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THE CANONICAL RELATIONS BETWEEN THE SYSTEMS OF VARIABLES OF BASIC MOTOR AND COGNITIVE ABILITIES OF TOP FOOTBALLERS

KANONIČNE POVEZAVE MED SISTEMI SPREMENLJIVK OSNOVNIH MOTORIČNIH IN KOGNITIVNIH SPOSOBNOSTI VRHUNSKIH NOGOMETAŠEV

ABSTRACT

A system of 12 variables (9 motor and 3 cognitive variables) was applied to a sample of 136 footballers, aged between 18 and 27, with the aim of determining significant relations between the systems of basic motor variables and the system of cognitive variables. The data is processed with a canonical correlation analysis. The application of the Bartlett chi-square between the system of basic motor variables and the system of cognitive variables produced a significant canonical correlation. The relations between the first canonical factor from the system of cognitive variables (interpreted as a general cognitive factor), and the first canonical factor from the system of basic motor variables (interpreted as a canonical factor of structuring the movement, regulation of intensity and duration of excitation) show that footballers have good results in basic motor abilities if they have increased values in cognitive abilities and vice versa. The results of the research have shown that footballers achieve better results in basic motor variables of structuring the movement and regulation of intensity, if they have increased values in cognitive variables of efficiency of perceptive processor, efficiency of serial processor and efficiency of parallel processor. Therefore, it can be concluded that cognitive mechanisms generally influence the successful performance of basic motor abilities of footballers where the impact of the efficiency test of the serial processor is the most important, because it is responsible for the ability to operate with symbols, especially in case of structuring movement, which is the ability regarded as the most dominant in footballers.

Key words: footballers, motor abilities, cognitive abilities, relations.

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Izvleček

Sistem 12 spremenljivk (9 motoričnih in 3 kognitivne) smo uporabili na vzorcu 136 nogometašev, starih od 18 do 27 let, da bi ugotovili statistično pomembne povezave med sistemom osnovnih motoričnih spremenljivk in sistemom kognitivnih spremenljivk. Podatki so bili obdelani s kanonično korelacijsko analizo. S pomočjo Bartlettovega testa s hi-kvadratom med sistemom osnovnih motoričnih spremenljivk in sistemom kognitivnih spremenljivk smo ugotovili statistično pomembno kanonično korelacijo. Povezave med prvim kanoničnim dejavnikom iz sistema kognitivnih spremenljivk, ki smo ga interpretirali kot splošni kognitivni dejavnik, na eni strani in prvim kanoničnim dejavnikom iz sistema osnovnih motoričnih spremenljivk, ki smo ga interpretirali kot kanonični dejavnik strukturiranja gibanja, uravnavanja intenzivnosti in trajanja vzdraženja, na drugi strani so pokazale, da nogometaši dosegajo dobre rezultate v osnovnih motoričnih sposobnostih, če imajo povečane vrednosti kognitivnih sposobnosti, in obratno. Rezultati raziskave so pokazali, da nogometaši dosegajo boljše rezultate v osnovnih motoričnih spremenljivkah strukturiranja gibanja in uravnavanja intenzivnosti, če imajo višje vrednosti kognitivnih spremenljivk učinkovitosti zaznavnega procesorja, učinkovitosti serijskega procesorja in učinkovitosti vzporednega procesorja. Lahko zaključimo, da kognitivni mehanizmi v splošnem vplivajo na uspešno izvajanje osnovnih motoričnih sposobnosti nogometašev, ko je vpliv testa učinkovitosti serijskega procesorja največji, saj je ta odgovoren za sposobnost operiranja s simboli, zlasti v primeru strukturiranja gibanja, ki pri nogometaših velja za prevladujočo sposobnost.

Ključne besede: nogometaši, motorične sposobnosti, kognitivne sposobnosti, povezave

INTRODUCTION

Football is a game that requires motor ability from its players, which is intercepted with shorter and longer pauses, and which is characterised with abrupt and fast changes of intensity, direction of movement and position of the player along with permanent jump performance during the match and continuous intensive anaerobic and aerobic work.

Bearing in mind the fact that a footballer solves problem situations of motor and cognitive status in the field, which requires evaluation, prediction and reaction to the constant changes of situation, it is assumed that determination and analysis of relations between basic motor and cognitive abilities may be one of the most important indicators of their anthropological status and mutual functioning (Malacko & Rađo, 2004).

Determining the relations between basic motor abilities and other segments of the anthropological status of players in certain sports is a topically practical and a scientific problem needing solutions for forming rational procedures within the technology of sports training (Malacko & Popović, 2001; Stanković & Malacko, 2008).

The influence of cognitive regulative mechanisms on success in different sports activities is of different intensity, depending on the type of mechanism and type of sports as well as on other predicted and/or unpredicted endogenous and exogenous situations and circumstances; thus, the sports achievements will be optimal regarding cognitive abilities, sports knowledge, structuring the movements and trained skills of sportspeople (Blažević & Malacko, 2007; Kirkendall & Gruber, 1970).

The aim of the research is to determine, with a sample of footballers, statistically significant relations between the system of variables of basic motor abilities and system of cognitive variables in order to form rational procedures for more optimal sports orientation and selection, planning and programming of training activities as well as the monitoring and controlling transformational processes of relevant anthropological characteristics.

METHOD

Participants

A system of 12 variables (9 basic motor and 3 cognitive) has been applied to a sample of 136 top footballers.

Instruments

The following latent and manifest variables have been used for estimating basic motor abilities from the model of structure of motor abilities (Gredelj, Hošek, Metikoš, & Momirović, 1975; Metikoš, Prot, Horvat, Kuleš & Hofman, 1982):

a) structuring the movement:

1. figure eight with swaying (FIEISW),
2. tapping the foot (TAPFOO),
3. clapping the legs with hands (CLLEHA),

b) regulation of excitation intensity:

4. standing long jump (STLOJU),

5. Sargent's test (SARGTE),

6. running for 20 metres from standing starting line (R20STL),

c) regulation of duration of excitation:

7. knuckle (KNCKLE),

8. lifting the torso (LIFTOR) and

9. stamina when doing semi-squats (SDOSSQ).

The following variables have been used for estimating cognitive abilities from the model of the KOG 3 battery (Wolf, Momirović, Džamonja, 1992):

10. Test IT–1 for the efficiency of perceptive processor,

11. Test AL–4 for the efficiency of serial processor and

12. Test S–1 for efficiency of parallel processor.

When calculating the relations between the system of basic motor and the system of cognitive variables, a canonical correlation analysis has been applied. Testing the statistical significance of the hypothesis about global linking between two different anthropological systems of variables has been carried out with: λ – statistically significant characteristic roots, Rc – canonical correlation quotient, Rc^2 – squared canonical correlation quotient, χ^2 – Bartlett chi-square test and p – testing of statistic significance at the level of .05 - .00 (p = .05 - .00).

RESULTS

Table 1 shows the results of the basic central and statistical dispersion parameters of cognitive variables and variables of basic motor abilities as well as their discrimination. When analysing the skewness (Sk), the asterisk (*) indicates that the variables that have normal (symmetric) distribution, which means that the result is in the range from 0–1.00 of the standard deviation.

Table 1: The basic statistical parameters and testing the normality of their distribution

Variable	M	min	max	S	Sk	Ku
	Cognitive abilities					
IT1	20.79	9.00	36.00	4.92	.59*	1.03
AL4	27.83	8.00	39.00	6.57	-.42*	-.23
S1	16.22	4.00	29.00	5.58	-.06*	-.56
	Motor abilities					
FIEISW	79.35	73.00	88.00	3.38	.08*	-.49
TAPFOO	22.79	21.00	29.00	1.16	1.10	4.76
CLLEHA	7.39	4.00	10.00	1.47	-.00*	-.82
STLOJU	231.72	211.00	255.00	8.60	.50*	-.13
SARGTE	49.75	42.00	62.00	4.69	.68*	-.14
R20STL	33.33	30.00	35.00	1.09	-.46*	-.13
KNCKLE	6.20	1.00	15.00	2.84	.67*	.31
LIFTOR	47.36	31.00	62.00	6.80	.09*	-.60
SDOSSQ	584.55	220.00	960.00	146.22	.14*	-.22

The above table clearly presents all the applied cognitive and basic motor variables that have satisfactory discrimination, since the values of skewness do not exceed 1.00, except in case of the variable tapping the foot (Sk=1.10), which shows that they are adapted to the respondents and that they are appropriate for further statistical processing and methodological interpretation and conclusion.

The analysis of the cross-correlation matrix between the system of cognitive variables and the system of basic motor variables (Table 2) shows statistically significant correlations of the pairs of variables at the levels of .01 (** $p._{01}$) and .05 (*$p._{05}$).

Table 2: Cross-correlation between basic motor and cognitive variables

Variables	**IT1**	**AL4**	**S1**
FIEISW	-.13	-.05	-.12
TAPFOO	.03	-.06	.11
CLLEHA	.38**	.49**	.39**
STLOJU	.08	.12	.08
SARGTE	.17*	.13	.15
R20STL	-.19*	-.09	-.21**
KNCKLE	.09	.05	.14
LIFTOR	.08	-.02	.09
SDOSSQ	.18*	.13	.16*
Rc	Rc2	$\chi 2$	p
.58	.33	71.21	.00*
.34	.11	18.31	.30
.13	.01	2.25	.94

Legend: Rc – canonical correlation quotient
Rc^2 – squared canonical correlation quotient
χ^2 – Bartlett chi-square test
p – statistical significance

*P_{05} = .159
**P_{01} = . 208

There are statistically significant correlations at the levels p=.01 and p=.05 between cognitive variable IT–1 – efficiency of perceptive processor and basic motor variables CLLEHA – clapping the legs with hands (.38**), SARGTE – Sargent's test (.17*), R20STL – running for 20 metres from standing starting line (-.19*) and SDOSSQ - stamina when doing semi-squats (.18*). There is a statistically significant correlation at the level of .01 between cognitive variable S–1 – efficiency of parallel processor and basic motor variables CLLEHA – clapping the legs with hands (.39**) and R20STL - running for 20 metres from standing starting line (-.21**), whereas there is the level p= .05 in case of the variable SDOSSQ - stamina when doing semi-squats (.16*)

The canonical correlation analysis with the parameters of canonical correlation (Rc), determination quotient (Rc^2), chi-square test (χ^2) and its statistical significance (p) has been applied in the procedure of determining statistically significant relations, i.e. of getting maximum linking between the multivariate system of cognitive variables and system of basic motor variables.

The Bartlett chi-square test (χ^2=71.21) has been used for testing statistical significance of the canonical correlation quotient (Rc=.58), which explains linear combinations between the sets of variables, i.e., linking of the two different systems of variables. Solving the characteristic equations of the cross-correlation matrix has brought, as the roots of these equations, the squares

(determination quotients) of canonical correlation (Rc^2 =.33), which explain the common variant of variables from two sets out of the total variability of analysed system of variables.

Bearing in mind that structure of the first isolated canonical factor (Table 3) is composed of all statistically significant cognitive variables, it can be interpreted as general cognitive factor.

Table 3: Canonical structure of basic motor and cognitive variables

Variables	Fc - 1
	Cognitive variables
IT1	.79*
AL4	.97*
S1	.69*
	Basic motor variables
FIEISW	-.14
TAPFOO	-.06
CLLEHA	.88*
STLOJU	.22*
SARGTE	.27*
R20STL	-.24*
KNCKLE	.13
LIFTOR	.01
SDOSSQ	.27*

Legend: Fc - 1 = the first canonical factor

The isolated first canonical factor in the basic motor space is defined by the values of statistically significant canonical correlation quotients. The largest and statistically most significant correlation with the basic motor canonical factor is in case of the variable CLLEHA – tapping the legs with hands (.88*), and then there are the variables STLOJU – standing long jump (.22*), SARGTE – Sargent's test (.27*), R20STL – running for 20 metres from standing starting line (.24*) and SDOSSQ – stamina when doing semi-squats (.27*), so it can be interpreted as the canonical factor of the structuring of movement, regulation of intensity and duration of excitation.

DISCUSSION AND CONCLUSION

The ability of people to observe, understand, adapt and reproduce some complex moving structures primarily depends on their cognitive abilities. The cognitive processes and cognitive functioning represent the central mechanisms of cortex regulation. The central nervous system primarily has an integrative function, which enables purposeful and adaptable human behaviour. The integration at the cortex level is of paramount importance, because purposeful behaviour is directly linked to the integrated function of the cerebral cortex. There is also the integration at the sub-cortex level, but it is less flexible and it controls reactions in standard situations that require automatic reactions.

It is assumed that there are no sports, no matter how it is easy, where cognitive abilities do not play a part in performance. Likewise, it has been determined that there are many top sportspeople whose intelligence is above-average in most cases; there are even those who have substantially

above-level intelligence quotients, which are usually in the range from 110 and 120, especially in case of highly complex sports, including football. Since footballers solve many problem situations in the field, which require observation, estimation, prediction and reaction to the constantly changing situation in various circumstances, the estimation of cognitive mechanisms is of the highest importance; they can be best estimated by determining the relations with other segments of anthropological status of sportspeople.

On the basis of this empirical research, the general assumption that cognitive mechanisms in statistically significant relations (p=.00) with the basic motor abilities of footballers has been confirmed. The particular cognitive test of efficiency of serial processor – symbolic resolving (AL-4) is especially important. This test is intended for the estimation of verbal understanding and it represents the process of abstraction and generalisation that is responsible for operating with symbols, fast application of successive analysis and processing the memorised information in a verbal form, which is a good sign of the efficiency of serial information processing. Regarding the basic motor abilities of footballers, the ability to structure movement is especially significant (CLLEHA – clapping the legs with hands) which is in a statistically significant correlation (.49) with cognitive test of efficiency of serial processor – symbolic resolving (AL-4).

The relations between the first canonical factor from the system of cognitive variables (IT–1, AL–4, S–1), interpreted as the general cognitive factor (G), and the first canonical factor from the system of basic motor variables, interpreted as canonical factor of structuring the movement (CLLEHA), regulation of intensity (STLOJU, SARGTE, R20STL) and the duration of excitation show that footballers achieve good results in basic motor variables if they have increased values in cognitive variables, and vice versa.

As general conclusion of this research, it is worthwhile to emphasise that activities within the training and competition process of top footballers are well-balanced, which means that they have been directed optimally to the development of relevant basic motor abilities, which are in statistically significant relations with cognitive abilities (Rc=.58; p=.00) and they the basis of the training process of footballers.

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