

Scientific Paper

**THE RELATION OF SITUATIONAL-MOTOR COORDINATION
TO THE COMPETITIVE SUCCESS OF FEMALE GYMNASTS**

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Abstract. *On a sample consisting of 58 gymnasts, ages 7 through 9, from 8 cities in Serbia & Montenegro, a set of 10 predictor variables was applied for the purpose of evaluating situational-motor coordination, along with a set of 5 criterion variables for the purpose of evaluating the female gymnasts' competitive success. By means of the canonical-corelational analysis the relations between situational-motor coordination and competitive success in sports gymnastics were determined. The relations were presented by means of two significant factors. The two-dimensional structure of the situational-motor coordination indicates that the first factor is responsible for the execution speed of complex motor tasks, and the second for rhythmic coordination, the correct performance of hand motions on the sagittal and frontal plains, determined by set angles. Within the two-dimensional structure of the competitive success of gymnasts, it is possible to meaningfully interpret the second factor which is responsible for overall success, as it is significantly defined by all the variables used for evaluating short routines on individual pieces of apparatus (Vaults, Parallel bars, Balance beams, and Floor exercises) and the all-around competition.*

Key words: *gymnastics, success, coordination, competition, relations*

1. INTRODUCTION

The development of modern-day sport, as a widely understood social phenomenon, is connected with the progress in achieving sports results. Up to now, all the competition achievements, especially of late, point to the fact that this activity is developing at a quick pace. Still, no matter how sports gymnastics continues to develop in the future, we can, even at this moment, without conducting any particular research, conclude that the results of the "gymnastics elite" are moving further and further away from the results of all the other gymnasts. Many authors state that in sports gymnastics, coordination plays the most important part. This is understandable, bearing in mind the fact that this sport is ranked as

a poly-structural, conventional sport, at the basis of which lie coordination-wise very complex movements performed in accordance with certain aesthetic criteria. It is due to this fact that coordination skills are a very important criterion for choosing candidates for sports gymnastics. The basic problem that imposes itself there are the differing opinions regarding the ways of obtaining reliable information regarding coordination quality. Most authors think that it is the coordination skills that are responsible for the execution of complex movements. The problem surfaces when one tries to define the term coordination, especially when it comes to determining its latent structure. Every school of gymnastics and every system of selection has its own "methods" and instruments of measurement by means of which they obtain the necessary information regarding coordination skills. This research aims to conduct a scientific examination of the proposed instruments of measurement for situational coordination, which are used in the selection process for sports gymnastics.

There is very little scientific data regarding the sensitive phases of the development of coordination skills. Still, both the older and the more recent research confirm that the sensitive phase lasts between the ages of 7 and 12. Winter (1984) concludes that the sensitive phase for developing girls' coordination skills is around the age of 7, and boys', the age of 12. What is understood by motor abilities is a certain level of development of the motion and motor structures of humans, not taking into consideration the fact whether or not they have been achieved by means of exercise or through competitions, and which are responsible for the basically infinite number of the manifested motor reactions and which can both be altered and described.

Science makes the distinction between three theoretical concepts about coordination structure, and they are: the phenomenological, the functional and the functional-phenomenological. The phenomenological approach takes the stand that what is responsible for coordination structure are factors of an active and topological type, such as general coordination ((Hempel and Fleishman, 1955) according to Kurelić et al.), the speed at which complex motor tasks are learnt (Hošek et al., 1975), the reorganization of motor stereotypes (Gredelj et al., 1973), the coordinated performance of set motions to a rhythm (Hošek et al., 1973), the execution speed of complex motor tasks (Metikoš and Hošek, 1972; Momirović et al. (1975) according to Kurelić et al.; Gredelj et al., 1975), agility, motor information (Gredelj et al., 1975), and timing (Hošek, 1976). The functional model of coordination is defined as the useful and controlled energetic, temporal and spatial organization of motions into a unified whole.

On the basis of what we have mentioned, we can define three levels of coordination: the first, which is defined by the spatial precision of motions, the second, which is defined by spatial-temporal precision and the third, which consists of motions that require precision in both space and time (Popović, 1998). The functional-phenomenological concept, in spite of a great number of attempts to verify it in practice, has remained within the realm of mere hypotheses.

Apart from all this, a large amount of research (Mejovšek, 1977) has proven that coordination has a greater correlation with intellectual abilities in relation to other motor abilities. The coefficient for inborn coordination is .80, so that developing this ability should begin at the earliest possible age (Malacko, 1991).

Proje (1983) researched the predictory value of a polygon for the process of the selection of children, age 9, for sports gymnastics. The author concluded that it was possi-

ble to predict the success rate in sports gymnastics on the basis of the applied polygons for whose execution both coordination and explosive type strength were necessary.

Petković (1984) while conducting experimental research on the influence of the morphological and motor dimensions on the results in sports gymnastics, reached the conclusion that the influence of motor abilities is statistically significant (.64 in the case of boys and .55 in the case of girls).

In the research carried out by Novak (1984) on gymnasts, ages 7 through 9 from the city of Ljubljana, a motor type of the successful gymnast based on strength, coordination and balance was defined.

Veličković (1999) carried out research on the applicability of all the instruments of coordination measurement that had been used up to that point (9 in total) in the selection process in sports gymnastics. The author had, by means of a factor analysis, obtained 5 hypothetical factors including: the ability to precisely execute complex motor tasks, agility, the ability to correctly manage motions of the shoulder area, rhythmic coordination, and the execution speed of complex motor tasks.

The subject matter of this research is the identification of the means and methods for the purpose of proving any possible relations of relevant anthropological dimensions to the success in young girl sports gymnastics. The subject matter of the research are coordination skills and competitive success in young girl sports gymnastics. The area of study of this research is the situational-motor coordination of female gymnasts ages 7 through 9, who were included in the competition system of the Pioneer League of the Gymnastics Association of SMN and its predictive value in regards to the results in the four-event competition. The aim of this research is to determine the relation of the coordination skills to competitive success in the four-event competition, in particular when it comes to young female gymnasts. Bearing this in mind, we begin with the assumption that what will be found are statistically significant relations between the system of variables for the evaluation of situational-motor coordination and the variables by means of which we can evaluate the competitive success of young female gymnasts in a four-event competition.

2. METHODS

The sample of examinees

For the sample of examinees consisting of young female gymnasts from SMN, only those who had participated in the finals of the Pioneer League of SMN for sports gymnastics were singled out. The gymnasts were ages 7 through 9, with a sports record of at least one year, and three at the most, and who represent a total sample (58 gymnasts) from 8 cities in SMN.

The sample of variables

The sample of variables used in this research represents a set of tests, whose metric characteristics were determined (Veličković, 1999). On the basis of the five factors extracted for this research, two instruments of measurement with top metric characteristics were chosen for each. All the variables used in the research were divided into predictor and criterion variables.

The sample of predictor variables

- I For the evaluation of the execution speed of complex motor tasks
 1. The skill polygon, the more difficult version (POLD),
 2. The backward polygon (POLB)
- II For the evaluation of agility
 1. 10 × 4 lying down, squatting and jumping (LSJM)
 2. Running 2 × 15 m from a lying start (R2 × 15)
- III For the evaluation of the precise management of motion in the shoulder area
 1. Hand motions in the frontal plain (defined by the set angles) (HMEP)
 2. Hand motions in the sagittal plain (defined by the set angles) (HMSP)
- IV For the evaluation of rhythmic coordination
 1. Arhythmic hand drumming (ARHD)
 2. Somersault exercises and walking a line accompanied by asymmetrical hand motions (SWAH)
- V For the evaluation of the execution correctness of complex motor tasks
 1. Depth jump exercises, accompanied by asymmetrical "activities" of the extremities (DJAЕ)
 2. Movement exercises accompanied by asymmetrical hand motions (MEAH)

The sample of criterion variables

For the evaluation of competitive success (the gymnastics four-event competition), the following variables were used:

1. Vault (with a forward approach with a flip in post-flight into a standing position on the mat) (VAU)
2. Uneven bars (a short mandatory routine) (BAR)
3. Balance beam (a short mandatory routine) (BAL)
4. Floor exercise (a short mandatory routine) (FLR)
5. The all-around competition (The total amount of all the scored points for each of the individual disciplines) (AAC)

The scoring was carried out by three judges, one of whom was a lead judge and two of whom were scoring judges. The scoring was carried out according to a predetermined set of values presented in the tenths of a point for each of the routines or exercises, according to set penalties leading to a final score of 10.00. The results for the all-around competition are in fact a total of all the scores from the individual disciplines (carrying a maximum of 40.00). The scoring was carried in accordance with the FIG Rulebook for scoring and the activities of the „B"panel of judges regarding deducting points for performance, as well as scoring for the mandatory routines (Rulebook GAY-GASMN).

The methods of data processing

The central tendency and result distribution values were calculated for all the variables. Statistical processes were applied along with methods which enable drawing conclusions. In order to determine the connection between situational-motor coordination and the competition results in sports gymnastics in the case of female competitors at a multivariate level, a canonical correlational analysis was applied. The correlation between two sets of variables was determined by means of the method developed by Ho-

teling (1935), according to Malacko & Popović (1997). The following coefficients were calculated:

- Can R – the value for the correlation coefficient for the set of predictors and criteria
- Can R² – the value for the correlation coefficient for the set of predictors and criteria
- Chi-sqr – The test results of the function by means of Bartlett's chi square test
- df – the number indicating the degree of freedom
- p – the extent of the margin for error while rejecting a hypothesis, the significance of the relations
- lambda – Bartlett's lambda test

The cross-correlational matrix for situational coordination and competitive success of the female gymnasts was also calculated.

The data was analyzed by means of the "SPSS-8" and the "STATISTIKA-6" statistical program.

3. THE RESULTS AND THE DISCUSSION

The central and dispersive parameters of situational-motor coordination and the competitive success rate of the female gymnasts are shown in Tables 1 and 2.

Table 1. The central and dispersive parameters for the situational-motor coordination of female gymnasts

Variable	N	Mean	Min	Max	Rang	SD	St. Err.	Skew.	Kurt.
POLD	58	11.46	9.25	14.57	5.32	1.48	.19	.47	-.67
POLB	58	15.12	10.00	22.80	12.80	3.19	.41	.48	-.52
LSJM	58	25.94	19.50	32.00	12.50	3.10	.40	-.00	-.82
R2X15	58	8.92	7.20	11.40	4.20	.81	.10	.31	.39
ARHD	58	7.81	1.00	14.00	13.00	3.25	.42	-.31	-.49
SWAH	58	5.69	1.00	13.00	12.00	2.90	.38	.22	-.49
DJAE	58	5.27	1.00	10.00	9.00	2.99	.39	-.06	-1.38
MEAH	58	5.00	1.00	14.00	13.00	3.30	.43	.66	.01
HMEP	58	8.15	5.00	10.00	5.00	1.26	.16	-.64	-.08
HMSP	58	7.83	4.00	9.50	5.50	1.27	.16	-.93	.93

Table 2. The descriptive statistical parameters of the competitive success of female gymnasts

Variable	N	Mean	Min	Max	Rang	SD	St. Err.	Skew.	Kurt.
VAU	58	7.85	5.30	9.65	4.35	1.13	.14	-.67	-.58
BAR	58	7.78	4.20	9.50	5.30	1.30	.17	-.79	-.17
BAL	58	8.31	4.20	9.65	5.45	1.18	.15	-2.01	3.72
FLR	58	8.02	5.20	9.60	4.40	.88	.11	-1.41	3.06
AAC	58	31.86	19.30	38.25	18.95	4.15	.54	-1.25	1.34

What was determined by means of the canonical correlational analysis (the bi-orthogonal method) was the *relation of one multi-dimensional system* of manifested variables for the evaluation of situational-motor coordination, as a system of predictor variables, to an *alternate multi-dimensional system* for the evaluation of the competitive suc-

cess of female gymnasts, as a system of manifested criterion variables. The basic goal behind the application of this statistical method is its formation of a linear combination within a group of independent variables, but in such a way as to enable a maximal correlation between those two linear combinations (Momirović, 1970).

The relations of the predictor system of variables which refer to situational-motor coordination, and the criterion system of variables which refer to the competitive success of female gymnasts are shown in Table 3. The results indicate that there are two significant canonical factors by means of which the relations are explained.

Table 3. The canonical analysis of situational-motor coordination and the competitive success of female gymnasts

	Can. R	Can. R ²	Chi- sqr.	df	p	LAMBDA
0	.78	.62	99.00	50	.00	.13
1	.61	.37	51.38	36	.04	.35

The first canonical factor significantly explains the extent of the connection between the set of predictor and the criterion variables (Can. R = .78). The margin for error while rejecting a hypothesis in the sense of whether the function is significant or not, has been determined between the predictor and criterion ($p = .00$) at the 100% level. The determination coefficient (Can. R² = .62) gives an explanation of this affect in percentages. Thus, the affect of situational coordination on competitive success was explained by a 62%. *The second* canonical factor also significantly explains the relation between the set of predictor and the criterion variables (Can. R = .61). The margin for error while rejecting the hypothesis in the sense of whether the function is significant or not, was established between the predictor and the criterion ($p = .04$) at a 96% level of significance. The determination coefficient (Can. R² = .37) is somewhat lower in this case and explains this influence with a 37%.

With an insight into the structure of the canonical factors (Table 4), the conclusion can be reached that the area of situational-motor coordination is defined by the factors responsible for:

- the execution speed of complex motor tasks and agility on one hand, as well as
- rhythmic coordination and execution precision of complex motor tasks via arm motions of the shoulders region, on the other.

Table 4. The canonical factors of situational coordination and the competitive success of female gymnasts.

Coordination			Gymnastics		
Variable	Root 1	Root 2	Variable	Root 1	Root 2
POLD	-.49	-.12	VAU	.08	.67
POLB	-.35	-.12	BAR	.07	.84
LSJM	-.37	-.25	BAL	-.33	.75
R2X15	-.82	-.04	FLR	.22	.44
ARHD	-.25	.49	AAC	.01	.84
SWAH	-.04	-.16			
DJAE	.16	.62			
MEAH	-.21	-.72			
HMEP	.05	.28			
HMSP	.16	.68			

The first factor is best defined by the variables by means of which we evaluate the execution speed of complex motor tasks (POLD = $-.49$ and POLB = $-.35$) as well as the variables used for the evaluation of agility (LSJM and R2x15). The second factor is best defined by the variables by means of which we evaluate rhythmic coordination (ARHD and SWAH), followed by the execution precision of complex motor tasks (DJAE and MEAH), but also including the execution precision of hand motions in the frontal and sagittal plains (HMEP and HMSP) defined by the set angles.

Two significant canonical factors indicate that the relations of situational coordination to the competitive success of female gymnasts cannot be explained only by a single, general factor, but by several of them. A multi-dimensional approach is also necessary so that the applied situational-motor coordination skills of female gymnasts can be recognized in the two significant factors.

The canonical factors of competitive success in sports gymnastics (Table 4) indicate the existence of a two-dimensional spatial structure. High projections of the second factor enable it to be distinguished from the first, and defined as the factor of general competitive success in gymnastics. It is significantly defined by the high projections for the Parallel bars and in the all-around competition ($.84$), followed by the Balance beam ($.75$), the Vault ($.67$) and finally the Floor ($.44$) exercises.

By examining the cross-relational matrix of the results of coordination skills and competitive success in the all-around competition and on other individual pieces of apparatus (Table 5), the individual contribution of the coordination skills to competitive success can be analyzed. By analyzing the cross-relational matrix, we can determine that the following variables: ARHD, DJAE, MEAH and HMSP are part of the significant correlations between situational-motor coordination and the results of competitive success.

The following situational coordination skills, primarily, have a statistically significant influence on the competitive success of female gymnasts:

1. *rhythmic coordination;*
2. *precision in executing complex motor tasks and*
3. *precision in performing hand motions in the sagittal plain defined by the set angles.*

Table 5. The cross-relational matrix of situational-motor coordination and the results of the competitive success of female gymnasts

No.	Variable	VAU	BAR	BAL	FLR	AAC
1	POLD	$-.12$	$-.14$	$.03$	$-.21$	$-.12$
2	POLB	$-.14$	$-.21$	$.09$	$-.10$	$-.10$
3	LSJM	$-.16$	$-.24$	$.03$	$-.12$	$-.14$
4	R2X15	$-.18$	$-.09$	$.20$	$-.18$	$-.06$
5	ARHD	$.26$	$.19$	$.38$	$.17$	$.30$
6	SWAH	$-.15$	$-.02$	$-.01$	$.04$	$-.05$
7	DJAE	$.32$	$.35$	$.17$	$.12$	$.30$
8	MEAH	$-.31$	$-.35$	$-.31$	$-.25$	$-.38$
9	HMEP	$.23$	$.20$	$.16$	$.18$	$.22$

As the execution speed of complex motor tasks and agility play no statistically significant role in the competitive success of female gymnasts, the statistically significant correlation between the three (of a total of five) aforementioned factors of situational-motor coordination and the competitive success of female gymnasts has been verified.

4. CONCLUSION

This research has verified that relations exist between situational-motor coordination and the competitive success of female gymnasts. For the purpose of determining these relations, a canonical-corelational analysis was used. On the basis of the results and the discussion, it can be concluded that a two-dimensional model by means of which we can determine the significant canonical relations between situational-motor coordination and competitive success has been obtained.

Female gymnasts with a high level of situational-motor rhythmic coordination on one hand, and the skill to precisely execute complex motor tasks accompanied by a precise performance of hand motions in the sagittal plain on the other, can successfully complete a sports gymnastics competition routine of the Pioneer League of the Gymnastics Association of SMN.

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RELACIJE SITUACIONO - MOTORIČKE KOORDINACIJE I TAKMIČARSKE USPEŠNOSTI GIMNASTIČARKI

Emilija Petković

Na uzorku 58 gimnastičarki, starih sedam do devet godina iz osam gradova Srbije i Crne Gore primenjen je set od deset prediktorskih varijabli za procenu situaciono-motoričke koordinacije i set od pet kriterijumskih varijabli za procenu takmičarske uspešnosti gimnastičarki. Primenom kanoničko-korelacione analize utvrđene su relacije situaciono-motoričke koordinacije sa takmičarskom uspešnošću u sportskoj gimnastici. Relacije su iskazane kroz dva značajna faktora. Dvodimenzionalna struktura situaciono-motoričke koordinacije ukazuje da je prvi faktor odgovoran za brzinu izvođenja složenih motoričkih zadataka, a drugi za koordinaciju u ritmu, tačno izvođenje složenih motoričkih zadataka i preciznost izvođenja pokreta rukama u sagitalnoj i frontalnoj ravni pod zadatim uglovima. U okviru dvodimenzionalne strukture takmičarske uspešnosti gimnastičarki moguće je smislaono interpretirati drugi faktor koji je odgovoran za generalnu uspešnost jer ga značajno definišu sve varijable za procenu uspešnosti izvođenja kratkih sastava na pojedinačnim spravama (Preskok, Razboj, Greda, Parter) i Višeboj.

Ključne reči: *gimnastika, uspešnost, koordinacija, takmičenje, relacije.*