Psychophysiological Peculiarities of Sexual Dimorphism in Athletes

Georgiy Korobeynikov, Lesia Korobeinikova
National University of Physical Education and
Sport of Ukraine, Kiev, Ukraine

Andrey Chernozubz
Nikolaev National University named V. A.
Suhomlinsky, Nikolaev, Ukraine

To determine the influence of sexual dimorphism on mental characteristics in elite athletes, 24 athletes (18-27 years old) (17 men and seven women members of National Judo Team of Ukraine), 20 sedentary men and 20 sedentary women (20-29 years old) were studied in the present paper. Obtained results confirmed significant difference of sexual dimorphism indices in athletes and sedentary people. It was determined that sexual dimorphism manifestations in athletes were as follows: (1) Short memory capacity ($62.58\% \pm 3.21\%$) and coefficient of operational thinking ($2.67\% \pm 0.16$ standard units) were increased in women in comparison with men ($55.78\% \pm 2.07\%$ and 1.44 ± 0.30 standard units, $p < 0.05$, accordingly); and (2) To the contrary, neuro-dynamic functions were decreased in women (latent time of simple (266.92 ± 4.73 ms)) and composite (494.44 ± 6.38 ms) visual-motor reactions and power of nervous processes ($18.49\% \pm 8.93\%$) in comparison with men (239.62 ± 5.26 ms, 440.10 ± 6.61 ms, $5.33\% \pm 0.59\%$, $p < 0.05$, accordingly). Obtained results indicate influence of sexual dimorphism on psychophysiological functions.

Keywords: psychophysiological peculiarities, sexual dimorphism, higher qualification athletes

Introduction

The first evidences of sexual dimorphism appear in a period of prenatal development of the organism. At the early stage of ontogenesis, sexual dimorphism among individuals is detected on the level of primary sexual characteristics. With puberty, the differences between men and women become more expressed through secondary sexual characteristics (Baker & Wilkinson, 2001).

Modern sport is characterized by emancipation, assimilation of female sportsman non-traditional, purely "male" kinds of sports (Lubisheva, 2004). In addition to morphological and functional changes that occur in the women body because of power-speed "male" sports, there are also changes in mentalities: the behavioral reactions and psychoemotional individual traits (Nyaury, Evdokimova, & Kurhanova, 2003).

All the mental reactions which occur in athletes under training and competitive activity are caused due to primarily changes in psychophysiological functions. Thus, we can assume the presence of changes at the level of cognitive functions in athletes in sports of higher achievements.

Some studies show increase of the rate of visual-motor reactions with decrease of the quality of tests at the same time (Shinkaruk & Lysenko, 2004). Obviously, it is related to gender characteristics of attention and

---

Georgiy Korobeynikov, Ph.D., professor, National University of Physical Education and Sport of Ukraine.

Lesia Korobeinikova, Ph.D., associate professor, National University of Physical Education and Sport of Ukraine.

Andrey Chernozubz, Ph.D., associate professor, Nikolaev National University named V. A. Suhomlinsky.

peculiarities of taking the research.

In general, there is the thought of level of sexual dimorphism in some sports with increase of the skill level in athletes (women) (Negri-Cesi, Colciago, & Motta, 2004; Soboleva, 1997).

In our mind, this thesis is somewhat subjective and does not consider the peculiarities of sexual dimorphism for individual-typological characteristics of athletes.

The aim of this work was to study the physiological characteristics of sexual dimorphism in sportsmen of high qualification.

Method

The study involved 24 athletes, members of the team of Ukraine Judo, 17 men and seven women, aged from 18 to 27 years old. Twenty women and 20 men aged from 20 to 29 years old who were not involved in sports (sedentary people) were the control group.

Consents for research in writing form were given by the sportsmen, according to the recommendations to ethics committees for biomedical research.

The individual-typological characteristics of higher nervous system of the athletes were examined by a computer system "Diagnost-1" which is author's work by Makarenko and Lyzogub (Makarenko et al., 2001).

The psychophysiological functions: Functional mobility of nervous processes, strength of nervous processes and neuro-dynamic functions were registered by a computer system.

The system has three modes of testing: optimal, feedback, and imposed rhythm. The latent period of visual motor (simple and complex) reactions, functional strength of nervous processes, and functional mobility of the nervous processes were examined. The functional mobility of the nervous processes measure was the value of the minimum exposure of visual signals with which the number of erroneous reactions did not exceed 5% in a series of some sensor motor choice reactions.

The states of psychical functions, perception, and information process were studied by a special computer test (Korobeynikov, 2011).

Four digits (from 0 to 9) were presented on the computer's monitor randomly. The subjects were asked to perform a combination digit test, the task was to calculate (in mind) the number of digits transposed on the display. The aim of each presented digits road was to transpose in the increasing order.

For example:

5 2 3 4—initial order;

2 5 3 4—first transposition;

2 3 5 4—second transposition;

2 3 4 5—final transposition, the result.

Thus, the result of this task consists of "3" transpositions which need four digits on the display in the increasing order. To answer, a person must press the computer's key "3".

The time and the accuracy of performing each assignment were registered for each person. The used model of visual perception and informational processing was submitted as part of the computer's system of psychophysiological capacity diagnosis (Korobeynikov, 2011).

Based on the testing results, the following psychophysiological parameters were determined: AV (attention volume) and OT (operational thinking) coefficient:

$$AV = (N_r/N) \cdot 100\% \quad (1)$$

where

Nr—the number of tasks performed successfully;

N—the number of all tasks performed.

$$OT = (Nr/T) \cdot 100 \quad (2)$$

where

T—average time of solving a test problem (msec.);

100—coefficient.

For the evaluation of time perception, we used a modified “individual minute” test proposed by Halberg (1978, time perception error (Halberg, Lee, & Nelson, 1978)).

The memory function was determined by using a method for measuring short-term MV (memory volume), which consists in estimating the correctly memorised digits among 12 two-digit figures presented for a subject on a display within 30s.

Results and Discussion

The results of neuro-dynamic functions studied of judokas in different sexes are presented in Table 1. This can be seen from Table 1 the latent periods of simple and complex motor reaction as well as strength of the nervous processes are statistically significant differences between men and women.

The decreasing duration of latent periods of simple and complex motor reaction in men in comparison to women is shown in the improvement of sensomotor response. A similar trend is observed concerning nervous processes (see Table 1).

Table 1

Parameters of Neuro-dynamics Functions of Elite Judokas in Different Sexes

Parameter	Women	Men
Latent period of simple visual-motor response, ms	266.92 ± 4.73	239.62 ± 5.26*
Latent period of complex visual-motor response choice of two of the three stimuli, ms	494.44 ± 6.38	440.10 ± 6.61*
Functional mobility of nervous processes (imposed rhythm), stimuli/min	95.00 ± 6.19	92.67 ± 2.67
Strength of nervous processes (imposed rhythm), % errors	18.49 ± 8.93	5.33 ± 0.59*

Note. * $p < 0.05$; compared with a group of women.

Table 2

Parameters of Neuro-dynamics Functions of Sedentary Persons in Different Sexes

Parameter	Women	Men
Latent period of simple visual-motor response, ms	279.26 ± 8.52	289.22 ± 9.74
Latent period of complex visual-motor response choice of two of the three stimuli, ms	477.62 ± 2.12	493.21 ± 3.06*
Functional mobility of nervous processes (imposed rhythm), stimuli/min	73.88 ± 2.27	83.48 ± 3.72*
Strength of nervous processes (imposed rhythm), % errors	9.34 ± 0.43	10.45 ± 0.73

Note. * $p < 0.05$; compared with a group of women.

The data of neuro-dynamic functions of sedentary persons in different sexes are shown in Table 2. The decline of duration of latent periods of complex motor reaction in women is signified the increase of speed of sensomotor reaction. At the same time, the functional mobility of nervous processes was significantly better in

men in comparison to women.

Thus, the studies show different signs of sexual dimorphism of athletes of high qualification and sedentary persons for neuro-dynamic functions parameters.

The cognitive functions of judokas in different sexes are presented in Table 3. According to Table 3, the short-term MV and OT coefficient are statistically significant increasing in women in comparison to men.

Table 3

Parameters of Cognitive Functions of Elite Judokas in Different Sexes

Parameter	Women	Men
Time perception error, s	7.17 ± 2.35	7.07 ± 1.72
AV, %	77.67 ± 7.58	72.47 ± 6.59
Short-term MV, %	62.58 ± 3.21	$55.78 \pm 2.07^*$
OT coefficient, standard units	2.67 ± 0.16	$1.44 \pm 0.30^*$

Note. * $p < 0.05$; compared with a group of women.

This result is shown that the development of cognitive characteristics compared with growth of neuro-dynamic functions is related to peculiarities of sexual dimorphism of women athletes of higher qualification.

The cognitive functions of sedentary persons in different sexes are presented in Table 4. The data showed the greater meanings of AV, short-term MV and operational thinking coefficient in men comparison to women.

Table 4

Parameters of Cognitive Functions of Sedentary Persons in Different Sexes

Parameter	Women	Men
Time perception error, s	9.89 ± 4.07	9.89 ± 4.07
AV, %	74.30 ± 4.9	$98.00 \pm 1.3^*$
Short-term MV, %	50.35 ± 0.89	$52.62 \pm 1.63^*$
OT coefficient, standard units	0.86 ± 0.97	$1.41 \pm 0.44^*$

Note. * $p < 0.05$; compared with a group of women.

According to this fact there is distinction of peculiarities of sexual dimorphism among athletes and sedentary persons. First of all, it manifested improving memory function and operational thinking in the women engaged in judo.

Thus, developments of cognitive functions with the increase of neuro-dynamics level in women in comparison to men are demonstration of psychophysiological peculiarities of sexual dimorphism in athletes.

This result is associated with relationship of mental and motor components with resulting in the observed and estimated plurality executive activity of the features of combat sport as a kind of human activity (Rodionov, 2003).

Thus, the authors can admit that organization of psychophysiological functions in athletes of high qualification has different strategies for information processing which sex depends on.

The use of traditional statistical method analysis for study of the visual perception and informational processing capability in athletes was insufficient. The application of informative mathematical methods to the study of these processes was more correct. The information processing was studied by informative mathematical methods. According to entropy of systems by Shannon (1948), Glushkov (1963) has proposed the self-organization theory. The use of basis of self-organization theory of Förster (1964) and later one of the major parameters of the system organization (as a reflection of the information processing) that Antomonov

(1969) has proposed are the following organization measure:

$$R = 1 - \frac{H}{Hm} \quad (3)$$

where

R —measure of system organization (Glushkov, 1963);

H —current entropy;

Hm —maximum entropy.

The current entropy was determined by Shannon (1948):

$$H = - \sum_{i=1}^n P_i * \log P_i \quad (4)$$

where

P_i —probability of i -state system;

n —number of system states.

Probability of i -state system in informational processing was determined:

$$P_i = \frac{Nr}{N} \quad (5)$$

where

Nr —number of correct information processing;

N —number of total information processing.

Maximum entropy was determined:

$$Hm = \log n \quad (6)$$

The number of system states for visual information processing was determined as maximum number of one information processing stimulus ($n = 6N$).

The organization measure of information processing in different sex in judokas and sedentary persons is presented in Figure 1.

Figure 1. The organization measure of information processing in judokas and sedentary persons.

Notes. * $p < 0.05$ compared to the women's group; ** $p < 0.05$ compared to the judokas' group.

The analysis of different groups of athletes is showed that among judokas the parameter of R in women (0.42 ± 0.01) is more decreasing ($p < 0.05$) than in men (0.53 ± 0.07).

The same trend is observed in the group of sedentary persons (respectively of women $R = 0.74 \pm 0.05$, and in men $R = 0.92 \pm 0.03$). The only difference is that in athletes score is significantly lower R ($p < 0.05$), compared with sedentary people, both men and women (see Figure 1).

This fact reflects a stochastic growth of information processing: firstly, in women compared with men; and secondly, under the influence of sports activities.

Stochasticity of functional search system provides the necessary links for the optimal level of functioning (Korobeynikov, 2001).

Thus, a possible compensatory way of finding optimal brain functioning in conditions of adaptation to sports activities reflects the presence of stochasticity of information processing in women in sports activity.

The increase in stochasticity of processing information was also evident in judokas men, compared with sedentary persons.

However, compared with women, men are observed by the determinism of information processing. As a result, it is improving the performance of short-term memory and thinking operating ratio in women compared with men (see Table 3).

In our previous studies, the concept of psychophysiological stochastic organization in the mental activity was substantiated (Korobeynikov, 2001; 2011). According to this concept, the psychophysiological stochastic organization is a mechanism for the quest of optimal mental activity. In the process of sports activity, the adaptative-compensatory mechanisms of decline of visual perception and information processing capability protection get activated. One of these mechanisms is linked with the peculiarities of sex of psychophysiological dimorphism stochastic organization.

Conclusions

The development of cognitive function in women, and improving the value of neuro-dynamics in men are reflected in the psychophysiological peculiarities of sexual dimorphism in athletes of high qualification compared with sedentary persons.

Due to growth of stochasticity of information, processing in women was observed by improvement of short-term memory and operational thinking.

Stochasticity of information processing in women reflects a possible compensatory way of finding the optimal integrative brain function in adaptation to sports activities. In men, the organization of information processing is characterized by greater determinism, especially those not involved in sports than in athletes.

References

- Abramov, A., Smirnova, E., & Abramov, S. (2004). Becoming a function of the endocrine system of female athletes puberty. In *Sports medicine* (pp. 21-28). Kiev: Olympic Books.
- Antomonov, Y. G. (1969). *Systems, complexity, dynamics*. Kiev: Naukova Dumka.
- Baker, R. H., & Wilkinson, G. S. (2001). Phylogenetic analysis of sexual dimorphism and eye-span allometry in stalk-eyed flies. *Evolution: International Journal of Organic Evolution*, 55(7), 1373-1385.
- Förster, H. (1964). Biological computers. In *Bioastronautics* (pp. 333-360). New York: K. E. Schaefer, Macmillan Co..
- Glushkov, V. M. (1963). *Introduction to cybernetics*. Kiev: Naukova Dumka.
- Halberg, F., Lee, J. K., & Nelson, W. L. (1978). Time-qualified reference intervals—Chronodesms. *Experientia: Basel*, 34, 713-716.

- Korobeynikov, G. (2001). Aging peculiarities of informational processing organization. *Studia Psychologica*, 43(1), 69-75.
- Korobeynikov, G. (2011). *Psychophysiology of human activity*. Saarbrücken: Lambert Academic Publishing.
- Lubisheva, L. A. (2004). The woman in the world of sports: A view of sports sociologist. In *Science in Olympic sports* (pp. 3-6). Kiev: Olympic Books.
- Makarenko, N. V., Lyzogub, V. S., Boreyko, T. I., ... Andrienko, E. D. (2001). Sensory-motor function in human ontogeny and their relationship with the properties of the nervous system. In *Human physiology* (pp. 52-57). Kiev: Naukova Dumka.
- Negri-Cesi, P., Colciago, A., & Motta, M. (2004). Sexual differentiation of the brain: Role of testosterone and its active metabolites. *Journal of Endocrinol Invest*, 27(Suppl. 6), 120-127.
- Nyaury, D. A., Evdokimova, T. A., & Kurhanova, M. Y. (2003). *Reproductive health of women in sport*. Sankt Petersburg.
- Rodionov, A. (2003). Principle of psychophysiological conjugation in the preparation of athletes of higher qualification. In *Science in Olympic sports* (pp. 143-146). Kiev: Olympic Books.
- Shannon, C. E. (1948). *A mathematical theory of communication*. Bell. System. Tech. J..
- Shinkaruk, O., & Lysenko, E. (2004). The influence of sexual dimorphism, and physical activity in the manifestation of neurodynamic properties in high-class sportsmen. *Science in Olympic Sports*, 1, 75-79.
- Soboleva, T. S. (1997). *Formation sexuality characteristics in girls and young women against the backdrop of sports*. Sankt Petersburg.