonov (2001), and Wutscherk (1988) determine morphologic indices of disposition toward swimming according to the specialty. According to Martirosov et al. (1977, p. 12), Tumanyan (2006, p. 365), Witte et al. (2008, p. 566), the key problem for wrestlers is to keep weight according to their weight category or to gain weight in the optimal way.

Taking into consideration the fact that one of the criteria of a wrestler technical competence is his morphofunctional type, we performed a correlation analysis between weight categories and anthropometric markers (Table 1).

Table 1. Interrelation of anthropometric markers correlation structures with weight categories in Greco-Roman wrestlers, cm

Weight category	Anthropometric markers characteristic (r)					
	Body height	Arm length	Shoulder length	Chest circumference	Hip circumference	Waist circumference
Lightweight	0.84	0.88	0.93	0.93	0.82	0.89
Middleweight	0.96	0.96	0.94	0.92	0.87	0.93
Heavyweight	0.98	0.95	0.92	0.96	0.94	0.92

As Table 1 shows, lightweights are characterized by: average indices of body height, hip and waist

circumferences, short arms, relatively large chest circumference, long shoulder length, small body surface, and relatively narrow hips. Middleweights are characterized by: relatively tall height, big body surface, large chest circumference, cluneal circumference, hip circumference, long shoulder length, arms and legs. Heavyweights are characterized by: big body surface, tall height, large chest circumference, cluneal circumference, hip circumference, long shoulder length, arms and legs. The higher weight within the category is, the more distinct the body height, shoulder and leg lengths, chest circumference and hip width are. Long arms are well-balanced by shoulder length.

The calculation of correlation dependence between weight category and morphofunctional markers showed that each category is characterized by a different correlation dependence coefficient, which varies in the range of 0.82 to 0.98 at high significance level ($p > 0.001$). We took into account the revealed interrelation between anthropometric markers and weight categories both in sporting selection, as well as in wrestler technical and tactics training.

Shchedrina & Marinin (2000, p.13), Nikolaev (2001, p.80), Moskovchenko (2004, p.49) distinguish in their works the variability forms of morphofunctional, somatopsychic, and personal and sociocultural integrity of today's human, living in Siberia, and factors that influence this integrity. These authors think that morphofunctional type changes every five years. So, models of athlete morphologic peculiarities, developed ten years ago, cannot correspond to the criteria of today.

We analyzed various morphologic markers over time through the example of Greco-Roman wrestlers (Table 2).

Table 2. Comparison study of total body measurements in Greco-Roman wrestlers of Krasnoyarskiy Krai team with the data of other authors

Body measurements	Weight categories, kg	Author, date of publishing				
		V. Gesilevich, 1963	E. Martirosov, 1968	N. Tarva, 1972	L. Sergienko, 2013	O. Moskovchenko A. Shumakov, 1963–1972
Body height, cm	42	158.9	156.2	157.8	156–158	149.4–152.6
	48	163.0	159.0	160.0	159–163	154.2–158.3
	52	165.0	164.2	163.5	164–165	162.3–164.6
	57	168.3	166.4	165.5	166–168	163.3–164.6
	62	171.1	171.1	169.2	169–175	167.3–168.4
	68	175.3	176.4	172.4	160–176	169.7–170.3
	74	176.6	181.0		176–184	178.8–180
Chest circumference, cm	42	81.2	86.8	82.0	85–91	75.7–80.5
	48	90.0	88.8	82.5	88–90	79.6–85. 2
	52	96.7	92.4	88.2	92–96	83.1–85.2
	57	98.1	94.7	90.1	92–98	89.6–93.4
	62	105.0	99.1	93.6	96–105	94.3–101.4
	68	102.6	101.5	95.5	101–108	97.9–105.7
	74	105.3	107.0		105–109	99.7–109.3

According to the table, the wrestlers of Krasnoyarskiy Krai have a 7.1–11.1 cm lower height (according to V. Gesilevich, E. Martirosov) and a 7–4 cm lower height (according to L. Sergienko). They also have smaller chest circumference depending on the weight category. The markers under study increased within the period of five years (1963–1972) and according to the weight category. Our data differ at most from measurements of the wrestlers given by V.A. Gesilevich and E.G. Martirosov and are very close to the data given by N. Tarva, as exemplified by athletes of Mongolia national team. We believe that so close total measurements of Krasnoyarsk and Mongolian wrestlers can be explained, firstly, by the fact that during the examination period 50% of Krasnoyarskiy Krai team were represented by Khakas wrestlers, who have ethnic anthropology similar to the Mongols. Secondly, climatic conditions of the group under study (the Khakas plains) and Mongolian athletes are also close, which cannot but influence their morphotype. Nevertheless, this supposition is not a dogma and it needs further studies. At the same time, the information received proves Anderson & Gustafson's point of view (1989) on the fact that environmental factors have a particular effect on total measurements and morphotype of a person. Other researchers (Budd (1973), Palushka & Schwenk (1985) support this point of view and notify that various environmental factors influence not only the human constitution, but they also cause stress.

Underwater sport refers to cyclic kinds of sport and includes sprint and long-distance swimming, where national, European and world records are registered (Ivanitsky & Moskovchenko, 2012; Moskovchenko; 2016).

The anthropometric examinations that we performed allowed us reveal, thanks to correlation analysis, physical development indices and their contribution into the result. It was found (Ivanitsky & Moskovchenko, 2012, p. 1096) that a physical development criteria of underwater swimmers were: height, weight, body-weight

ratio, chest circumference, VC, birth-death ratio, handgrip test, back strength, strength index, and flexibility at shoulder. At the initial selection stage, while examining morphofunctional parameters and fitness level, we used these criteria as reference. Specialty choice orientation was performed at further stages through a combination of morphofunctional indices, biomedical, bioenergetics, and sensorimotor (taking into account typological peculiarities of a person) parameters. We built rating scales and predicted the athlete's perspectivity.

The character of morphofunctional parameters changes of underwater swimmers differs from that of wrestlers. Consequently, we decided to analyze how morphofunctional parameters of underwater swimmers changed over the past 30 and 10 years (Table 3).

Table 3. Morphofunctional parameters of underwater swimmers

Indices	**Time period**					
	1974		**2004**		**2014**	
	♀	♂	♀	♂	♀	♂
Body height, cm	169–170	173–176	168–170	172–179	169–171	175–178
Weight, kg	62–68	72–77.5	64–69	76–79	58–61.5	75–79.5
Chest circumference, cm	79–83	87– 98.5	76–79	89–98.5	79–80.5	90–100
Body-weight ratio	339–400	394–478	355–404	379–494	325–409	375–497
Birth-death ratio	63.5–68	73–79	58–62.5	76–81	59.5–69.5	79.5–84
Right arm strength, kg	27–29	46–48.5	28–29	47–50	29.5–32	46.5–52
Left arm strength, kg	25–27	46–49	26–28	47–50	28–29	46.5–50
VC, ml^3	3800-3980	4900–5450	4295–4890	5700-6000	4700-4900	6900-7830

Note: First values belong to Krasnoyarskiy Krai team athletes, second values belong to national team athletes.

As the table shows, body height of both male and female underwater swimmers during the whole period of time varied within 2–9 cm, weight varied within 1–3 kg. Hand muscle strength has insignificant changes in both men and women, which can be explained by the specific character of this sport. Monofin swimming makes arms work unnecessary. Vital capability of lungs underwent the largest changes. Correlation coefficients between VC, body height and birth-death ratio vary in the range of 0.85 to 0.87. Tall swimmers have broad chest, high VC and birth-death ratio values, which means that their respiratory status is one of the most important functions providing the specific performance capability of an underwater swimmer and points at the potential opportunities of aerobic capacity development.

Thus, the formation of human morphofunctional peculiarities is considerably stipulated by ancestral influences and can bear predictive significance for this or that sport. Nevertheless, it should be born in mind that morphofunctional type changes with time, so, models built several years ago cannot correspond to the criteria of today. The established morphofunctional markers can be applied successfully in athlete sporting selection and technical training.

Discussion

Russian scientific community started discussing the issues of sporting selection grounding in the 1970s. And since 1980s the issues received applied development in the purposefully created centres – sporting selection laboratories attached to All-Union Research Institute of Physical Education (Moscow) and the sporting selection centre attached to Kiev Institute of Physical Education (Kiev).

A specific place in the numerous literature on the sporting selection issues is held by the studies on the athletic reserve training (Anderson & Gustafson, 1989; Aschkenazi et al., 1993; Bril, 1974; Bulgakova, 1986; Hirtz, 1985; Palushka & Schwenk, 2000; Peredelskiy, 2017; Schwartz & Khrushcev, 1984; Siris et al., 1983; Tkachuk & Dyusenova, 2015; Volkov & Filin, 1983; Walilko et al., 2005; Witte et al., 2008; Zaporozhanov et al., 1990), on the grounding of methodological approaches to sporting selection in separate kinds of sport (Bril, 1974; Bulgakova, 1986; Korobov & Korobova, 2014; Siris et al., 1983; Wutscherk, 1988), on targeting, tasks and descriptive characteristic of the sporting selection stages. The analysis of various approaches to the sporting selection periodization showed that the supporters of the four-stage (Bril, 1974; Bulgakova, 1986; Schwartz & Khrushcev, 1984; Siris et al., 1983;Volkov & Filin, 1983; Zaporozhanov et al., 1990) and five-stage (Platonov, 2001; Seluyanov & Shestakov, 2000; Sergienko, 2013; Tumanyan, 2006) models of sporting selection have similar opinion, that anthropometric and morphofunctional parameters should be taken into account during the first (initial) stage.

A number of works prove that quality selection and sporting orientation allow optimizing the training process, if not only selection criteria, but also the state of health, body adaptive abilities (Anderson & Gustafson, 1989; Batenko, 2015; Budd, 1973; Schwartz & Khrushcev, 1984; Siris et al., 1983) and also coordination abilities (Blume, 1984; Hirtz, 1985) are taken into account.

The works by V.V. Ivanitsky & O.N. Moskovchenko (2012, pp. 1092-1095), O.N. Moskovchenko et al.

(2005, pp. 26-38; 2015, pp.108-110) review the search for training load optimization ways on the basis of morphofunctional criteria taken into consideration in sporting selection. The authors note that the long-term training can be a success only if age and individual development peculiarities, development of physical abilities level and formation of kinetic abilities, which are developed during sporting selection stages, are taken into deep consideration. The significance of the selection and athlete's focus on high achievement grow at the stage of advanced specialization.

A wide range of articles (Gorsky, 2005; Ivanitsky & Moskovchenko, 2012; Kogan, 2003; Koryagina, 2016; Moskovchenko, 2012, 2014; Shcedrina & Marinin, 2000; Shumakov & Moskovchenko, 2010 etc.), educational and monographic literature (Guba & Marinich, 2016; Kholodov & Kuznetsov, 2009; Vasilkov, 2008; Moskovchenko, 2005, 2012; Platonov, 2001; Tumanyan, 2006;) draw attention to the morphologic, psychophysiological and genetic components that should be taken into account in sporting selection. Other researchers also attach particular importance to the issues of genetic factors balance (Anderson & Gustafson, 1989; Ashkenazi et al., 1993; Bartels et al., 2002; Voroshin et al., 2016, etc.). On the basis of contemporary scientific data scientists (Seluyanov & Shestakov, 2000, and Sergienko, 2013) reveal various aspects of aptitude and talent search, theoretical and practical grounds of the sporting selection as referred to various kinds of sport.

Definitions underwent considerable changes: from "choice of individuals for the present athletic activity" to "sporting orientation" and, finally, "sporting selection". The most stable linguistic constructs in sporting selection are as follows:

– system of organizational and methodical measures aiming at the selection to initial training groups appropriate in the places where the number of those willing to practice particular sports exceeds the maximum number per group (Volkov, & Filin, 1983);

– process of search and recognition (detection) of gifted people, capable of achieving high results in a particular sport (Vasilkov, 2008);

– package of measures that allow determining high degree of a person's disposition (aptitude) to this or that sporting activity (Siris et al., 1983);

– selection of sporting elite, talent, i.e. selection of athletes capable of competing on the international scene and representing the country in the national teams, including selection to the national Olympic team and professional sport (Bulgakova, 1986; Ivanitsky & Moskovchenko 2012; Moskovchenko & Shumakov, 2005; Moskovchenko & Tolstopyatov, 2015).

It seems logic to represent here common characteristic of the contemporary five-stage model of sporting selection.

Initial (primary) selection takes place at the first stage. L.P. Sergienko (2013, pp. 140-143) distinguishes two steps in this stage. The first step takes into account sporting interests of a child, his wish to go in for sports. Any sort of human activity requires particular psychophysiological conditions. The child aiming for sporting activity should have a specific set of morphological and psychological traits, functional and kinetic showings. The most important showing is the absence of medical contraindications to sporting activity. Focus on biological age, estimation of abilities and skills that determine success in the chosen sport happen at the second step. Tasks of the first stage: health assessment, determination of the motivation to sports, focus on the most favourable age for sports.

The second stage is a stage of "genetic selection". It includes the selection of kinetic capable children. It is necessary to detect in the child genetic showings in the development of morphological markers, kinetic abilities and functional capability of the organism. High indices of genetic factors in the development of particular traits point at the child's perspectivity in speed and strength, complex coordination, competitive sports, combat sports or endurance sports. Important criteria that allow determining genetic factors in the kinetic abilities development are: assessment of individual prediction of morphofunctional, functional indices and psychophysiological condition, including psychic, vegetal and kinetic levels. M. Bartels et al. (2002), I.Yu. Gorsky (2005, p. 55) also stick to this opinion. They studied morphogenetic varieties in teenage girls' recreational aerobics practice.

Consequently, the tasks of the second stage are: kinetic abilities assessment, individual prediction of development of a child's morphofunctional indices and kinetic abilities, comparison of the real age with biological age, detection of disease resistance and susceptibility to injures.

The third stage is the stage of intermediate selection, basic training. Choice of the most prospective sport for a young athlete takes place at this stage. Not only perspectivity to the chosen sport in general is assessed, but also as applied to its separate events. In fact, sporting orientation (choice of focus sport specialization) in the present kind of sport is done.

Tasks of the third stage: to keep the significance of all the principles of the second selection stage, to assess perspectivity in the chosen kind of sport as well as in its separate events, to take into account rate of the increase and predictive value of the results achieved in competition; focus on morphofunctional characteristics, tolerance included.

The fourth stage is final (basic). It is the stage of maximum realization of individual abilities, stage of

search for sporting geniuses. That means the search of such combination of morphofunctional indices and kinetic abilities in one person that would allow the athlete achieving world-class results is carried out. Orientation on model characteristics of high-class athletes becomes very important at this stage. The perspectivity criteria are high efficiency of competitive activity, level of specific training and high psychological reliability, i.e. athlete's talent is determined. At the same time, it should be noted that at the present stage there remain not more than 0.13% of talented athletes from the initial selection.

Tasks of the fourth stage: perspectivity complex assessment, orientation on model characteristics.

The fifth stage is the stage of excellence. Selection of sporting elite, their specialty passes at the present stage. That is they select future athletes for the national team (for instance, national Olympic team), athletes for large-scale sporting competitions. Complex assessment of the given athlete perspectivity, dynamics of his expertise formation, characteristic of the strongest world sportsmen, etc. serve as selection criterion.

Conclusion

In conclusion, constant growth of sporting achievements and increasingly competitive climate in our country, as well as on the international scene, increase the requirements put forward to athletes' selection and training at the stage of detailed specialization, and predetermine the search for rational ways of complex selection that should be performed at various training stages.

Based on our real-life experience, we suggest that primary selection of children for entering the youth athletic centre should be performed together with the teacher of physical education. By mutual agreement it is possible to choose special measures and influence purposefully the formation of the abilities for this or that sport in preteens. This process will encourage specific orientation. Sports shows that it is impossible to detect the ideal type of children who would combine morphological, biomechanic, functional and mental qualities necessary for further specialization in a particular kind of sport at the first stage.

Physical development of children is assessed by a number of external features: height, weight, body proportions, shape of the backbone and chest, pelvis and legs build, and foot size (Moskovchenko, 2004; Peredelskiy, 2016). After that it is necessary to study kinetic abilities of the children. At this selection stage there can be significant individual differences in biological development, which complicates considerably the assessment of the athlete's perspectivity. That is why the data received at the first selection stage should be treated as approximate.If the athlete achieved high results and got into the national team, we can really say that his focus on the long-term training was reasonable.

Conflicts of interest - The authors have no conflicts of interest to declare.

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