Correlation between Psychophysiological and Genetic Factors for Top-level and Middle-level Athletes in Sports with Physical Endurance

P. Bundzen¹, K. Korotkov² and V. Muhin¹

¹Research Institute of Physical Culture, ²Technical University "ITMO", St.Petersburg, Russia

INTRODUCTION

Prognosis of performance effectiveness for yang athletes, as well as the definition of skilled athletes' readiness for competitive activity is one of the actual problems of sport science. The athletes' psychophysical readiness is defined by several factors, namely, genetic predisposition, organism's psycho-physiological reserves, level of training, and, the last but not the least, mental preparation. Interrelation of these factors for the particular athlete at the given moment depends on the athlete's performance level (outstanding or average), psychophysical state, sporting discipline, and the type of loading during performance. Development of practical approaches for the investigation of these factors would be significant both for the sport practice of different levels, and preserving athletes' health and well-being.

The aim of this study was twofold: first, to study the interrelations of different factors, influencing athlete's performance for different groups of sportsmen using complex approach, and second, to develop a computerized technology for assessment and prediction of competition effectiveness. The method should be available for any coach or athlete being simple in work, reliable and with automated processing of data.

TECHNIQUES AND METHODS

A set of methods were utilized for this study allowing to create a characteristic profile of the sportsmen's organism psychophysical condition and genetic status:

1. Psychoenergy potential and psychical activity evaluated with Profile of Mood States (POMS) questionnaire test¹. The complex parameter, characterizing relative scale of psychoenergetic readiness (PER), was determined by a formula:

$$PER = \frac{V}{\sum (A_n + D + A + F + C)},$$

where: A – Aggression, An – Anxiety, C – confusion, D – Depression, F – Fatigue, V – Vigor – standard scales of POMS.

The test was run prior to the beginning of the overall testing program.

2. Functional state with maximum oxygen consumption test and tests using critical load holding²,³.

3. Genotype characteristics of the athletes, i.e. those attributed to II, ID and DD variants of the angiotensin converting enzyme (ACE) gene, shown to be correlated with elite athletes endurance performance in power-oriented events⁴. In this analysis, genome DNA was extracted with alkali from the cells of oral mucous membrane, with the polymorph part of the gene amplificated by polymerize chain reaction, and these reaction products determined via electrophoresis in 8% polyacrilamid gel⁵.

4. Physical endurance test exercises, measures of speed-strength qualities and explosion force. Treadmill by "Quinton" (USA) was used in the following regimes: the athlete speeded 6 km/h at the first step, 9 km/h at the 2^{nd} step and 12 km/h at the 3^{rd} step. Inclination angle was 5% and duration of every step three minutes. Then inclination angle was increased to 10.5% with duration one minute. At the last step the angle was 12.5%, speed 12 km/h and athlete was motivated to run as long as possible.

During this test heart rate was continuously registered with "Polar Electro" tester and every third minute outward breath was analyzed with "Bekkman" gas-analyzer.

5. Quantum-field level of organism bioenergetics based on measurements of GDV bioelectrography evoked emission processes with computerized complex "GDV-camera" instrument⁶ produced by the "Kirlionics Technologies International", Saint-Petersburg, Russia, utilized in experiments had the following parameters: single impulse duration – 10 microseconds; repetition frequency – 1000 Hz; induction interval – 0,5-1 s; electrode voltage – 3-15 kV. Average basic parameters of the fingers glow patterns (BEO-grams): area, density, spectrum, entropy, and fractality were calculated using the standard sowtware; parameters were calculated both for every finger and averaged by ten fingers of the left and the right hands; integral logarithmic parameters of BEO-grams of the left (JSL) and the right (JSR) hands and also their dispersions (DJSL and DJSR) together with BEO-grams types (Ia, Ib, Ic, IIa, IIb) [6].

6. Heart Rate Variability: Heart rate variability was registered using "Polar Electro" tester and Software (Finland). Short-term (5-minutes) HRV assessment occurred in a dim, quiet room with subjects resting in the supine position for 5 - 10 minutes before the start of the HRV test. Total power of Very Low Frequency bands (VLF, 0.003–0.04 Hz), low-frequency bands (LF, 0.04-0.15 Hz) and high-frequency (HF, 0.15-0.4 Hz) were calculated.

7. Rating of competitive effectiveness of participation in international and Russian championships.

<u>Statistical processing.</u> The results of investigation were processed, using methods of multi-factor analysis by means of statistics software package "STATGRAPH-5" using Fisher and Student criteria. Reliability of test was accepted with p < 0.05.

<u>Contingent</u>: The research was performed at the Olympic Reserve College No1 and No2 and North-West Center of Olympic Training of St. Petersburg during 1999-2003 in several independent sessions. Groups of athletes of both genders demonstrating various levels of skills and specialization were tested, including members of the Russian Olympic team. 40 athletes were examined in 1999, 110 athletes in 2000-2001. All selected athletes were involved in sports, which demanded a high level of psychophysical endurance (pentathlon, triathlon, 800 and 1500 m middle-distance race, 50 m sprint, hurdle race). 79 students of Lesgaft State Academy of Physical Training, specializing in track-and-field athletics were considered as average-level sportsmen.

In accordance with their performance results in 1998-2002 all participants were distinguished in two main groups: "elite" athletes and "average" athletes.

EXPERIMENTAL RESULTS

First, it was noted, that the comparison of the group score of the athletes subjective psycho-emotional status, revealed by the "POMS" method, demonstrated statistically reliable differentiation of the groups in psychophysical readiness. Statistically reliable differentiation between the groups of athletes was also found in GDV-grams parameters of fingers: area of glow, entropy, fractality and the type of BEO-gram.

It was demonstrated that at rest the BEO-grams of the "average" athletes is typical for the healthy subjects of the same age and mainly belong to I a-I b types. For the elite athletes the BEO-gram at rest is much less structured belonging mainly to I c-II a types with significant percentage of II type. After physical loading for all the athletes transition to the "worse" type of BEO-gram in accordance with a sequence: I b \Rightarrow I c \Rightarrow II a \Rightarrow II b mostly happened. These results confirm conclusions of our long-term studies of BEO-grams of top-level athletes: their dominant type of BEO-grams at rest is quite different from the types of BEO-grams of relatively health people and "worsens" after training and mostly in the process of sport competition. It is also significant that the groups of athletes differing by performance results have essential difference in GDV patterns. Very important from our point of view, that for top-level athletes at the competition conditions or during exercises with mental imagination of a pick performance moments, BEO-grams transformed to highly scattered patterns, typical for the state of deep meditation or hypnosis⁷.

This last conclusion was confirmed statistically for a group of athletes having passed the course of mental training in accordance with Swedish model⁸. After this course they were able to create mental images of the moments of their pick performance in a competition. The main psychophysiological characteristics of their state at these moments were as following:

- full concentration of attention on the goal (result) in combination with dissociation with the surroundings;
- change of perception of time and space;
- reduction of pain sensitivity and removal of psychological barrier (transformation of estimation of achieving the goal);
- generation of a bright motor-psychic image of realisation of sport skills;
- harmonisation of bioelectric activity of the brain and parts of the organism bioenergy system (meridian acupuncture points).

This may be interpreted as an evidence for short-term transition of top-level athletes to the state of Altered State of Consciousness (ASC)⁹ during training and competition. After several years of experiments training of athletes in ASC self-induction was postulated as a key value of technology of psycho-training in the course of mental preparation. And testing of sportsman's ASC self-induction ability is, in its turn, of principal importance in the diagnostics of quality of sportsman's psychic (mental) preparation.

Investigations carried out with a group of top athletes, having passed a mental training course, afford ground for claiming that imaging act leads to an abrupt transformation of BEOgrams, and particularly to an emergence of distant emission phenomenon¹⁰. These changes may be attributed to short-term explosive psycho-energy activation of the athlete. They were the results of an athlete's concentration on mental images or ideomotor reproduction of psycho-motor attainment. This phenomenon was statistically reliable and was measured both for top athletes in the process of competition imagination, and in different experiments: in hypnotic states, for actors during theatrical performance, and for healers in the healing mode. Sharp decreases in GDV-gram areas and increases in image fractality in the process of mental training were registered for a lot of professionals in these fields in Russia, Sweden, Finland and USA.

Correlations between different parameters were found in a set of complex experiments with participation of big groups of athletes of different level. Most reliable correlations were found for top-level athletes.

Multi-factor statistical analysis revealed reliable correlations of BEO-gram parameters with maximum oxygen consumption (MOC) rate, which characterized the aerobic workability of athletes. It is known that MOC rate is closely related to the athletes' competition effective-ness and genetically determined¹¹.

To check the genetic determination of the denoted parameters a complex research with the same group of 40 athletes was organized 6 month later after the initial test. It is well accepted in modern sport medicine, which ACE genetic marker determines the quality of the physical (aerobic) power of endurance and its influence depends on the qualification of athlete and the type of sport. Factor analysis based on 22 indexes confirmed correlations between parameters revealed in the first experiment. As we see from the Table 1, first factor with high reliability denote direct functional correlation between GDV parameters, ACE genotype (0.602) and MOC index (0.618) and reverse correlation with the heart loading – myocardium disoxya (-0.428). As a whole the structure of the first factor reflects well-known tendency of genetic and in particular, psychogenetic determination of the MOC level. At the same time from the presented data it is clear, that energy-emission GDV processes are ruled by genetic determination as well, and their indexes may be explored in the functional analysis of top-level athletes.

Functional structure of the second factor confirms data of the correlation graph of fig.6: high factor weights have the type of sport (0.592), effectiveness of competition activity (0.552), time of loading holding (0.860), psychoenergetic coefficient of POMS (0.777) and qualification (0.386). Relatively high is the weight of MOC index (0.398), but MOC-per weight index is much higher (0.675). Quantum GDV parameters are included in the second factor by their deviations with negative values, that may be interpreted as negative influence of excessive energy field variations on the sport effectiveness of an athlete.

Functional loads (treadban training and ideomotor modeling of competition performance elements) exerted a pronounced influence both on BEO-gram types and on GDV integral indexes. After the load the GDV parameters of the right hand had higher weight factors as they are correlated with physical activity. After the load the correlation with the coefficient of psycho-energy by "POMS" test increased. This data statistically confirmed a concept of importance of psychological factor in effectiveness of purposeful physical activity.

The results of multivariate factor analysis of data, as compared to sport effectiveness, in three separate measurements demonstrated presence of reliable functional bond between the ACE-genotype, integrated GDV-parameters, and middle-distance race (800-1500 m), i.e. sport activity connected with endurance quality. In this case maximum effectiveness is characteristic of the athletes having II and ID alleles of the ACE genotype and minimum one is typical of athletes with DD genotype (p<0,05).

Very important correlations were revealed between psychological state of a person measured with POMS, quantum parameters measured with GDV and Heart Rate Variability (HRV) (fig.1). As we see from this graph, POMS mostly correlate with activity of sympathetic nervous system, while GDV with parasympathetic one. This character of correlations was found in a lot of independent experiments.

At the same time strong dependence of HRV specters from athlete's level was revealed in a lot experiments. Fig.2 demonstrates Fourier specters of four athletes: two of them are top-level athletes (graphs A and B) and two are middle-level (C and D). As we see from the graphs, for top-level athletes the Very Low Frequencies dominate in the specter, while for middle-level sportsmen specter shifted to High Frequencies.

Results of three years of study allowed developing practical approach for evaluation of the top athletes effectiveness. It is based on simultaneous measurement of several parameters and presenting the measured data in the form of Sport Diagram (fig. 3). This Diagram presents different profiles of the psycho-physical status of the athlete and allows to attribute the particular measured person to the "effective" or "unsatisfactory" domain. The software program for the automatic implementation of this principle is under construction. It allows to calculate group rating for athletes after measuring a set of their parameters. Several trials in Saint Petersburg Schools of Olympic Reserve demonstrated the high reliability of the developed approach.

DISCUSSION AND CONCLUSION

Research carried out on a large contingent of top athletes indicates complimentary dependence of BEO-gram parameters both on ACE genotype, determining predisposition to the top achievements in endurance, and on actual psychophysical potential of top athletes. BEOgram parameters of sportsmen, registered in the state of relative calmness, owing to their polifunctional specific character, obtain an important independent diagnostic value in objectivisation of psychophysical reserves of athletes, directly characterising their actual motor-psychic potential.

All correlations statistically significant for top-level athletes were much less pronounced for "averaged" sportsmen. For them all parameters had more diffuse distribution that correlated with conclusions of.

Revealed correlations and ranges of parameters typical for elite and "average" athletes allowed us offering a method for assessment and prognosis of sportsmen effectiveness for different levels of athletes depending on sporting discipline. It is based on complex approach with computer processing and evaluation of the following stages.

COMPLEX EVALUATION OF PSYCHOPHYSICAL POTENTIAL OF ATHLETES <u>Stage 1.</u>

Genetic Predisposition and Psycho-Somatic Health Level

- 1. Questionnaire for sport training genetic predisposition.
- 2. Molecular genetic study: polymorphism of ACE gene.
- 3. Psychogenetic characteristics: psycho-type (extraverts introverts), type of nervous activity, neurotism, psychotism.
- 4. "HELPSY" test: evaluation of health level.
- 5. Dermatoglific evaluation.
- 6. Bioenergetic status: functional-energetic index, bilateral balance index, vegetative regulation index (GDV program "Pattern 30").

Stage 2.

Psycho-Physical Readiness

- 1. Test on Physical loading (treadmill, bicycle-ergometer): time of loading.
- 2. MOC (Maximum Oxygen Consumption) test (or PWC-170).
- 3. POMS test, calculation of the psycho-energy index and construction of the multifactor profile.
- 4. HRV spectral analysis at rest and after ortho-test. Calculation of VLF/HF and LF/HF coefficients characteristic of humoral-metabolic and sympathetic-parasympathetic balance. Myocardium disoxia index.
- 5. Quantum indexes from GDV bioelectrography: bioenergy index, entropy index, tomography index.
- 6. Group Rating.

Stage 3.

Actual Psycho-Energetic Status

- 1. Psycho-energy self-regulation (mobilization) level: modulation of BEO-grams and formation of distant emission, dynamic analysis of the BEO-grams' area.
- 2. Evaluation of the psychic profile important for sport activity. "TUFFHETTEST" on 7 parameters.
- 3. Heart activity regulation: Baevsky P.M. index of tension and VLF/(LF + HF) index.
- 4. Chrono-biology analysis. Evaluation of positive and negative periods during the year.

Multivariate computer analysis of the received data allows calculation of a set of psycho-energy coefficients, which characterize current state of an athlete, as well as evaluation of over-training situations. This technology especially applicable for elite athletes in sport disciplines with high level of endurance, but to some extend may be used for heterogeneous cohort of mixed athletic ability and discipline.

REFERENCES

- ¹ McNair DM Profile of Mood States. San Diego, California. 1992
- ² Karpman V., Belotserkovski Z., Gudkov I. Testing in sport medicine. Moscow: FIS. 1988
- ³ Lear S., Brozic A., Myers J., Ignaszewski A. Exercise Stress. Sport Medicine. 1999:2:5:275-345.

⁴ Montgomery H., Clarkson P., Barnard M. et al.. Angiotensin-converting-enzyme gene insertion/deletion polymorphism and response to physical training. Lancet. 1999:353:541-545.

⁵ Nazarov I., Woods D., Montgomery H., Shneider O., Kazakov V., Tomilin N., Rogozkin V. The angiotensin converting enzyme I/D polymorphism in Russian athletes. European Journal of Human Genetics. 2001:9:797-801.

⁶ Korotkov K. Human Energy Field: study with GDV bioelectrography. Backbone publishing, NY. 2002.

⁷ Bundzen P., Korotkov K., Unestahl L.-E. Altered States of Consciousness: Review of Experimental Data Obtained with a Multiple Techniques Approach. J of Alternative and Complementary Medicine, 2002, 8 (2), 153-167.

⁸ Unestahl LE and Bundzen P. Integrated Mental Training - Neuro-Biochemical Mechanisms and Psycho-Physical Consequences. J. Hypnos. 1996:23(3):148-156.

⁹ Kripper S. Altered States of Consciousness, in J. White, ed., The Highest States of Consciousness, New York, 1972:1-5.

¹⁰ Bundzen P., Korotkov K., Nazarov I., Rogozkin V. Psychophysical and Genetic Determination of Quantum-Field Level of the Organism Functioning. Frontier Perspectives, 2002,11,2,8-14

¹¹ Ravich-Scherbo I.V., Marutina T., Grigorenko E. Psycho-genetics. Moscow. 1999