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The Impact of Cognitive Processors and Conative Regulators on Specific Motor Abilities in Boxers

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A B S T R A C T

The aim of the study was to analyze the relations of cognitive processors and conative regulators with specific motor abilities of elite boxers. Three sets of variables including 3 cognitive and 6 conative variables as predictors, and 6 specific motor (boxing) variables as criteria were used in a sample of 92 boxers. A series of regression analyses between the set of cognitive variables and particular criterion variables revealed a predominant impact of serial processor on specific motor abilities based primarily on specific speed (frequency of boxing technique performance). The series of regression analyses also showed a predominant negative impact of dysregulation of the organ function regulators from the set of conative variables on the manifestation of specific motor abilities in boxers. The data obtained in the study were used to develop an alternative model of the motor – cognitive – conative processes in boxing.

Key words: *elite boxing, specific motor – cognitive – conative parameters, model of selection*

Introduction

Previous studies have demonstrated the existence of positive correlation between intelligence and performance of complex motor tasks[1–5], and thus also with specific motor knowledge in various sports. This correlation is explained by the general speed of information flow as well as by the role of cognitive processes in motor activity. Cognitive processes and cognitive functioning are central mechanisms of cortical regulation. Central nervous system (CNS) has primarily an integrative function, ensuring reasonable and adaptive behavior in humans. Integration at the cortical level is of utmost importance because reasonable behavior is directly linked with the integrative function of the cerebral cortex. The integration also exists at the subcortical level, especially in the situations that require automatic reaction. Luria's study (1973)[6] has shown that tertiary zones of cerebral cortex play the main role in ensuring simultaneous (spatial) syntheses, and include cortical segments of the visual, auditory, vestibular and tactile-kinesthetic analyzer. According to Semmes (1968)[7], left hemisphere favors integration of similar units into information, whereas right hemisphere favors integration of dissimilar units. Marteniuk (1976)[8] reports that perceptive-motor skills include a major cognitive component which influences activities related to organization, direction and control of movements. Ismail and El-Naggar (1981)[4] emphasize that both successive and simultaneous processes including left and right cerebral hemispheres are present on performing motor coordination tasks. In a study performed in high-school students, Katić (1977)[3] found a high positive correlation of coordination, speed and explosive strength tests with the tests of visual spatialization (simultaneous processor) and perceptive reasoning (perceptive processor). Investigating the relations of motor abilities and knowledge in school subjects among high-school students, Katić (1988)[5] concluded that the success in the subject of physical education significantly depended on the function of simultaneous (parallel) and perceptive (serial) processors in both sexes.

There are various theories (Schmidt, 1975; Ackerman, 1988)[9,10] on what is necessary in the formation of the motor program. Task duration and structure definitely are the main characteristics that influence the

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mode of the motor program formation. When a child is acquiring a motor program (motor knowledge or skill), it initially occurs at a cortical level, to continue at the subcortical level as the program is gradually being mastered[1–5,11–13].

Accordingly, cognitive functions that depend on integration of the mechanisms for the receipt, transmission and decoding of information in the CNS, are connected to the mechanisms of motor regulation of movement. As many motor behaviors are complex and include a variable component of cognitive behavior, it is presumed that the same and/or similar mechanisms are responsible for the motor and intellectual behavior in humans. Cognitive mechanisms will certainly influence performance in boxing; however, it should be assessed whether this performance is predominantly influenced by the perceptive and simultaneous (spatial) processor.

Behavioral modalities are more or less responsible for performance in any human activity. Therefore, kinesiology studies of relations between different conative factors and sports engagement and performance are of utmost importance. Some conative space characteristics are known to limit efficiency in various activities. In addition, the same conative characteristics may have a restricting role in some activities while stimulating efficiency in others, especially when implicated in the particular activity performance. Considering the fact that conative factors are not independent of the process of conditioning during one's lifetime, sports turns to be a very important activity because it provides an opportunity to almost naturally reduce the adaptively unwanted behavioral modalities while developing the individually and socially desirable ones. Being aware that other functions, along with motor and intellectual abilities, can also be upgraded through proper treatment or control of particular conative features, is highly relevant for both sports and social efficiency. Mraković and Katić (1989)[14] analyzed association of some typical conative characteristics with the intensity of kinesiologic activities in women. The relations thus obtained showed bipolar properties: kinesiologic activities of women was found to depend on the negative effect of anxiety on the one hand, and on the positive impact of hypomania on the other hand, whereby the negative influence of anxiety greatly outweighed the positive impact of hypomania. In other words, anxiety limited kinesiologic activity to a significantly greater extent than it was stimulated by hypomania. In male *versus* female subjects (high-school students), Katić (1977)[15] defined canonic relation between psychomotor and pathologic conative factors[16] by a general degree of equilibrium of psychomotor characteristics determined by pathologic conative characteristics, positively by elevated values of the sthenic and negatively by elevated values of the asthenic syndrome. The results obtained are explained as follows: anxious symptoms predominated by inhibition reduce, while sthenic symptoms (hypomania in particular) predominated by nervous system excitation improve motor efficiency (explosive strength in particular). The present study determined conative structure, i.e. conative features that determine results of tests of specific motor abilities in boxing.

Subjects and Methods

Subjects

Study sample included 92 boxers from Croatian boxing clubs (Rijeka, Pula, Split, Zagreb, Slavonski Brod, Osijek, Varaždin and Zadar). At the time of study measurements, the subjects were healthy, regularly performing their training activities, and free from pronounced morphological, motor and physiologic deviations.

According to boxing categories, there were three flyweight (≤50 kg), six bantam-weight (≤54 kg), eight featherweight (≤57 kg), ten lightweight (≤60 kg), 12 light-welterweight (≤64 kg), 14 welterweight (≤69 kg), 15 middleweight (≤75 kg), ten light-heavyweight (≤81 kg), eight heavyweight (≤91 kg) and six super-heavyweight (>91 kg) boxers.

Variable sample

The variable sample consisted of 15 variables including 3 cognitive variables and 6 conative variables as predictor sets of variables, and 6 variables of specific motor abilities as a criterion set of variables.

Cognitive abilities were assessed by use of three representative tests for determination of the main cognitive processor function efficiency (Momirović et al., 1982)[17]:

- efficiency of perceptive processor – IT_1 (designed to measure perceptive ability which represents synthesis of the ability of perceptive analysis, perceptive structuring and perceptive identification. Test tasks are of the multi-choice type; the subject has to identify which of the four images is identical to the given image. The test consists of 39 tasks that have to be solved in 4 minutes, thus meeting the criteria of a speed test);
- efficiency of serial processor – AL_4 (designed for assessment of verbal comprehension and contains 40 tasks consisting of pairs of words; the subject has to determine whether the pair words have identical or opposite meaning. The time allowed for the test is 2 minutes, thus the test meets the criteria of a speed test); and
- efficiency of parallel processor – S_1 (designed for assessment of visual spatialization; the test consists of 30 tasks, each of them representing a three-dimensional image of a pile of bricks; the subject has to choose one of the four transverse projections of the brick pile which corresponds to the given image when observed from a particular angle; the time allowed for the test is 8 minutes).

Conative characteristics were assessed by use of measuring instruments designed on the cybernetic model of conative regulatory functions (Momirović, Horga and Bosnar, 1982)[18]. These tests estimate six conative regulatory mechanisms of the model:

- activity regulator – ε (one of the elementary and lowest subsystems in the hierarchy, which is responsible for the activity and energy level at which other subsystems are functioning, including cognitive and motor processors);

- organ function regulator – χ (formed by correlated action of subcortical centers for the regulation of organ functions, mostly located in the hypothalamic region, and superior cortical systems responsible for the regulation and control);
- regulator of defense responses – α (located in the hypothetical center for the regulation of defense responses, in the limbic system; it modulates tonic excitation, probably on the basis of appropriate programs transmitted by genetic code or formed during the ontogenic development, as a rule due to conditioning);
- regulator of attack responses – σ (located in the hypothetical center for the regulation of attack responses, in the limbic system; likewise the center for regulation of defense responses, it also modulates primary tonic excitation, however, based on the program of destructive response, formed during the phylogenic or ontogenic development);
- system for coordination of regulatory functions – δ (coordinates functions of the subsystems that are functionally or hierarchically different, including the functions of cognitive processors; therefore, this system is functionally superior to the regulators of organ functions, regulators of attack responses and defense responses, and to a certain extent also to the activity regulator); and
- system for integration of regulatory functions – η (it is superior to all conative regulatory systems, it integrates conative processes within the psychological area structure, and the social area structure and its changes in particular, thus the level of socialization directly depending on this system).

Each of the six conative tests contains 30 statements, and the subject has to mark one of the five answers on Likert scale. The time to solve the test is not limited (some 30 minutes for the whole test battery), and each test score can range from 30 to 150 points.

The following variables were used to assess *specific motor abilities* of speed and speed-strength endurance in boxing:

- speed of performing 100 straight punches against punching bag (at an arm distance from the punching bag; at this distance, the subject assumes boxing guard, then at the timekeeper's sign alternately hits left and right straight punches against the punching bag at the chest level; the time needed for 100 straight punches is recorded);
- speed of performing combined punches against punching bag, i.e. two straight punches, two hooks and two uppercuts (at a 60-cm distance from training bag; at this distance, the subject assumes boxing guard and at the timekeeper's sign alternately hits punches against the punching bag at maximal speed in the following order: left and right straight punches, left and right hooks, and right and left uppercut, 100 punches in total; the time needed for all 100 punches is recorded);
- jumps while performing left-right straight punches in 10 seconds (at the sign given by the timekeeper, the subject performs jumps and left-right straight punches at maximal speed; at 10 seconds it is interrupted and the number of properly performed straight punches is recorded as test result);
- jumps while performing left-right hooks in 10 seconds (at the sign given by the timekeeper, the subject performs jumps and left-right hooks at maximal speed; it is interrupted at 10 seconds and the number of properly performed jumps and hooks is recorded as test result);
- jumps while performing left-right uppercuts in 10 seconds (the subject performs jumps and left-right uppercuts in 10 seconds; the number of correctly performed jumps and uppercuts during the given period of time is recorded as test result); and
- defense from left straight punch and countering three straight punches – defense from right straight punch and countering three straight punches against coach's arms (the subject has to perform defense by avoiding the coach's left straight punch and to counter three straight punches (right-left-right) as quickly as possible, then defending from the coach's right straight punch and countering three straight punches (left-right-left); the time to perform this motor task is recorded as test result.

The first and second tests are predominated by the integration of specific speed, strength and endurance (speed-strength endurance), whereas the third, fourth, fifth and especially sixth tests are predominated by specific speed.

Data processing

The basic descriptive statistics parameters of arithmetic mean and standard deviation (SD) were calculated for each of the variables used in the study. A series of regression analyses were used to calculate the influence of the cognitive variable and conative variable systems (as sets of predictor variables) on particular variables of situation motor abilities (as a set of criterion variables). Regression coefficients of each standardized predictor variable upon a particular criterion variable (β), multiple correlation between the set of predictor variables and the criterion variable (ρ), and coefficient of determination, i.e. overall variance of the system of predictor variables and the criterion (ρ^2) were calculated.

Results

Descriptive statistics parameters of the cognitive, conative and specific motor space variables in elite Croatian boxers are presented in Table 1. In elite boxers, cognitive abilities are strongly pronounced, functioning of the serial processor (AL_4) in particular, followed by the perceptive processor function (IT_1) and parallel proces-

TABLE 1
DESCRIPTIVE STATISTICAL PARAMETERS (X, SD) OF COGNITIVE, CONATIVE AND SPECIFIC MOTOR VARIABLES IN ELITE BOXERS (n=92)

Variable	X	SD
Perceptive processor efficiency (IT_1)	33.25	3.30
Serial processor efficiency (AL_4)	35.97	2.55
Parallel processor efficiency (S_1)	22.11	3.03
Activity regulator (ε)	129.65	7.38
Organ function regulator (χ)	38.94	4.60
Defense response regulator (α)	38.43	3.41
Attack response regulator (σ)	139.10	6.22
Coordination of regulatory functions (δ)	38.30	3.24
Integration of regulatory functions (η)	38.18	3.39
100 straight punches (100S)#	185.80	25.93
100 combined punches (100C)#	249.86	37.65
Jumps and straight punches in 10 s (JS)	18.96	2.43
Jumps and hooks in 10 s (JH)	17.95	2.45
Jumps and uppercuts in 10 s (JU)	17.48	2.75
Defense – counter straight punch (DCS)#	21.48	4.79

#variable with opposite metric orientation

sor function (S_1). It results from the selection and long-term training processes directed to achieving the goal, i.e. top result in boxing. The highest variability, i.e. between-boxer differences, was recorded in the function of parallel processor, followed by the perceptive processor function, and lowest in the serial processor function. The arithmetic means and standard deviations (SD) of cognitive variables suggested the performance in elite boxing to be determined by serial, perceptive and parallel processing of the nervous system information.

The basic statistical parameters of conative variables showed the values in the regulatory mechanisms of attack response (σ) and activity (ε) to be generally very high in elite boxers, which is quite conceivable considering that innate aggressiveness and ability of energy mobilization are major preconditions to engage in combat sports, boxing in particular. In contrast, rather low values were obtained in other conative regulators, i.e. integration of regulatory functions (η), coordination of regulatory functions (δ), defense response regulator (α) and organ function regulator (χ). It should be noted that the function of these four regulators is inversely proportional to the value of the respective test result. As data processing yielded a high variability, i.e. differences among boxers, in these regulators, being highest for the organ function regulator (χ), it could be postulated that various conversions such as cardiovascular, respiratory, gastrointestinal, etc., would limit the level of performance in boxing.

The basic statistical parameters of the specific motor ability tests revealed differences in their duration. So, the first and second specific motor tests took a mean of 19 and 25 seconds, respectively, suggesting them to be saturated by the speed, strength and endurance. The mean length of the third, fourth and fifth specific motor tests was 10 seconds each, indicating them to be saturated by speed and strength. The sixth specific motor test took a mean of 2 seconds, thus being predominantly saturated by psychomotor speed. Individual boxers differed most in the test assessing specific speed in terms of punch defense and multi-punch counter (defense – counter straight punch, DCS), suggesting that this specific motor ability may serve as a major determinant of performance in elite boxing.

Correlations between cognitive variables and specific motor variables (Table 2) revealed marked complexity of specific motor abilities in the area of cognitive processors. All three cognitive processors showed significant correlation with criterion variables. There was a predominant correlation between serial processing of CNS information and the criteria, followed by the correlation of perceptive processing and parallel processing of CNS information with the criteria. Accordingly, the correlations between cognitive abilities and specific motor abilities followed the level of development of particular processing functions in elite boxers.

Table 3 indicates the set of cognitive predictor variables to have a statistically significant effect on all the criterion variables used in the study, i.e. speed of performing 100 straight punches against punching bag (100S), with multiple correlation coefficient of 0.54 and determination coefficient of 0.29; speed of performing combined punches against punching bag – two straight punches, two hooks and two uppercuts (100C), with multiple correlation coefficient of 0.53 and determination coefficient of 0.29; jumps while performing left-right straight punches in 10 seconds (JS), with multiple correlation coefficient of 0.57 and determination coefficient of 0.32;

TABLE 2
CORRELATIONS BETWEEN COGNITIVE VARIABLES AND VARIABLES OF SPECIFIC MOTOR ABILITIES IN ELITE BOXERS

Variable	100S#	100C#	JS	JH	JU	DCS#
	R	r	R	r	R	R
IT_1	–0.37	–0.22	0.42	0.43	0.33	–0.39
AL_4	–0.49	–0.39	0.53	0.55	0.48	–0.44
S_1	–0.31	–0.19	0.41	0.42	0.33	–0.34

#variable with opposite metric orientation, r – correlation coefficient, IT_1 – perceptive processor efficiency, AL_4 – serial processor efficiency, S_1 – parallel processor efficiency, 100S – 100 straight punches, 100C – 100 combined punches, JS – jumps and straight punches in 10 s, JH – jumps and hooks in 10 s, JU – jumps and uppercuts in 10 s, DCS – defense – counter straight punch

TABLE 3
RESULTS OF REGRESSION ANALYSIS BETWEEN THE SET OF PREDICTOR COGNITIVE VARIABLES AND INDIVIDUAL CRITERION VARIABLES

Variable	100S#	100C#	JS	JH	JU	DCS#
	β	β	β	β	β	β
IT_1	0.24	0.67[a]	–0.45	–0.45	–0.59[a]	–0.02
AL_4	–1.00[b]	–1.25[b]	0.96[b]	0.98[b]	1.08[b]	–0.58[b]
S_1	0.33	0.28	0.00	–0.01	–0.06	0.17
ρ	0.54[b]	0.53[b]	0.57[b]	0.58[b]	0.54[b]	0.45[b]
ρ^2	0.29[b]	0.29[b]	0.32[b]	0.33[b]	0.29[b]	0.20[b]

#variable with opposite metric orientation, [a]$p<0.01$, [b]$p<0.001$, β – regression coefficient, ρ – multiple correlation, ρ^2 – coefficient of determination, IT_1 – perceptive processor efficiency, AL_4 – serial processor efficiency, S_1 – parallel processor efficiency, 100S – 100 straight punches, 100C – 100 combined punches, JS – jumps and straight punches in 10 s, JH – jumps and hooks in 10 s, JU – jumps and uppercuts in 10 s, DCS – defense – counter straight punch

TABLE 4
CORRELATIONS BETWEEN CONATIVE VARIABLES AND VARIABLES OF SPECIFIC MOTOR ABILITIES IN ELITE BOXERS

Variable	100S#	100C#	JS	JH	JU	DCS#
	r	r	r	r	R	r
ε	–0.51	–0.44	0.51	0.52	0.43	–0.54
χ	0.66	0.65	–0.66	–0.67	–0.58	0.70
α	0.62	0.57	–0.59	–0.59	–0.55	0.51
σ	–0.45	–0.36	0.45	0.46	0.38	–0.43
δ	0.55	0.50	–0.56	–0.56	–0.50	0.49
η	0.55	0.53	–0.54	–0.54	–0.51	0.43

#variable with opposite metric orientation, r – correlation coefficient, ε – activity regulator, χ – organ function regulator, α – defense response regulator, σ – defense response regulator, δ – coordination of regulatory functions, η – integration of regulatory functions, 100S – 100 straight punches, 100C – 100 combined punches, JS – jumps and straight punches in 10 s, JH – jumps and hooks in 10 s, JU – jumps and uppercuts in 10 s, DCS – defense – counter straight punch

jumps while performing left-right hooks in 10 seconds (JH), with multiple correlation coefficient of 0.58 and determination coefficient of 0.33; jumps while performing left-right uppercuts in 10 seconds (JU), with multiple correlation coefficient of 0.54 and determination coefficient of 0.29; and defense from left straight punch while countering three straight punches – defense by avoiding right straight punch while countering three straight punches against the coach's arms (DCS), with multiple correlation coefficient of 0.45 and determination coefficient of 0.20.

In the set of cognitive predictor variables, only AL_4, i.e. efficiency of serial processor, elicited a statistically significant effect (regression coefficient, β) on all criterion variables. This means that subjects with better serial processor efficiency achieved better results in each criterion variable. However, there was a significant unfavorable impact of perceptive processor on the criterion variables of performing combined punches against punching bag (100C) and jumps while performing left-right uppercuts in 10 seconds (JU), indicating the inclusion of perceptive processor during the course of these specific tasks to be unnecessary.

The complexity of specific motor abilities in the area of conative regulators was very pronounced, as indicated by the correlations between these two sets of variables (Table 4). The activity regulator (ε) and attack response regulator (σ) yielded positive correlation with criterion variables, whereas dysregulation of the organ function regulator (χ), of defense response regulator (α), of the coordination mechanism of regulatory functions (η) showed negative correlation with the criteria. Considering the specificity of boxing, boxers obviously possess a specific conative structure, as suggested by both basic statistical parameters of conative variables and their correlations with the criteria.

Table 5 clearly shows the system of predictive conative variables to exert a statistically significant impact on all the criterion variables used in the study, i.e. speed of performing 100 straight punches against punching bag (100S), with multiple correlation coefficient of 0.68 and determination coefficient of 0.47; speed of performing combined punches against punching bag – two straight punches, two hooks and two uppercuts (100C), with multiple correlation coefficients of 0.69 and determination coefficient of 0.47; jumps while performing left-right

TABLE 5
RESULTS OF REGRESSION ANALYSIS BETWEEN THE SET OF PREDICTOR CONATIVE VARIABLES AND INDIVIDUAL CRITERION VARIABLES

Variable	100S#	100C#	JS	JH	JU	DCS#
	β	β	β	β	β	β
ε	0.00	0.10	0.02	0.01	–0.06	–0.13
χ	0.51[b]	0.73[b]	–0.52[b]	–0.54[b]	–0.46[b]	0.85[b]
α	0.26	0.18	–0.17	–0.17	–0.20	–0.01
σ	0.05	0.19	–0.06	–0.06	–0.07	0.16
δ	–0.08	–0.18	–0.00	–0.00	0.06	0.02
η	0.06	0.18	–0.03	–0.02	–0.15	–0.18
ρ	0.68[b]	0.69[b]	0.67[b]	0.68[b]	0.61[b]	0.72[b]
ρ^2	0.47[b]	0.47[b]	0.45[b]	0.46[b]	0.37[b]	0.51[b]

#variable with opposite metric orientation, [b]$p<0.001$, β – regression coefficient, ρ – multiple correlation, ρ^2 – coefficient of determination, ε – activity regulator, χ – organ function regulator, α – defense response regulator, σ – attack response regulator, δ – coordination of regulatory functions, η – integration of regulatory functions, 100S – 100 straight punches, 100C – 100 combined punches, JS – jumps and straight punches in 10 s, JH – jumps and hooks in 10 s, JU – jumps and uppercuts in 10 s, DCS – defense – counter straight punch

straight punches in 10 seconds (JS), with multiple correlation coefficient of 0.67 and determination coefficient of 0.45; jumps while performing left-right hooks in 10 seconds (JH), with multiple correlation coefficient of 0.68 and determination coefficient of 0.46; jumps while performing left-right uppercuts in 10 seconds (JU), with multiple correlation coefficient of 0.61 and determination coefficient of 0.37; and defense from left straight punch while countering three straight punches – defense by avoiding right straight punch while countering three straight punches against the coach's arms (DCS), with multiple correlation coefficient of 0.72 and determination coefficient of 0.51.

According to regression coefficients (β), in the set of conative predictor variables only the variable assessing the factor responsible for organ function regulation (χ), formed by coordinated action of subcortical centers for organ function regulation, mostly located in the hypothalamic region, and superior cortical regulatory and control systems, had a statistically significant impact on all criterion variables. Thus, even low values of the organ function regulator dysregulation will have adverse impact on the performance of specific motor tasks in boxing, the efficiency of defense from punches and performance of counter punches in particular. Therefore, influencing a small part of the variability in dysregulation of the organ function regulators is of utmost importance for upgrading the boxer's adaptive ability. An increase in the level of control of the organ function regulator dysregulation symptoms, i.e. conversion responses, will improve not only motor functions but also other function that may be blocked by this dysregulation.

Discussion

Study results revealed the boxers to possess some specific motor abilities, cognitive abilities and conative properties, which taken together limit their engagement and top performance in boxing. An appropriate motor, cognitive and conative structure determining superior performance in boxing is formed by the selection and training processes. The motor structure is predominated by specific speed of movement frequency (mostly punches), which is saturated by coordination and explosive strength. The ability of coordination manifests in the integration of successive-individual movements into a unique structure, i.e. performing a series of boxing techniques (primarily punches). The cognitive structure is predominated by serial processing of information, i.e. flow rate of successive CNS information, which is closely related to the speed of performing a series of identical or combined punches in boxing. The conative structure is predominated by the attack response regulator, underlain by the intensity of CNS excitation and intensity of energy mobilization, which is expressed by aggressive behavior. This is supported by the regulator of activity in terms of excitation to inhibition balance. In addition, the organ function regulator tends to eliminate or at least minimize various conversions, thus facilitating great strain and pain to endure, and urgent combat situations to master.

The basic motor, cognitive and conative properties of boxers are generally listed. However, the question is what anthropological properties determine performance in boxing. To answer this question completely, one has to have information on the results that the boxers achieve at contests. As no such information was available in the present study, only a hypothetical, alternative model of the motor – cognitive – conative processes in boxing is proposed.

Certain anthropological properties determine the inclusion of individuals in boxing training. This has been related to various selection procedures, while the long-term training in boxing also leads to the formation of an ideal anthropological structure needed for achievement of top results. The formation of an ideal anthropological structure assumes that primary selection is followed by the action of training processes, primarily producing qualitative modifications within and across the subsegments of the anthropological structure (morphological, motor, cognitive and conative), with all these relations among the anthropological dimensions assessed brought to optimal position. Development of the relevant anthropological characteristics is paralleled by the stages of selection, characterized by more or less different predictors of boxing performance. Therefore, efficient selection in boxing cannot be performed exclusively on the basis of information obtained by the analysis of relations among some anthropological status dimensions and specific motor abilities in the definitive, ultimate state. Thus, a new, alternative, 3-stage (age 12–14, 15–17 and 18–20 years) model of selection in boxing is proposed on the basis of the results obtained in the present study, results of studies in elite athletes[19–21], and information on developmental processes of anthropological status dimensions in elementary school children[11–13] and high-school children[3,5,15].

In stage one (age 12–14), the initial anthropological status of the children disposed to boxing training should be assessed and primary selection according to their health status performed, as all body functions should be optimally developed and free from impairments (e.g., the function of the vegetative nervous system, sensorimotor nervous system, transport system and locomotor system). Considering conative regulators involved in the vegetative nervous system, the individuals with above-average dysregulation of the defense response regulators, manifesting by pronounced symptoms of anxiety, phobia, obsession, depression, and predominant nervous system inhibition in general, should be eliminated from further training procedures by selection. Only the individuals with above-average functions of the attack response regulators and activity regulators, manifesting by innate controlled aggressiveness and hypomania, i.e. good energy mobilization and predominant nervous system excitation in general should be accepted.

At the same time, these individuals will show good function of the superior conative regulators and facilitated function of cognitive and motor processors. The function of all cognitive processors involved in the sensorimotor nervous system should be at an above-average level, with the simultaneous processor proved to be a better predictor of performance in boxing at this stage; it is responsible for simultaneous, i.e. parallel processing of information, which enables integration of different information for reasonable action in a particular situation, thus also facilitating motor learning, i.e. acquiring new motor programs. The adoption of new motor programs depends most on coordination, which is defined as the ability to integrate different movements or motor routines into a unique movement structure. Although simultaneous processor as well as cortical regulation of movement is expected to better predict performance in boxing than other cognitive processors at the beginning, selection should still primarily rely on the basic motor abilities of movement speed and coordination, and on cognitive processor for serial information processing because these abilities, along with the mentioned conative regulators will ultimately limit performance in boxing. At this stage, the boys should acquire basic motor knowledge, i.e. basic techniques in boxing, while motor learning of this specific knowledge will take place from cortical through subcortical level, and from simultaneous and perceptive information processing through serial information processing. The interaction of speed, coordination and serial processor plays a major role at the end of this stage.

In stage two (age 15–17), all cognitive processors, i.e. perceptive, simultaneous and serial ones, should be included in motor learning and adoption of the greatest possible number of new motor programs, whilst a certain number of basic specific motor knowledge-techniques in boxing should reach full automatism through numerous repeats. Motor coordination has developed to the level that enables quality performance of basic techniques and simple yet efficient combinations, along with optimal use and regulation of strength, speed and muscle tone. Training processes increase in volume and intensity, influencing not only the development of explosive strength but also the development of specific endurance and improves conative regulation of organ functions. At this stage, the interaction of speed, strength, coordination, cognitive processors and stability of organ function regulators in particular is crucial, along with due control of aggressive responses.

In stage three (age 18–20), all relevant body functions should reach the highest possible level. Training processes are predominated by an extremely high work volume, with maximal and submaximal load. Specific motor abilities, cognitive processors and conative regulators should be in optimal interrelations. Appropriate mechanisms are activated on solving a particular combat task. As combat situations are diverse and complex, performance depends on the interaction of all relevant specific motor abilities, from specific speed (movement frequency), specific strength (power), specific endurance through coordination of all cognitive processors and proper functioning of all conative regulators, the regulators of organ functions (where even a minor dysregulation of the organ function regulators exerts unfavorable effect on combat performance) in particular. The present study demonstrated favorable impact of serial processor on the specific motor ability tests, where a series of punches should be performed as fast as possible, by nature of these tasks predominantly saturated by the speed of frequency and serial processing of information. However, many other combat situations also require inclusion of the other two processors, simultaneous information processing in particular. The combat situation has to be identified and the most efficient of a number of possible responses to the opponent's activity should be chosen. Deciding on the choice of response is a special aspect of coordination, representing simultaneous information processing. Accordingly, combat performance will greatly depend on the number and quality of the programs acquired, i.e. on the use of various combinations of boxing techniques, such as efficient defense and efficient countering with a series of punches[20,21]. In this stage, interaction of specific endurance and stability of organ function regulators plays a crucial role, manifested as endurance in delivering and receiving punches.

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UTJECAJ KOGNITIVNIH PROCESORA I KONATIVNIH REGULATORA NA SPECIFIČNE MOTORIČKE SPOSOBNOSTI BOKSAČA

SAŽETAK

Cilj istraživanja je bio analizirati relacije kognitivnih procesora i konativnih regulatora sa specifičnim motoričkim sposobnostima vrhunskih boksača. U tu svrhu na uzorku od 92 boksača primijenjena su tri skupa varijabli i to: 3 kognitivne i 6 konativnih kao prediktori i 6 specifičnih motoričkih (boksačkih) varijabli kao kriteriji. Serija regresijskih analiza između skupa kognitivnih varijabli i pojedine varijable iz kriterijskog skupa utvrdila je dominantni utjecaj serijalnog procesora na specifične motoričke sposobnosti u osnovi kojih je prvenstveno specifična brzina (frekvencija realizacije boksačkih tehnika). Serijom regresijskih analiza je također utvrđen dominantni negativni utjecaj disregulacije regulatora organskih funkcija iz konativnog skupa varijabli na manifestaciju specifičnih motoričkih sposobnosti boksača. Temeljem informacija ovog istraživanja izrađen je alternativni model: motoričkih – kognitivnih – konativnih procesa u boksu.