

KINESIOLOGY / COACHING

GEORGIY KOROBAYNIKOV^{1(CDEFG)}, MARIA BULATOVA^{2(ACD)}, OLEKSANDR ZHIRNOV^{1(BE)},
WOJCIECH J. CYNARSKI^{3(EFG)}, JACEK WASIK^{4(DF)}, LESIA KOROBAYNIKOVA^{5(AD)},
DENIS VOLSKIY^{1(BD)}, VICTORIA MISHCHENKO^{1(BD)}, IGOR MALINSKIY^{6(CBG)},
URIY SERGIENKO^{6(CBG)}

1 Department of Biomechanics and Sport Metrology, National University of Ukraine on Physical Education and Sport, Kiev (Ukraine)

2 Department of History and Theory of Olympic Sport, National University of Ukraine on Physical Education and Sport, Kiev (Ukraine)

3 Institute of Physical Culture Sciences, University of Rzeszow, Rzeszow (Poland)

4 Jan Dlugosz University in Czestochowa, Institute of Physical Education, Tourism and Physiotherapy, Czestochowa (Poland)

5 Department of Psychology and Pedagogy, National University of Ukraine on Physical Education and Sport, Kiev (Ukraine)

6 Department of Physical Education, Sport and Health, University of the State Fiscal Service of Ukraine, Irpin, (Ukraine)

Contact: Dr Georgiy Korobaynikov, National University of Ukraine on Physical Education and Sport, 03150, Kiev, Ukraine

e-mail: k.george.65.w@gmail.com, +380971491559, +38044289-73-27

Links between postural stability and neurodynamic characteristics in kickboxers

Submission: 8.05.2019; acceptance: 19.01.2020

Key words: kinetic stability, neurodynamics characteristics, kickboxers

Abstract

Purpose – study of links between neurodynamic functions and postural stability in elite kickboxers.

Methods. 27 kickboxers, aged 12-15 were examined. The apparatus-programs complex «Psychotest-NS» was used for the study of neurodynamic functions. The study of postural stability was conducted using the plural stabilograms «Stabilan» method.

Results. The results show that kickboxers with a higher level of postural stability have a lower square of oscillation of the total center of mass of the body during visual deprivation. This higher level of postural stability in kickboxers is linked to increasing accuracy and attention in conditions of differential informational processing, with a simultaneous decline in muscular force and lowering of speed of sensory-movement response to complex stimulus. Kickboxers with lower levels of postural stability revealed more high meanings of muscular force and speed of sensory-movement response to differential visual stimuli.

Conclusions. The study has revealed the functional links between postural stability and neurodynamic characteristics in kickboxers. Received data can be used in the training process of qualified kickboxers to improve training activity and give higher sport results.

Introduction

Sport of high achievements is an uncial phenomenon which demonstrates of maximum indication and realization of abilities and human talents [Martindale, Collins, Abraham 2007; Phillips *et al.* 2010]. As a result of long term of physical loads a basic functional system of organism, which is responsible for efficacy of sport activity, is formed [Ebrahimi *et al.* 2013; Chernozub *et al.* 2019; Xianglin *et al.* 2019].

One of the current problems in modern sport is the improvement of capacity in athletes [Issurin 2013]. Different authors think that increasing the level of sport

achievements is linked with account of individual peculiarities of neurodynamics functions in athletes which derive from typological characteristics of high nervous system [Kozina *et al.* 2018; Podrigalo 2019].

The neurodynamics functions are supported by abilities of perception and information processing, balance of processes of arousal and inhibition, and decision making during sport activity [Makarenko, Lyzohub 2007; Korobaynikova *et al.* 2016]. In martial arts the neurodynamic functions play a key role during a fight [Starosta 2017]. The athlete has the perception of external information about the position of a rival, decision making of tactical strategy and the athlete has to react on the

situation [Arziutov *et al.* 2016; Chernozub *et al.* 2018]. Especially important is the influence of neurodynamic functions to efficacy of sport activity in kickboxers.

However, not much work which is devoted to kickboxing and studies of neurodynamic functions and psychophysiological states during training and competitions activities.

The sport preparedness in kickboxing includes training and competition activities which are subordinate to the life of the athletes. That is why the high motivation to achieve the higher sport results is relied on the implementation of individual-typological peculiarities of nervous system [Makarenko, Lyzohub 2007; Sterkowicz-Przybycien, Miarka, Fukuda 2017; Castro-Sanchez *et al.* 2016].

Among specialists who study martial art including kickboxing the main purpose of investigations is variation and efficacy of technical-tactical movement of athletes [Romanenko *et al.* 2018] and improvement of level of special physical preparedness [Chernozub *et al.* 2018; Starosta 2017]. However, in different works there is a lack of the link between possibilities of realization of technical-tactical movements and properties of nervous system.

Besides, some authors investigate the relation of methodological and theoretical problems of sport preparedness in athletes, peculiarity of diagnostics of functional states, motivation of sport activity and emotional states during competition activity [Makarenko *et al.* 2016].

But more and more scientists are beginning to investigate the relation between motor and sensory components of functional states and focus their attention on studying complexity of biomechanics and psychophysiological control and influence of physical loads on cognitive functions [Lenetsky, Harris, Brughelli 2013; Dudnyk *et al.* 2017].

This fact has developed in connection with the study for some reasons. Firstly, individual-typological characteristics of high nervous system related to potential peculiarities of human to information processing with limit time [Korobeynikova *et al.* 2016].

Secondly, the neurodynamic functions have important meaning in conditions of forming of functional system which is responsible for sport results [Morgan, Fletcher, Sarkar 2017].

Thirdly, some authors believe that motor activity which supports movement functions is an external manifestation of higher nervous activity [Makarenko *et al.* 2011].

Thus, we can resume that in sport training the athletes have opportunities to achieve their results due to their own genetically determined typological properties of nervous system. That is why the training of elite kickboxers needs from our coaches the information about the state of neurodynamics functions.

Thus, as seen in the analysis of last publications there are little studied aspects which are related to peculiarities of development and forming of neurodynamic functions of athletes during training and competition

activities. Especially there are no studies of links between biomechanic peculiarities and postural stability in elite kickboxers. The investigation of this problem is a very important for martial arts.

Purpose

The purpose: study of links between neurodynamic functions and postural stability in elite kickboxers.

Methods

Participants

27 junior kickboxers, aged 12-15, who have qualification level, were examined. The results of postural stability all of athletes were separate in two groups: with high (13 persons) and low (14 persons) level.

Measures

According to recommendations of the ethical committee written authorization of the study was received from all of athletes. The experimental study was approved by the Ethics Committees for Biomedical Research in accordance with the ethical standards of the Helsinki Declaration.

Procedure

In order to achieve the purpose, the method of estimated complex time of visual-movement reaction was used. The model of information processing for visual stimulus to different colour: red, white and green was used. When on display a red stimulus appears a person can press the right key, when a green stimulus appears the person can press the left key, when a white stimulus appears the person should not press any key.

As a result, the variables: average time of reaction, average deviation of time reaction and coefficient of accuracy were determined. Besides the force of right and left arms were determined. These tests are included in software complex for psychophysiological diagnostics «Psychotest-PS».

The methods of stabilometry «Stabilan-01» were used to study postural stability of athletes. As a result of investigation the variables: length of the trajectory of moving the center of mass of the body in the frontal and sagittal planes, the displacement velocity and the area of oscillation of the total center of mass of the body were determined.

Statistical analysis

For statistical analysis of the study the program of “Statistica-6” (StatSoft) was used. Due to the results of data which are not in accordance with the law to normal distribution we used the non-parametric criterions: median (Me), lower (25%) and upper (75%) quartiles [Pett 2015].

In order to determine the changes between and inside in groups the criteria of Wilcoxon-Manna-Whitney were used [Martindale, Collins, Abraham 2007; Pett 2015].

Results

As the criterion of postural stability, the variable of square of fluctuations of the center of the mass of the body of the athlete in the conditions of the visual test was used. The received results are presented in Table 1.

Table 1. Variables of square of fluctuations of total center of mass of the body of kickboxers with different level of kinetic stability during visual test (mm²)

Conditions of test	High postural stability (n=13)			Low postural stability (n=14)	
	Mediana	Lower quartile	Upper quartile	Mediana	Lower quartile
open eyes	396,20	360,80	468,50	316,10	285,70
closed eyes	492,60*	486,70	526,90	764,55* [*]	690,00

Notes:

* p<0,01 – significant changes between athletes who have higher level of postural stability

^{*} p<0,01 – significant changes for comparison to open eyes

The received results showed that athletes with lower level of postural stability have bigger fluctuations area of total center of mass of body in comparison with the athletes with high level of postural stability (p < 0,05). Especially this is indicated in the test with eyes closed when the deprivation of visual information was observed.

This fact testifies the more perfect system of vestibular apparatus in kickboxers with high level of postural stability in condition of deprivation of visual control.

The variables of neurodynamic functions in kickboxers with different level of postural balance during visual test are presented in Table 2.

The analysis showed that athletes with lower level of postural stability have higher meaning of force of right and left arms in comparison to athletes with higher level of postural stability.

The variables of average time of complex visual-movement reaction in athletes with high level of postural stability are significantly bigger in comparison with the athletes of another group of (p<0,05). This fact indicated the decline of speed of information processing and motor reply in athletes with higher level of postural stability.

Respectively, in athletes with lower level of postural stability the speed of sensory-movement reaction on different stimulus are significantly bigger than in athletes with higher level of postural stability (p<0,05). This fact indicates the activation of the compensatory mechanisms for achievement of high sport results in athletes with non stability vestibular apparatus.

Table 2 Variables of neurodynamic functions of kickboxers with different level of postural stability (n=27)

Variables	Mediana	Lower quartile	Upper quartile
High postural stability (n=13)			
Force of right arm, kg	17,50	12,70	24,00
Force of left arm, kg	15,20	13,70	19,80
Time of visual-movement reaction, ms	348,00*	323,00	374,00
Average deviation of time reaction, ms	76,00	62,30	95,30
Coefficient of accuracy, secret unit	0,09	0,05	0,10
Low postural stability (n=14)			
Force of right arm, kg	22,30*	10,80	31,50
Force of left arm, kg	22,15*	12,65	28,65
Time of visual-movement reaction, ms	315,00	300,00	359,00
Average deviation of time reaction, ms	72,00	62,40	80,60
Coefficient of accuracy, secret unit	0,07	0,05	0,09

Notes:

* p<0,01 – significant changes in athletes who have higher level of postural stability

There were no significant differences between individual groups of athletes in terms of the parameter of average time response deviation. (Table 2).

Thus, the analysis showed that athletes with higher level of postural stability are characterized by decreasing importance of force of both arms and lower speed of sensory-movement reaction to complex different stimulus.

On the other hand, in athletes with a lower level of postural stability, the importance of muscle strength and the speed of the complex visual-motor response is greater than in other groups of athletes.

In this regard, one of the main factors which influence the quality and efficacy of sport activity in martial arts are accuracy and productivity of information processing. Apart from athlete's ability to practise force and speed characteristics, very important is accuracy of strike technique in boxing and kickboxing. As a seen in the result, coefficient of accuracy indicated the accuracy of selective attention during performing processing of visual stimulus.

The analysis of coefficient of accuracy showed the tendency to greater absolute importance among athletes with higher level of postural stability compared to athletes with lower level of postural stability. This fact showed that the athletes with higher level of postural stability have increasing accuracy and attention during processing of visual information.

Discussion

The results of the study showed that for martial arts the functional system of postural stability is very important for realization of efficacy of sport activity. The structure of

movement actions of kickboxers is characterized by changes in the static and dynamic motion used in coordination and balance of body in the field. That is why in different situations the postural stability is linked with the efficacy of kickboxers activity [Podrigalo *et al.* 2019]. The postural stability and visual-movement responses are related to united neurophysiology mechanisms [Starosta 2017].

The analysis of the study showed that athletes with high level of postural stability have decline of area of oscillation of the total center of mass of the body.

The area of oscillation of the total center of mass of the body in athletes with lower level of postural stability is increasing during the complexity of task with deprivation of visual analyzer. The obtained fact indicates a more complex system of vestibular apparatus, which provides high postural stability of kickboxers with lower changes of area of oscillation of the total center of mass of the body in absence of visual control. These results are consistent with studies of authors who have demonstrated the dynamic activity of mechanism of postural balance while effectively searching for the most important central nervous system the most relevant vestibular information [Smetanin, Popov, Kozhina 2006; Herpin *et al.* 2010; Barcala *et al.* 2013].

The athletes with high level of postural balance have lower values of static muscular force and speed of visual-movement response. The results indicate that the effectiveness of movement in kickboxers depends not only on strength and speed characteristics, but also on quality.

In view of the psychophysical mechanisms, the sensory-movement response depends on two factors: afferent (sensory) and efferent (motor) components. The improvement of sensory component is linked with liability of nervous process and possibilities of nervous system to speed switching of process excitation and inhibition. The motor component depends on status of nervous-muscular apparatus and is characterized by speed and force performance [Korobeynikova *et al.* 2016; Chernozub *et al.* 2019].

The highest value of postural balance in kickboxers is due to the quality of the sensory component. The reduction of postural balance is linked with the domination of motor component. The development of sensory component is a more optimal way for kickboxers. This is related to the possibility for of athletes to perform of precise motor activities and maintain body balance.

Conclusions

1. Kickboxers with higher level of postural stability have less area of oscillation of the total center of mass of the body during visual deprivation.
2. Higher level of postural stability in kickboxers is linked with the increase of accuracy and attention in condition of differential informational process-

ing with simultaneous to decline of muscular force and low of speed of sensory-movement response to complex stimuluses.

3. Kickboxers with a lower level of posture stability have shown greater importance of muscle strength and speed of sensory-motor response to various visual stimuli.

References

1. Arziutov G., Iermakov S., Bartik P., Nosko M., Cynarski W.J. (2016), *The use of didactic laws in the teaching of the physical elements involved in judo techniques*, “Ido Movement for Culture. Journal of Martial Arts Anthropology”, vol. 16, no. 4, pp. 21-30; doi:10.14589/ido.16.4.4.
2. Barcala L., Grecco L.A.C., Colella F., Lucareli P.R.G., Salgado A.S.I., Oliveira C.S. (2013), *Visual biofeedback balance training using wii fit after stroke: a randomized controlled trial*, “Journal of physical therapy science”, vol. 25, no. 8, pp. 1027-1032.
3. Castro-Sanchez M., Zurita-Ortega F., Martinez-Martinez A., Chacon-Cuberos R., Espejo-Garcés T. (2016), *Motivational climate of adolescents and their relationship to gender, physical activity, sport, federated sport and physical activity family*, “Revista Internacional de Ciencias del Deporte”, vol. 12, no. 45, pp. 262-277; doi: 10.5232/ricyde.
4. Chernozub A., Danylchenko S., Imas Y., Natalia I., Korobeynikov G., Korobeynikova L., Gorashchenko A. (2019), *Peculiarities of correcting load parameters in power training of mixed martial arts athletes*, “Journal of Physical Education & Sport”, vol. 19, no. 70, pp. 481-488; doi: 10.7752/jpes.2019.s2070.
5. Chernozub A., Korobeynikov G., Mytskan B., Korobeynikova L., Cynarski W.J. (2018), *Modelling Mixed Martial Arts Power Training Needs Depending on the Predominance of the Strike or Wrestling Fighting Style*, “Ido Movement for Culture. Journal of Martial Arts Anthropology”, vol. 18, no. 3, pp. 28-36; doi: 10.14589/ido.18.3.5.
6. Dudnyk O., Yarmak O., Dotsyuk L., Mykhaylyshyn G., Zoriy Y., Moseychuk J. (2017), *Assessment of human psychophysiological responses to intense exercise: a survey of Greco-Roman wrestlers and unqualified competitors*, “Journal of Physical Education and Sport”, vol. 17, no. 3, pp. 2089-2096; doi:10.7752/jpes.2017.s4212.
7. Ebrahimi M., Rahmani-Nia F., Damirchi A., Mirzaie B., Pur S.A. (2013), *Effect of short-term exercise on appetite, energy intake and energy-regulating hormones*, “Iranian journal of basic medical sciences”, vol. 16, no. 7, pp. 829-834.
8. Herpin G., Gauchard G.C., Lion A., Collet P., Keller D., Perrin P.P. (2010), *Sensorimotor specificities in balance control of expert fencers and pistol shooters*, “Journal of electromyography and kinesiology”, vol. 20, no. 1, pp. 162-169; doi:10.1016/j.jelekin.2009.01.003.
9. Issurin V.B. (2013), *Training transfer: scientific background and insights for practical application*, “Sports medicine”, vol. 43, no. 8, pp. 675-694; doi: 10.1007/s40279-013-0049-6.

10. Korobeynikova L.G., Makarchuk M.Y., Korobeynikov G.V., Mischenko V.S., Zapovitryana O.B. (2016), *States of psychophysiological functions of elite athletes in different aging groups*, "Fiziolohichniy zhurnal", vol. 62, no. 6, pp. 81-87.
11. Kozina Z., Goloborodko Y., Boichuk Y., Sobko I., Repko O., Bazilyuk T., Osipov A. (2018), *The influence of a special technique for developing coordination abilities on the level of technical preparedness and development of psycho-physiological functions of young volleyball players 14-16 years of age*, "Journal of Physical Education and Sport", vol. 18, no. 3, pp. 1445-1454; doi: 10.7752/jpes.2018.03214.
12. Lenetsky S., Harris N., Brughelli M. (2013), *Assessment and contributors of punching forces in combat sports athletes: Implications for strength and conditioning*, "Strength & Conditioning Journal" vol. 35, no. 2, pp. 1-7; doi: 10.1519/SSC.0b013e31828b6c12.
13. Makarenko M.V., Lizogub V.S., Yukhymenko L.I., Khomenko S.M., Koval Y.V. (2016), *Technological Support of Estimating Functional Opportunities of Higher Parts of Central Nervous System in the Individuals with Auditory Deprivation*, "American Journal of Engineering Research" (AJER), vol. 5, no. 10, pp. 67-71.
14. Makarenko M.V., Lysohub V.S., Kozhemiako T.V., Chernenko N.P. (2011), *Age-dependent speed of the central information processing among persons with the different level of the nervous processing functional mobility*, "Fiziolohichniy zhurnal", vol. 57, no. 1, pp. 88-93.
15. Makarenko M.V., Lysohub V.S. (2007), *The speed of central information processing in humans with different properties of basic nervous processes*, "Fiziolohichniy zhurnal", vol. 53, no. 4, pp. 87-91.
16. Martindale R.J., Collins D., Abraham A. (2007), *Effective talent development: The elite coach perspective in UK sport*, "Journal of applied sport psychology", vol. 19, no. 2, pp. 187-206; doi: 10.1080/10413200701188944.
17. Morgan P.B., Fletcher D., Sarkar M. (2017), *Recent developments in team resilience research in elite sport*, "Current opinion in psychology", vol. 16, pp. 159-164.
18. Pett M.A. (2015), *Nonparametric statistics for health care research: Statistics for small samples and unusual distributions*, Sage Publications.
19. Phillips E., Davids K., Renshaw I., Portus M. (2010), *Expert performance in sport and the dynamics of talent development*, "Sports medicine", vol. 40, no. 4, pp. 271-283; doi: 10.2165/11319430-000000000-00000.
20. Podrigalo L., Cynarski W.J., Rovnaya O., Volodchenko O., Halashko O., Volodchenko J. (2019), *Studying of physical development features of elite athletes of combat sports by means of special indexes*, "Ido Movement for Culture. Journal of Martial Arts Anthropology", vol. 19, no. 1, pp. 51-57; doi: 10.14589/ido.19.1.5.
21. Romanenko V., Podrigalo L., Iermakov S., Rovnaya O., Tolstoplet E., Tropin Y., Goloha V. (2018), *Functional state of martial arts athletes during implementation process of controlled activity - comparative analysis*, "Physical Activity Review", vol. 6, pp. 87-93; doi: <http://dx.doi.org/10.16926/par.2018.06.12>.
22. Smetanin B.N., Popov K.E., Kozhina G.V. (2006), *Dependence of joint stiffness on the conditions of visual control in upright undisturbed stance in humans*, "Neurophysiology", vol. 38, no. 2, pp. 157-166; doi: 10.1007/s11062-006-0036-8.
23. Starosta W. (2017), *Importance of movement symmetry in technical and tactical preparation of high advanced judokas different level of mastership*, "Journal of Combat Sports & Martial Arts", vol. 8, no. 1, pp. 25-29.
24. Sterkowicz-Przybycien K., Miarka B., Fukuda D.H. (2017), *Sex and weight category differences in time-motion analysis of elite judo athletes: Implications for assessment and training*, "Journal of strength and conditioning research", vol. 31, no. 3, pp. 817-825.
25. Xianglin K., Pengcheng G., Rusanova O., Diachenko A. (2019), *Reaction of the organism to repeated training loads, directed to improve the performance of the qualified rowers of China*, "Journal of Physical Education & Sport", vol. 19, no. 70, pp. 453-460; doi: 10.7752/jpes.2019.s2066.

Powiązania między stabilnością postawy a cechami neurodynamicznymi kickboksersów

Słowa kluczowe: stabilność kinetyczna, charakterystyka neurodynamiki, kickbokserszy

Streszczenie

Cel. Badanie powiązań między funkcjami neurodynamicznymi a stabilnością postawy w grupie elitarnych kickboksersów.

Metody. Badaniu poddano 27 kickboksersów w wieku 12-15 lat. Do badania funkcji neurodynamicznych wykorzystano kompleks aparatów-programów „Psychotest-NS”. Badanie stabilności postawy przeprowadzono metodą mnogich stabilogramów „Stabilan”.

Wyniki. Wyniki pokazują, że kickbokserszy o wyższym poziomie stabilności postawy mają mniejszy pierwiastek kwadratowy oscylacji całkowitego środka masy ciała podczas deprywacji wzrokowej. Wyższy poziom stabilności postawy u kickboksersów łączy się ze zwiększeniem dokładności i uwagi w warunkach różnicowego przetwarzania informacji przy jednoczesnym spadku siły mięśniowej i niskiej prędkości reakcji zmysłowo-ruchowej na złożone bodźce. Kickbokserszy o niższym poziomie stabilności posturalnej ujawniają większy stopień znaczenia siły mięśni i szybkości reakcji zmysłowo-ruchowej na zróżnicowane bodźce wzrokowe.

Wnioski. Badanie wykazało funkcjonalne powiązania pomiędzy stabilnością postawy a cechami neurodynamicznymi kickboksersów. Otrzymane dane mogą być wykorzystane w procesie kwalifikacji kickboksersów do poprawy aktywności trenerskiej i uzyskania wysokich wyników sportowych.