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RELATIONS BETWEEN SYSTEMS OF MOTOR, COGNITIVE AND CONATIVE VARIABLES OF TOP-CLASS HANDBALL PLAYERS

ODNOSI MED SISTEMI GIBALNIH, KOGNITIVNIH IN KONATIVNIH SPREMENLJIVK VRHUNSKIH ROKOMETAŠEV

ABSTRACT

A sample of 180 handball players of the first and second Serbian handball league were examined according to a system of 27 variables (12 motor, 3 cognitive and 12 conative variables). The aim was to determine the statistically significant relations between the systems of variables of motor abilities, cognitive variables and variables of conative characteristics. The data were processed by canonical correlation analysis. With the application of Bartlett's Chi-square test (χ^2) between the system of motor variables and the system of cognitive variables, three canonical correlations were obtained (Rc=.57, Rc=.45, Rc=.35) which are statistically significant on the level of p=.00 that is p=.01. Between the system of motor variables and the system of conative variables two canonical correlations were obtained (Rc = .62 and Rc = .59), which are statistically significant on the level of p=.00. The results of the research showed that top-class handball players achieve better results concerning motor variables of the motion structure, tonus regulation, intensity and duration of excitation and synergy regulation if they have increased values concerning cognitive variables of efficiency of serial processing (IT – 1) as well as concerning conative variables of the efficiency of the system of regulation and control of the defence reaction (ALPHA), the efficiency of the system of regulation and control of offence reaction (SIGMA) and the efficiency of the system of coordination of regulative functions (DELTA).

Key words: handball players, motor abilities, cognitive abilities, conative characteristics, relations

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POVZETEK

V raziskavo je bilo vključenih 180 rokometašev prve in druge srbske rokometne lige, pri katerih smo proučevali sistem 27 spremenljivk (12 gibalnih, 3 kognitivne in 12 konativnih). Cilj raziskave je bil določiti statistično značilne povezave med sistemi spremenljivk gibalnih sposobnosti ter sistemi konativnih in kognitivnih spremenljivk. Podatke smo analizirali z kanonično korelacijo. Z aplikacijo Bartlettovega Chi-kvadrat testa (χ^2) med sistemom gibalnih spremenljivk in sistemom kognitivnih spremenljivk smo identificirali tri kanonične korelacije (Rc=.57, Rc=.45, Rc=.35), ki so bile statistično značilne na ravni p=.00 oziroma p=.01. Med sistemom gibalnih spremenljivk in sistemom konativnih spremenljivk smo identificirali dve kanonični korelaciji (Rc = .62 and Rc = .59), ki sta bili statistično značilni na ravni p=.00. Rezultati raziskave so pokazali, da vrhunski rokometaši dosegajo višje vrednosti gibalnih spremenljivk strukture gibanja, regulacije tonusa, intenzivnosti in trajanja ekscitacije ter regulacije sinergije, če imajo višje vrednosti kognitivnih spremenljivk učinkovitosti zaporednega procesiranja (IT – 1), v tem primeru pa dosegajo tudi višje vrednosti konativnih spremenljivk sistema regulacije in nadzora obrambnih reakcij (ALPHA), učinkovitosti sistema regulacije in nadzora napadalnih reakcij (SIGMA) in učinkovitosti sistema koordinacije regulativnih funkcij (DELTA).

Ključne besede: rokometaši, gibalne sposobnosti, kognitivne značilnosti, konativne značilnosti, povezanost

INTRODUCTION

The determination of relations of motor abilities with other segments of anthropological status of athletes in particular sports is a highly current practical and theoretical issue. This issue is of a great importance firstly because of its possibility to form the most rational procedures in sport technology and sport training - athlete selection, training planning, programming and control as well as efficient monitoring of the development of relevant anthropological characteristics during the training process (Kurelić et al., 1975; Metikoš et al., 1982; Stanković, 2001; Malacko, Rađo, 2004).

Concerning handball, it is well known that it is a highly demanding game, requiring highly flexible motor abilities: constant jumping and intense anaerobic and aerobic exercise accompanied by sudden and fast changes of intensity, direction of motion and positions.

Furthermore, since handball players solve numerous problems on the court, including assessment, prediction and reaction to constant changes, it can be assumed that analysis of relations between motor abilities, cognitive abilities and conative characteristics of handball players can be one of the most important indicators of their anthropological status and interactive functioning.

The impact of cognitive regulative mechanisms on success in some sport activities is of different levels. It depends on the mechanism type and sport category as well as on other predictable and unpredictable situations and circumstances concerning optimal cognitive ability, sport knowledge, motion structure and athletic condition (Kirkendall, Gruber, 1970; Momirović, Gredelj, Hošek, 1980; Wolf, Momirović and Džamonja, 1992).

For conative characteristics, it has been determined that their increased intensity decreases the level of adaptation; they then cause disorders in personality integrity, which damages the balance between the process of irritation and inhibition. Moreover, they influence the disposition of the majority of particular characteristics or groups of characteristics; meaning they are mainly genetically conditioned (Cattell, 1956; Mraković et al, 1974; Powell, Royce, 1981; Momirović, Wolf, Džamonja, 1992).

The aim of the research is to determine statistically significant relations between the systems of motor ability variables, cognitive variables and variables of conative characteristics in top-class handball players in order to form rational procedures for optimal sport orientation and selection, planning and programming of training as well as the monitoring and control of the transformational process of relevant anthropological characteristics.

METHOD

Participants

A sample of 180 handball players of the first and second Serbian handball league was applied to the system of 27 variables (12 motor, three cognitive and 12 conative variables).

Instruments

For the assessment of motor abilities from the structure of motor abilities model (Gredelj, Hošek, Metikoš, Momirović, 1975), the following latent- manifesting variables were applied:

a) *the structure of motion:*
   1. coordination with a stick (COS),
   2. feet and hands banging (FHB),
   3. hand tapping (HTA),

b) *tonus regulation and synergy regulation:*
   4. deep pull-up hang on the bench (DPB),
   5. standing on one leg (SOL),
   6. aiming at a horizontal target (AHT),

c) *regulation of intensity of excitation:*
   7. standing long jump (SLJ),
   8. 20-m run from a standing start (20R),
   9. medicine ball throw from a supine position (MTL),

d) *regulation of duration of excitation:*
   10. sit-ups (MSU),
   11. under grip chin-ups (UCU) and
   12. endurance of seated hang (ISH).

For cognitive abilities assessment from the KOG 3 battery (Wolf, Momirović, Džamonja, 1992), the following variables were applied:

1. test IT-1 for perceptive processor efficiency assessment,
2. test S-1 for parallel processor efficiency assessment,
3. test AL-4 for serial processor efficiency assessment.

For conative characteristics assessment from the KON 6 battery (Momirović, Wolf, Džamonja, 1992), the following variables were applied:

a) efficiency of the system of regulation and control of organic functions (HI):

1. cardiovascular conversion (K10),
2. gastrointestinal conversion (G11),
3. inhibitor conversion (I7),
4. hypochondria (H13),

b) efficiency of the system of regulation and control of defence reaction (ALPHA):

5. anxiety (A1),
6. obsessiveness (O3),
7. hypersensitivity (S5),
8. phobia (F2),

c) efficiency of the system of regulation and control of offence reaction (SIGMA):

9. impulsiveness (N14),
10. aggression (T15) and

d) efficiency of the system of regulative functions coordination (DELTA):

11. paranoia (P18),
12. depression (D6).

Procedure

During the determination of relations between the system of variables of basic motor variables, cognitive abilities and conative characteristics, a canonical correlation analysis was applied. The testing of the statistical significance of the hypothesis of global correlation between two different anthropological systems of variables was done by: λ – statistically significant characteristic roots, Rc – coefficient of canonical correlation of statistically significant pairs of canonical factors, Rc^2 – canonical R-square, χ^2 – Bartlett's Chi-square test and p – testing of statistical importance on the level of .05 to .00 (p = .05 - .00).

RESULTS

With a cross-correlation matrix analysis between the system of motor variables and the system of cognitive variables (Table 1), statistically significant correlations of variable pairs are observed on the level of .01 (** p = .01).

Table 1: Cross-correlations of motor and cognitive variables

Variables	IT-1	S-1	AL-4
COS	-.07	.03	**-.32****
FHB	**.23****	.21	-.07
HTA	-.06	.04	-.00
DPB	-.15	.14	**.30****
SOL	-.09	.10	.12
AHT	-.12	.15	**.25****
SLJ	.07	.18	**.18****
20R	-.21	.16	**.25****
MTL	-.02	-.01	**-.33****
MSU	**.22****	.11	.07
UCU	.06	.01	-.09
ISH	.18	.12	**.23****
Rc	**Rc^2**	**χ^2**	**p**
.57	.32	129.47	**.00***
.45	.20	62.03	**.00***
.35	.12	23.12	**.01***

* $P_{.05}$ = .138
** $P_{.01}$ = .181

Legend: **Rc** – canonical correlation, **Rc^2** – canonical R-square, **χ^2** - Bartlett's Chi-square test, **p** - level of significance

Between the cognitive variable IT-1 – perceptive processor efficiency and motor variables FHB – feet and hands banging (.23**) and MSU – sit-ups (.22**), there are statistically significant correlations at the level of p= .01. Among cognitive variable S-1, parallel processor efficiency and motor variables there is no correlation. There is, however, correlation among cognitive variable AL-4 – serial processor efficiency and motor variables: COS – coordination with a stick (-.32**), DPB – deep pull-up hang on the bench (.30**), AHT – aiming at a horizontal target (.25**), SLJ – standing long jump (.18**), 20R – 20-m run from the standing start (.25**), MTL – medicine ball throw from a supine position (-.33**) and ISH – endurance of seated hang (.23**).

In the procedure of determining statistically significant relations (in other words: finding maximal correlation between multivariate system of motor variables and the system of cognitive variables)

a canonical correlation analysis was applied with the parameters of canonical correlation (Rc), the coefficient of determination (Rc^2), Chi-square test (χ^2) and its statistical importance (p).

With Bartlett's Chi-square test (χ^2=129.47, χ^2=62.03 and χ^2=23.12), the statistical significance of the coefficient of canonical correlation was tested (Rc=.57, Rc=.45, Rc=.35). The test explains linear combinations between groups of variables; that is, the correlation of two different systems of variables. By solving characteristic equations of matrix cross-correlation, the roots of these equations were obtained as well as squares (determination coefficients) of canonical correlation (Rc^2 =.32, Rc^2 =.20, Rc^2 =.12), which clarify the mutual variance of two group variables between the total variability of the analysed system of variables.

During the further procedure of data processing, three statistically significant structures of canonical factors were identified (p=.00, p=.00, p=.01); on one hand, within the system of motor variables and, on the other hand, within the system of cognitive variables.

From results given in the matrix of canonical structure of motor and cognitive variables (Table 2), a statistically significant correlation between motor variables and the first canonical factor can be observed.

Table 2: Canonical structure of motor and cognitive variables

Variables	**Fc-1**	**Fc-2**	**Fc-3**
Motor variables			
COS	-.47	-.25	**.56***
FHB	-.31	**.57***	.24
HTA	.04	-.04	**.21***
DPB	**.61***	.08	.26
SOL	.26	.04	**.29***
AHT	**.50***	.11	.31
SLJ	.22	**.42***	.15
20R	**.57***	-.01	.47
MTL	**-.51***	-.23	.36
MSU	-.06	**.52***	-.15
UCU	**-.19***	.06	.04
ISH	.22	**.54***	-.23
Cognitive variables			
IT-1	-.40	**.78***	-.47
S-1	.13	.67	**.72***
AL-4	**.89***	.39	-.20

Legend: **Fc-1** – first canonical factor, **Fc-2** – second canonical factor, **Fc-3** – third canonical factor

The first isolated canonical factor is defined by the relatively high values of statistically significant canonical correlation coefficients. Regarding the structure of the first isolated canonical factor that consists of variables DPB – deep pull-up hang on the bench (.61*), AHT – aiming at a horizontal target (.50*), 20R – 20-m run from the standing start (.57*), MTL – medicine ball throw from a supine position (-.51*) and UCU – undergrip chin-ups (-.19*), it can be defined as canonical factor of tonus regulation, excitation intensity and duration. The second canonical factor is defined by the variables FHB – feet and hands banging (.57*), SLJ – standing long jump (.42*), MSU – sit-ups (.52*) and ISH – endurance of seated hang (.54*) so it can be defined as canonical factor of the structure of motion and intensity regulation and excitation duration. The

third canonical factor is defined by variables COS – coordination with a stick (.56*), HTA – hand tapping (.21*), SOL – standing on one leg (.29*) so it can be defined as a canonical factor of the structure of motion and synergy regulation.

In the same table, the matrix of the structure of canonical factors of cognitive abilities is also presented, which shows that there are very high correlations between applied variables and canonical factors. Regarding that the first canonical factor is presented by only one cognitive variable (AL-4), it can be defined as serial processor efficiency; in other words, noticing relations and correlations. The third canonical factor is also presented by only one cognitive variable (IT-1), so that it can be interpreted as input processor efficiency; in other words, perceptive reasoning.

With cross-correlation matrix analysis between systems of motor variables and systems of conative variables (Table 3), statistically significant correlations of variable pairs can also be observed regarding variables of both anthropological fields. Statistically significant correlations of conative variables with motor variables were found among the following variables:

a) K10 – *cardiovascular conversion*:

HTA – hand tapping
SOL – standing on one leg
20R – 20-m run from the standing start
MTL – medicine ball throw from a supine position
MSU – sit-ups
UCU – undergrip chin-ups
ISH – endurance of seated hang

b) G11 – *gastrointestinal conversion:*

SOL – standing on one leg
20R – 20-m run from the standing start
MTL – medicine ball throw from a supine position

c) I7 – *inhibitor conversion:*

SOL – standing on one leg
H13 – *hypochondria:*
UCU – undergrip chin-ups
ISH – endurance of seated hang

d) A1 – *anxiety:*

FHB – feet and hands banging
20R – 20-m run from the standing start
UCU – undergrip chin-ups
ISH – endurance of seated hang

e) O3 – *obsessiveness:*

MTL – medicine ball throw from a supine position
UCU – undergrip chin-ups

f) S5 – *hypersensitivity:*

HTA – hand tapping

g) F2 – *phobia:*

SOL – standing on one leg

MSU – sit-ups

UCU – undergrip chin-ups

ISH – endurance of seated hang

h) T15 – *aggression:*

FHB – feet and hands banging

i) P18 – *paranoia:*

FHB – feet and hands banging

HTA – hand tapping

SOL – standing on one leg

MTL – medicine ball throw from a supine position

MSU – sit-ups

UCU – undergrip chin-ups

j) D6 – *depression:*

COS – coordination with a stick

FHB – feet and hands banging

SOL – standing on one leg

Table 3: Cross correlations of motor and conative variables

Variables	K 10	G11	I7	H13	A1	O3	S5	F2	N14	T15	P18	D6
COS	.00	.03	-.02	-.06	.10	.02	.05	-.03	.08	.05	.03	**.16***
FHB	.06	.12	.12	.13	**.16***	-.07	.07	.04	-.02	**.14***	**.16***	**-.17***
HTA	**.16***	.09	.11	.06	.00	.06	**-.15***	.07	.13	-.13	**.14***	-.01
DPB	-.08	-.11	.00	-.12	-.06	.06	.01	.04	.12	.06	-.12	.11
SOL	**.14***	**.17***	**.15***	.09	-.08	.08	.10	**.27***	**.27***	.02	**.22***	**.15***
AHT	-.02	-.09	-.08	-.10	-.09	.08	-.03	.01	.13	-.08	-.13	.07
SLJ	-.10	-.10	.07	.08	-.09	-.04	-.01	-.05	-.01	-.01	.02	-.01
20R	**-.25***	**-.24***	-.09	-.10	**-.15***	-.02	-.11	-.08	-.08	-.03	-.11	-.00
MTL	**.17***	**.14***	.01	-.09	.10	**.28***	.09	.10	**.23***	-.07	**.14***	.01
MSU	**-.15***	-.08	-.08	.00	-.07	-.10	-.06	**-.14***	**-.17***	.09	**-.22***	-.06
UCU	**.15***	.06	.13	**.19****	**.18***	**.15***	.01	**.16***	**.27***	-.12	**.21****	.06
ISH	**- 32****	-.13	-.12	**-.14***	**-.21****	-.12	-.13	**-.19****	**-.30****	-.03	-.11	-.00

Rc	Rc^2	χ^2	p
.62	.39	273.32	**.00***
.59	.34	189.17	**.00***

* **P.**05 = .138

** **P.**01 = .181

Legend: **Rc** – canonica relation, Rc^2 – canonical R-square, χ^2 – Bartlett's Chi-square test, **p** – level of significance

Solving characteristic equations of cross-correlation matrix, two canonical factors were isolated as factors of roots of these equations. During the determination of relations with Bartlett's Chi-square test (χ^2) between the system of motor variables and the system of conative variables, relatively high canonical correlations for both isolated canonical factors were obtained (Rc = .62 and Rc = .59) and they are statistically significant at the level of .00 (p=.00). The canonical correlation squares (Rc^2), which explain the mutual variance of variables from two groups within the total variability of analysed systems of variables, are .39 and .34 (Rc^2 = .39, and Rc^2 = .34).

According to the results obtained from the matrix of the canonical structure of motor and the conative variables, there are statistically significant correlations between the applied variables of first and second canonical factor. The first canonical factor in motor space is defined by the variables COS-coordination with a stick (.20*), HTA – hand tapping (.29*), SOL – standing on one leg (.39*), MTL-medicine ball throw from a supine position (.54*), MSU – sit-ups (-.40*), UCU – undergrip chin-ups (.52*) and ISH-endurance of seated hang (-.53*) so that it can be defined as canonical factor of the structure of motion, tonus regulation, intensity and duration of excitation. Since the second canonical factor is defined by variables FHB – feet and hands banging (.63*), DPB-deep pull-up hang on the bench (-.55*), AHT – aiming at a horizontal target (-.54*) and 20R – 20-m run from the standing start (-.41*) it can be defined as a canonical factor of the structure of motion, tonus regulation and excitation intensity.

The first canonical factor (Table 4) in conative space is defined by variables K10 – cardiovascular conversion (.56*), O3 – obsessiveness (.52*), S5 – hypersensitivity (.23*), F2 – phobia (.47*), N14 – impulsiveness (.85*) and T15 – aggression (-.15*) so that it can be interpreted as canonical factor of efficiency of the system of regulation and control of organic functions, defence reactions and offence reactions. Since the second canonical factor is defined by variables G11 – gastrointestinal conversion (.42*), I7 – inhibitor conversion (.35*), H13 – hypochondria (.44*), A1 – anxiety (.28*), P18 – paranoia (.50*) and D6 – depression (-.26*), it can be interpreted as a canonical factor of the efficiency of the system of regulation and control of organic functions, defence reactions and regulative functions coordination.

Table 4: Canonical structure of motor and conative variables

Variables	Fc-1	Fc-2	Variables	Fc-1	Fc-2
Motor variables			*Conative variables*		
COS	**.20***	.10	**K 10**	**.56***	.36
FHB	-.03	**.63***	**G11**	.33	**.42***
HTA	**.29***	.17	**I7**	.30	**.35***
DPB	.12	**-.55***	**H13**	.17	**.44***
SOL	**.39***	.05	**A1**	.26	**.28***
AHT	.21	**-.54***	**O3**	**.52***	-.20
SLJ	-.02	.01	**S5**	**.23***	.05
20R	-.15	**-.41***	**F2**	**.47***	.14
MTL	**.54***	-.07	**N14**	**.85***	-.02
MSU	**-.40***	-.10	**T15**	**-.15***	.11
UCU	**.52***	.13	**P18**	.45	**.50***
ISH	**-.53***	.17	**D6**	.17	**-.26***

Legend: **Fc-1** – first canonical factor, **Fc-2** – second canonical factor

DISCUSSION

In the discussion of relations between canonical factors from two different anthropological fields which were obtained by application of canonical correlation analysis, the usual rule is used, i.e. the linear increase of values of the resulting vector of the variables of canonical factor from the first field proportionally corresponds to the linear increase of the values of the resulting vector of variables of canonical factor from the second field if the correlation between the two tested variables systems in different fields is statistically significant. The same rule is true for the reverse direction of relations that the linear decrease of result values in the canonical factor of the first field corresponds to the linear decrease of result values in the first canonical factor of the second field.

The human ability to notice, understand, learn and reproduce some complex motion structures primarily depends on cognitive abilities. Cognitive processes and cognitive functions represent the central mechanism of cortical regulation. The central nervous system primarily has an integrating function; it thus helps reasonable and adaptable behaviour of the human personality. The most important is the integration on the cortical level, because reasonable behaviour is directly connected with integrated functioning of the cerebral cortex. Integration also exists on the sub-cortical level, but it is less flexible and it enables reaction in usual situations which entail automatic reaction.

In this study, the relations between the first canonical factor of the system of motor variables, interpreted as a canonical factor of tonus regulation, intensity and excitation duration and the first canonical factor of the system of cognitive variables, interpreted as efficiency of serial processor, show that handball players achieve good results in regulation of tonus, intensity and duration of excitation if they have increased values in the cognitive variable of efficiency of serial processor (AL-4) and vice versa.

The relations between the second canonical factor of the system of motor variables, interpreted as a canonical factor of the structure of motion and regulation of intensity and duration of excitation and the second canonical factor of the system of cognitive variables, interpreted as efficiency of parallel processor, show that handball players achieve good results in the structure of motion and regulation of intensity and duration of excitation if they have increased values in cognitive variable of efficiency of parallel processor (S-1) and vice versa.

The Relations between the third canonical factor of the system of motor variables, interpreted as canonical factor of the structure of motion and synergy regulation and the third canonical factor of the system of cognitive variables, interpreted as the efficiency of perceptive processor show that handball players achieve good results in the structure of motion and synergy regulation if they have increased values in cognitive variable of efficiency of perceptive processor (IT-1) and vice versa.

According to the results obtained in this research, it can be assumed that cognitive mechanisms generally influence success in handball, but it seems that the influence of perceptive and spatial (parallel) processors could be the most important. The test of perception was made with the intention of measuring the perceptive ability, which represents synthesis of perceptive analysis ability, perceptive structuring and perceptive identification while spatialization was defined as the ability to determine spatial relations or to solve spatial problems. However, as it is well known, the other cognitive factors are also important concerning every type of structure of every day

activity, so too in handball, which was proved by this research. However, it cannot be said that cognitive factors are the only ones that are primary for the success in any activity, including that of handball.

The efficiency of doing any human activity is not independent of the characteristics that regulate modalities of human behaviour, including handball. That is to say, it is known that some characteristics of conative field directly limit the efficiency in different activities while in some other activities they indirectly limit the efficiency (for example: because of the contamination effect on some other anthropological characteristics, abilities). It is not excluded that in some activities the same conative characteristics represent restriction while in some other activities they represent a stimulus to efficiency, especially if they contribute to success of the activity.

In connection to this, the rule that there are no two subjects with completely the same structure of any, including conative characteristics, regardless of their definite number is also valid. Because of this, the knowledge of the complexity of an activity, including the field of conative characteristics is very important hypothesis of operationalisation of the goal of each activity accordingly handball.

Relations between the first canonical factor of the system of motor variables (interpreted as a canonical factor of the structure of motion, regulation of tonus, intensity and duration of excitation) and the first canonical factor of the system of conative variables (interpreted as a canonical factor of efficiency of the system of regulation and control of organic functions, defence reactions and offence reactions) show that handball players achieve good results in the structure of motion, regulation of tonus, intensity and duration of excitation if they have increased values in conative variables of efficiency of the system of regulation and control of organic functions, defence reactions and offence reactions and vice versa.

Relations between the second canonical factor of the system of motor variables (interpreted as a canonical factor of the structure of motion, regulation of tonus and intensity of excitation) and the second canonical factor of the system of conative variables (interpreted as a canonical factor of efficiency of the system of regulation and control of organic functions, defence reactions and the system of coordination of regulative functions) show that handball players achieve good results in the structure of motion, regulation of tonus and intensity of excitation if they have increased values in conative variables of efficiency of the system of regulation and control of organic functions, defence reactions and the system of coordination of regulative functions and vice versa.

In the general conclusion of this research, it is worth emphasising that the results showed that in the training and competing process of top class handball players, training was well-balanced, which can mean that they were on one hand optimally oriented towards the development of relevant motor abilities that correlate with cognitive abilities and conative characteristics and represent the basis of the training process of handball players. On the other hand, the training of handball players greatly influenced improvement of results concerning the majority of relevant motor abilities.

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