



## HEREDITARY AND ACQUIRED CHARACTERISTICS IN THE PROCESS OF SPORTING SELECTION

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### Abstract

The modern task in sports is to achieve the highest results on the basis of a combination of natural enthusiasts of athletes with modern methods of their development. The main content of all stages of sporting selection in sports is the prediction of athletic talent (promising possibilities) with the help of special test procedures and objective quantitative indices.

*The objective* – to investigate the features of hereditary and acquired characteristics and to determine sporting abilities and dispositions and their use in the process of sporting selection.

*Methods*: the analysis of sources of literature and Internet, regulatory documents, analysis of practical knowledge, generalization, systematization.

*Results*. The weak manifestation of personality traits and qualitative characteristics of one kind of sports cannot be considered as a lack of sports ability. Unwanted characteristics in one type of the sporting activity may be advantageous and guarantee high performance in the other. In this regard, it is possible to predict sporting abilities only in a certain type or group of sports, proceeding from the general conditions that are characteristic of the selection system. The use of complex methods of identifying dispositions (genetical dispositions) and capabilities necessary for achieving the peak of sporting mastery allows to perform selection of children and teenagers for doing sport. Indicators, on which the sporting achievements depend and which can serve as a criterion for determining sporting aptitude, are the state of health; physical (conditional) abilities; coordination abilities; body constitution (stature); mentality of a person; genotype, functionality, motivation.

*Conclusions*. For sport selection of children, a particular importance acquire the factors which determine the successfulness of sporting activity, which are the most limited by the heredity and are of a conservative nature. For sporting selection and orientation, the knowledge is to determine the effect of an athlete's genotype on the prospects of achievements in sport.

**Key words**: selection, abilities, disposition, criterion, genetically determined characteristics, acquired characteristics.

### Introduction

Sporting selection and orientation is defined as practically uninterrupted process that covers all the long-standing trainings of a sportsman. This is determined by the impossibility of clear discovery of capabilities at a certain stage of lifespan development or long-standing training, as well as by the complicated character of mutual relations between the hereditary characteristics, which are demonstrated as dispositions, and acquired ones that are consequences of a specially organized training [16, 19].

Even extremely high dispositions for one or another type of activity, which are evidences of natural gifts of a person, serve only as the necessary basis of great capabilities for track-and-field athletics trainings. Real skills can be discovered only in the process of study and education and are a consequence of congenital and acquired, biological and social [17, 23]. Nowadays there is a serious matter for the sport – to achieve the highest results not due to the selection, but due to the combination of natural gifts of sportsmen with the modern method of their development. This is exactly what experts



have in mind when they talk about rise in sporting achievement due to the selection of sporting talents. That is why the aim of the sporting selection is defined not as determining aptitude of a sportsman for that particular sport, but as discovering potential capabilities of a sportsman and determining ways of developing their talent in the training process. A lot of experts, not excepting genetics methods, recommends to apply well-known in the sporting practice pedagogical, medical, biological and psychological methods of research [13, 16]. In such a way, each stage of sporting selection corresponds to a relatively homogeneous by the level of qualification quota of sportsmen, certain time limits (periods) of selection stages, as well as a specific complex of tasks, which are being solved, means, methods, which are used for this, parameters, the choice of which is done with consideration of particularities of a certain sport.

The main content of all the stages of sporting selection in all sports is the prediction of sporting gifts (prospective possibilities) of a sportsman with the help of special testing procedures and objective quantitative indices.

*The objective* – to study peculiarities of hereditary and acquired characteristics for determining sporting gifts and dispositions and their use in the process of sporting selection.

## Methods

*Methods:* the analysis of sources of literature and Internet, regulatory documents, analysis of practical knowledge, generalization, systematization.

## Results and discussion

The variety of sports promotes opportunities for an individual to reach mastery in one of the types of sporting activities. A faint demonstration of qualities of an individual and their qualitative peculiarities concerning one of the sports cannot be considered as a lack of sporting gifts. Unwanted characteristics in one type of the sporting activity may be advantageous and guarantee high performance in the other. Taking that into account to predict sporting gifts is possible only in a certain kind or a group of sports, considering in this case the general provisions typical for the selection system.

The use of complex methods of identifying dispositions (genetical dispositions) and capabilities

necessary for achieving the peak of sporting mastery allows to perform selection of children and teenagers for doing sport.

The problem of selection needs to be solved in its entirety, applying pedagogical, medical, biological, psychological and sociological methods of research. The pedagogical methods allow to establish the level of development of physical qualities, coordination capabilities and sporting and technical mastery.

Morphofunctional peculiarities, the level of physical development, the state of analyzers of systems of the sportsman's organism and their state of health are discovered on the basis of the use of medical and biological methods of the research.

Peculiarities of a sportsman's state of mind, as well as estimation of the psychological compatibility of sportsmen during solving tasks, which the sport team faces, are defined by psychological methods of research, which influence the solution of individual and collective tasks in the process of sport competitions.

Sociological methods of research allow to obtain data on sporting interest of children, to reveal cause-and-effect relations of formation of motivation for long-term sporting training and high sporting achievements.

It is possible to separate common for all sporting parameters, on which depend sporting achievements and which may serve as criteria while determining the sporting suitability: state of health; physical (conditional) capabilities; coordination capabilities; body constitution (stature); mentality of an individual; motivation.

Knowledge of the main factors which define the choice of sporting specialization will be incomplete for effective prediction of sporting achievements without regard to influencing them by the heredity and environment. Education in general and physical in particular favours the development of natural dispositions and transformation of these dispositions into skills. On condition of the presence of prominent dispositions and beneficial effects of the environment (in the first place, education, study) the talent is formed. In such a way, for a person as a biosocial creature, to which always peculiar biological, inherited, given by the nature, as well as social, acquired by the person itself in the process of activity on the basis of something that has already



been put in them. In that case it is necessary to keep in mind that the stage of manifestation of heredity and acquisition may be different and this plays an exceptionally important role in the definition of sporting aptitude [20].

For sportturn selection of children, a particular importance acquire the factors which determine the successfulness of sporting activity, which are the most limited by the heredity and are of a conservative nature. It is understood that any successful prediction is possible only in the case when stable factors are put in its basis.

For sporting selection and orientation, the definition of genetical constitution (genotype) of a sportsman's organism (total of all of their genes) for the prospects of achievements in sport is extremely important. The heredity of morphofunctional peculiarities of a person, various characteristics of motor function, the influence of genotype on a person's training ability, the presence of the family similarity of these parameters are defined [6, 10, 13, 22, 23].

The genotype determines the sportsman's training ability. Individuals of the same age, sex, initial training level react differently to standard training programs. The intensity of adaptive reactions, especially on weight, speed, aerobic and anaerobic training is defined by genetical factors. Some individuals stand out for high capability for adaptation under the influence of training, other – for medium one, the third – for a low one. The high level of adaptation to one loadings can be accompanied by both high and low adaptation to the other. For example, high training ability in regard to speed and speed-power work may be accompanied by low adaptation resources concerning aerobic work. Disposition to the development of coordination skills is usually accompanied by a significant

adaptation resource in regard to flexibility, time of simple and complex reactions [5].

To general characteristics of inheritance belong: morphological parameters – most hereditary parameters (for vertical body size and skeletal system it becomes apparent more than for volumetric sizes and muscular system). In 50 % of cases children of prominent sportsmen have clearly demonstrated sporting capabilities; and if both parents are sportsmen, children become sportsmen in 70 % of cases. The type of inheritance of sporting performances – dominant; motor functions descend to men through parental lineage. Distinguished sportsmen are mostly the youngest children in families with two-three children. The percent of the distinguished sportsmen born in the first quarter of the year is four times higher than the percent of those born in the last quarter [10, 22, 23].

At the age of five-six years old the most effective selection may be achieved due to discovery of genetic markers. To genetic markers belong: anthropogenetics (sthenic, hypersthenic), quantitative and qualitative hormonal composition in the tissues, blood group, dermatoglyphics, composition of muscle fibres, motor dominance, individual profile of functional and motor asymmetry, training ability, certain genotype (for example, gene ACE), etc. [1, 8, 13, 14, 15].

One of the factors limited by the heredity is a constitutional organization of the body, anthropometric data. Safe parameters of stature are height and other vertical (total) body sizes. In the sports, in which the height is of great importance, this parameter may be used as one of the main at the stage of primary selection [10, 22, 23]. To predict the length of the body of a child is possible practically at any age, for which it is possible to use the data provided in Table 1.

Table 1

**Length of the Body of a Child at Different Age Periods in Relation to the Height of an Adult**

Age, Years	Length of the Body, %	
	Boys	Girls
<b>1</b>	<b>2</b>	<b>3</b>
1	42,66	45,24
2	49,62	52,58



Table 1 continuation

1	2	3
3	54,47	58,41
4	58,85	63,19
5	62,36	67,35
6	65,94	71,17
7	68,67	74,22
8	71,97	77,60
9	75,18	81,17
10	78,17	84,64
11	80,88	88,50
12	84,13	92,50
13	87,94	95,91
14	95,41	99,10
15–16	97,64	99,53
17	98,89	99,61
18	99,59	100

A prospective criterion of sporting aptitude is a value of active body mass [1, 2]. The use of this parameter is defined by the fact that the somatic

type of a person is to a great extent determined by the correlation of fat-free and fat components (Table 2).

Table 2

### The Impact of Heredity on Anthropometric, Compositional and Biochemical Characteristics [1, 2]

Parameter	%	Source
1	2	3
Length of the body	81–93	Silventoinen K. et al., 2003, 2008; Zillikens M.C. et al., 2008
Body mass	52–84	Hunt M.S. et al., 2002; Souren N.Y. et al., 2007; Zillikens M.C. et al., 2008
Body mass index	44–90	Maes H.H. et al., 1997; Silventoinen K. et al., 2008; Zillikens M.C. et al., 2008
Total body area	73	Li X. et al., 2006
Chest circumference	77–89	Chen C.J. et al., 1990; Chatterjee S. et al. 1999
Hip circumference (musculoskeletal part)	85	De Mars G. et al., 2008
Waist circumference	40–82	Rose K.M. et al., 1998; Wardle J. et al., 2008; Zillikens M.C. et al., 2008
Endomorphic type of constitution	21–97	Bouchard C. et al., 1980; Peeters M.W. et al., 2003, 2007; Rebato E. et al., 2007; Reis V.M. et al., 2007; Saranga S.P. et al., 2008
Mesomorphic type of constitution	30–88	
Ectomorphic type of constitution	16–92	
Fat-free body mass	52–90	Arden N.K., Spector T.D., 1997; Rice T. et al., 1997; Souren N.Y. et al., 2007; De Mars G. et al., 2008; Zillikens M.C. et al., 2008

*Table 2 continuation*

1	2	3
Fat body mass	46–81	Souren N.Y. et al., 2007; Zillikens M.C. et al., 2008; Cheng S. et al., 2009
Thickness of subcutaneous tissue	41–74	Hunt M.S. et al., 2002; Schousboe K. et al., 2004; Souren N.Y. et al., 2007
Mass of left ventricular myocardium	36–70	Swan L. et al., 2003; Arnett D.K. et al., 2004; Sharma P. et al., 2006; de Simone G. et al., 2007; Vasan R.S. et al., 2007
Stroke volume	29–62	Snieder H. et al., 2003; de Simone G. et al., 2007
Pulmonary capacity	43–78	Coultas D.B. et al., 1991; McClearn G.E. et al., 1994; Chatterjee S., Das N., 1995
Composition of muscular fibres	45–99	Komi P.V. et al., 1977; Simoneau J.-A., Bouchard C., 1995
Bone mineral density	75–83	Nguyen T.V. et al., 1998; Videman T. et al., 2007
Erythrocyte concentration	42–79	Evans D.M. et al., 1999; Garner Cet al., 2000
Mean corpuscular volume of erythrocytes	94–97	Evans D.M. et al., 1999
Haemoglobin	37–87	Evans D.M. et al., 1999; Garner Cet al., 2000
Maximum concentration of blood lactate	28–98	Lesage R. et al., 1985; Rodas G. et al., 1998; Calvo M. et al., 2002; Maridaki M., 2006
Fasting blood glucose level	37–67	Santos R.L. et al., 2006; Souren N.Y. et al., 2007; Siimmi-Bik A.M. et al., 2008
Blood testosterone level	50–69	Hong Y. et al., 2001; Hoekstra R.A. et al., 2006; Kuijper E.A. et al., 2007; Bogaert V. et al., 2008
Resting energy spending	30	Wu X. et al., 2004; Bony Wettphal el al., 2008

Along with the body constitution the most genetically determined hereditary features are the main characteristics of the nervous system, which to a great extent define the mentality of an individual, their temperament, character (Table 3) [1,2].

*Table 3*
**Parameters of the Impact of Heredity on Some Mental Qualities [1, 12]**

Parameter	%	Source
Temperament	20–60	Carmelli D. et al., 1988; Saudino K.J., 2005
Extraversion-introversion showings	25–66	Floderus-Myrhed B. et al., 1980; Jang K.L. et al., 1996; Keller M.C. et al., 2005; Pincombe J.L. et al., 2007; Rettew D.C. et al., 2008
Aggression	28–71	Coccaro E.F. et al., 1997; Hudziak J.J. et al., 2003; Gelhorn H. et al., 2006; Baker L.A. et al., 2008
Novelty seeking	39–55	Gillespiea N.A. et al., 2003; Keller M.C. et al., 2005
Harm (damage) avoidance	41–57	Gillespiea N.A. et al., 2003; Keller M.C. et al., 2005; Isen J.D. et al., 2009
Dependence on reward (recompenses)	35–56	Gillespiea N.A. et al., 2003; Keller M.C. et al., 2005
Insistence	30–55	Gillespiea N.A. et al., 2003; Keller M.C. et al., 2005
Intelligence quotient (IQ)	30–87	Devlin B. et al., 1997; Ando J. et al., 2001; Posthuma D. et al., 2001; Wright M. et al., 2001; Polderman T.J. et al., 2006; Silventoinen K. et al., 2006
Memory	37–67	Ando J. et al., 2001; Singer J.J. et al., 2005, 2006; Friend A. et al., 2007; Kremen W.S. et al., 2007
Attention	29–88	Stins J.F. et al., 2005; Polderman T.J. et al., 2006; McLoughlin G. et al., 2007





Such characteristics of the nervous system as strength, mobility, dynamism and equilibrium, inherited from father or mother, do not practically change during the whole life. That is why in such sports in which one or another property of the nervous system has crucial significance, it may be a quite reliable factor while determining sporting aptitude [9].

One of the most important factors, which defines the successfulness of sporting activity and

the most commonly used in the process of sporting selection, is physical readiness, which is revealed at the level of the conditional physical qualities development. That is why it is highly important to consider the issue whether there is the upper limit of the development of these inherited qualities and whether the possibilities of their improvement are infinite (Table 4) [1,2].

Table 4

#### The Impact of Heredity on Physical Qualities and Some Functional Parameters [1,12]

Parameter	%	Source
Motor activity	29–68	Betmen G., Thomis M., 1999; De Moor M.H. et al., 2007; Duncan G.E. et al., 2008; Mustelin L. et al., 2009
Sporting activity	35–83	Beunen G. Thomis M., 1999; De Moor M.H. et al., 2007
Maximum oxygen consumption by untrained individuals	59–66	Fagard R. et al., 1991; Bouchard C. et al., 1998
Augmentation of maximum oxygen consumption	47	Bouchard C. et al., 1999
Handgrip test showing	30–65	Reed T. et al., 1991; Arden N.K., Spector T.D., 1997; Frederiksen H. et al., 2002; Tiainen K. et al., 2004
Isometric force	44–96	Huygens W. et al., 2004; De Mars G. et al., 2008; Tiainen K. et al., 2009
Dynamic force	29–87	Thomis M.A. et al., 1998; Huygens W. et al., 2004; Silventoinen K. et al., 2008
Eccentric force	62–82	Thomis M.A. et al., 1998
Explosive force	61–89	Calvo M. et al., 2002; Peeters M.W. et al., 2005; Tiainen K. et al., 2009
Speed	60–100	Komi P.V. et al., 1973; Malina R.M., Mueller W.H., 1981; Chatterjee S., Das N., 1995
Response time	40–70	Stins J.F. et al., 2004; Kuntsi J. et al., 2006; Finkel D., McGue M., 2007; Rijdsdijk F.V. et al., 2009
Flexibility	50–69	Kovar R., 1974; Chatterjee S., Das N., 1995; Battie M.C. et al., 2008
Neuromuscular coordination (dexterity)	41–87	Williams L.R., Hearfield V., 1973; Maes H.H. et al., 1996; Francks C. et al., 2003; Missitzi J. et al., 2004
Equilibrium	30–65	Williams L.R., Gross J.B., 1980; Carmelli D. et al., 2000; El Haber N. et al., 2006
Heart rate during exercise (including $HR_{max}$ )	32–43	Lesage R. et al., 1985; Ingelsson E. et al., 2007
Change of the heart rate in response to 20-week aerobic exercises	29–34	An P. et al., 2003
Resting systolic blood pressure (BPS)	19–74	Gu C. et al., 1998; Snieder H. et al., 2003; Zeegers M.P. et al., 2004; KupperN. et al., 2005; Hottenga J.J. et al., 2006
Change of the BPS in response to 20-week aerobic exercises	22	An P. et al., 2003
Resting diastolic blood pressure (BPD)	24–63	Gu C. et al., 1998; Snieder H. et al., 2003; Zeegers M.P. et al., 2004; Kupper N. et al., 2005; Hottenga J.J. et al., 2006
Frequency-amplitude showings of electro-encephalogram (EEG)	46–96	Anokhin A.P. et al., 2006; Smit CM. et al., 2006; Linkenkaer-Hansen K. et al., 2007; Zietsch B.P. et al., 2007; De Gennaro L. et al., 2008



Maximum oxygen consumption ( $VO_2$  max) as a main criterion of estimation of aerobic endurance lays within the framework defined by the individual genotype. The increase of  $VO_2$ max in the process of training does not exceed 20–30 % of the initial level. In such a way,  $VO_2$ max is one of the main characteristics which determine the selection of the sports with demonstration of the maximum aerobic endurance [4, 11, 12, 18, 21].

Another genetically defined parameter of the potential of aerobic endurance development is muscular structure [3, 6, 7]. Muscle fibres, which contract fast and slow (the names of fibres are defined by the time difference of their contraction) are distinguished in the composition of human muscles. Depending on the predominance of one or another type of fibres it is possible to define disposition of a sportsmen to the work of different directions (slow-twitch fibers – disposition to the work of aerobic character, fast-twitch fibers – disposition to the work of anaerobic character). Training cannot change the correlation. Muscular composition is a reliable parameter in defining a sporting aptitude already of a beginner sportsman (highly-qualified long-distance runners has the correlation of slow-twitch and fast-twitch fibers from 85–90 % to 10–15 % respectively).

It is worth noticing that there is a direct correlation between  $VO_2$ max and muscular slow-twitch fibers: the higher the  $VO_2$ max level the higher the percent of these fibres.

Considering the fact that determination of the muscular structure requires quite complex laboratory equipment and a corresponding qualification, the  $VO_2$ max parameter [4, 6, 10, 18] is most commonly used in practice.

In addition, a quite reliable characteristic of aerobic endurance is a physical efficiency.

Anaerobic mechanism of muscular activity support is also determined by a significant impact of genetic factors. Heritability coefficient of this mechanism is from 70 to 80 %. The main parameter of the anaerobic efficiency is a maximum oxygen debt ( $O_2$ debt) [6, 7, 18].

Individual distinctive features of speed capabilities depend on the nervous system, which, in its own turn, to a certain extent is genetically defined. In individuals prone to sprint work, correlation of fast-twitch fibers to slow-twitch ones makes from

80–85 % to 15–20 % respectively. The hereditary disposition also reveals itself in manifestation of reaction speed, the parameter of development of which it is possible to use with great reliability in the process of selection for trainings in the sports in which it is clearly observed a manifestation of this exact quality [10, 23].

Strength is determined by the heredity to a lesser extent than endurance and speed capabilities. Although it is important to state here that the relative muscular strength (strength per 1 kg of body mass) is prone to genetic control and may be used as a criterion in the process of selection for trainings in the sports which requires a manifestation of this quality.

A quite reliable criterion is the explosive force of muscles. The absolute force is mostly determined by influences of the environment and to a great extent falls under the training influence and cannot be a criterion for defining sporting aptitude [10, 13, 16].

Flexibility is genetically determined and may be used as a reliable parameter in the process of defining sporting aptitude, first of all in precise sports. The impact of the heredity on the flexibility is more a characteristic for girls comparing to the boys.

Coordination capabilities (a factor which fundamentally influences the formation of the sporting technique) are also to a great extent determined by the heredity influence. It can be explained by the fact that in the majority of coordination demonstrations genetically defined features of the nervous system have the crucial significance [16].

The influence of inherited factors on manifestation of individual capabilities for one or another sports is extraordinarily great and to find one's «own» sports is not easy. From the genetic point of view, a sport talent is a quite rare occurrence. The majority of people demonstrate sporting results close to the average, while there are very few individuals who cannot do this as well as individuals who are able to demonstrate results much higher than the average.

The influence of the family similarity on the sporting achievements proves multiple cases of successful performances of parents and children, brothers and sisters. Although it is necessary to take into account that the influence of the family similarity is demonstrated not only through genes, similar for all the family members, but through a



common for this family surrounding conditions, including treatment of sport, competition among different members of a family, etc. [16, 17].

### Conclusions

The sporting selection and orientation has to be conducted with consideration of the main

characteristics which define the success of sporting improvement in a certain sport, which is connected to the absence of the single criterion of endowments.

### Conflict of interest

The author does not have any conflict of interest to announce.

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