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Effects of Biomotor Structures on Performance of Competitive Gymnastics Elements in Elementary School Female Sixth-Graders

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A B S T R A C T

In order to identify biomotor systems that determine performance of competitive gymnastics elements in elementary school female sixth-graders, factor structures of morphological characteristics and basic motor abilities were determined first, followed by relations of the morphological-motor system factors obtained with a set of criterion variables evaluating specific motor skills in competitive gymnastics in 126 female children aged 12 years ±3 months. Factor analysis of 17 morphological measures yielded three morphological factors: factor of mesoendomorphy and/or adipose body voluminosity; factor of longitudinal body dimensionality; and factor of transverse arm dimensionality. Factor analysis of 16 motor variables produced four motor factors: general motoricity factor (motor system); general speed factor; factor of explosive strength of throwing type (arm explosiveness); and factor of arm and leg flexibility. Three significant canonical correlations, i.e. linear combinations, explained the association between the set of seven latent variables of the morphological and basic motor system, and five variables evaluating the knowledge in competitive gymnastics. The first canonical linear combination was based on a favorable and predominant impact of the general motor factor (a system integrating whole body coordination, leg explosiveness, relative arm strength, arm movement frequency and body flexibility) on performance of gymnastics elements, cartwheel, handstand and backward pullover mount in particular, and to a lesser extent front scale and double leg pirouette for 180°. The relation of the second pair of canonical factors additionally explained the role of transverse dimensionality of arm skeleton, arm flexibility and explosiveness in performing cartwheel and squat vault, whereas the relation of the third pair of canonical factors explained the unfavorable impact of adipose voluminosity on the performance of squat vault and backward pullover mount.

***Key words**: elementary school female students, morphological-motor status, competitive gymnastics, canonical relations*

Introduction

According to kinesiologic definition, competitive gymnastics is a sport of esthetically shaped acyclic structures that are evaluated on the basis of the regulated convention of movement, defined by the FIG Code of Points (FIG, 2006)[1].

The process of acquiring particular movement convention, i.e. the process of learning takes a certain period of time that can be divided into three stages: verbal-cognitive (where the task is completely new, and is predominated by verbal and cognitive activities of instruction, demonstration and information); motor (at the end of which students can control performance and identify errors themselves); and automation (when students perform sophisticated movements as a consequence of long-term training, now employing their maximal abilities)[2–5].

As the process of learning in sports is long-lasting, with a great number of particular movement repeats to achieve automation and stabilization of a movement technique, measurement of the level of particular motor skill acquisition is conducted through the second, motor stage using specific methods of evaluation and comparison with precisely defined criteria for each motor skill[6–10].

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Measuring instruments should be valid and appropriate for the respective population specificities (depending on age, sex and level of the motor structure acquired) in order to eliminate possible errors that may occur on assessment of the motor skills acquired. That is why the FIG Technical Board consisting of experts in gymnastics tends to provide in every new Code of Points as precise as possible descriptions of each gymnastics element, thus maximally objectifying the process of judging.

The process of learning gymnastics motor structures as part of physical education and health culture requires certain material conditions and due knowledge of the students' morphological-motor characteristics that facilitate learning and performance of gymnastics structure. These characteristics differ significantly from those found in the general population including elementary school students. Studies in the gymnast population found female gymnasts to be significantly shorter, with a significantly lower body weight, narrower hips and proportionally broader shoulders relative to hips (Claessens et al., 1992)[11], and a lower proportion of subcutaneous adipose tissue in comparison to the general population (Faria, 1989; Claessens, 1999)[12,13].

Weinmann et al. (1988)[14] investigated the impact of high-intensity training on biological age in female gymnasts. In female gymnasts, a delay in the bone mass growth by a mean of 1.7 years was recorded in female gymnasts as compared with age-matched control subjects.

In parallel with studies of the impact on biological age, the effects of gymnastics training on the gymnasts' bone tissue structure were also investigated. These studies showed high-intensity training to be associated with bone mineral content in the body as whole and specifically in particular topologic regions of female gymnasts. Helge and Kanstrup (2002)[15] report on body density to be associated with maximal muscle strength and progesterone concentration in female gymnasts. In addition, these authors found the strength and bone density to depend on the length of training in young female gymnasts.

Studies tackling the motor system found the factors of flexibility, repetititive arm and shoulder girdle strength, explosive and repetitive strength of anterior trunk and leg strength to contribute favorably to successful performance of the gymnastics motor structures (Faria, 1989; Tkalčić, 1986; Šadura, 1988 and 1989)[12,16–18]. These motor abilities yielded statistically significant differences between the gymnast and general population.

In a sample of female gymnasts from the Split Gym Club, Katić et al. (1991)[19] assessed the effects of 4-month kinesiologic treatment of competitive gymnastics on changes in some motor abilities and performance of particular gym apparatus exercises. Study results pointed to significant quantitative changes to have occurred in motor variables for assessment of explosive strength, repetitive strength of the trunk and repetitive arm and shoulder strength, as well as in the scores of some gym apparatus exercises, beam, parallel bars and floor in particular.

The studies mentioned above stimulated the present investigation, the aim of which was to determine relations of morphological characteristics and motor abilities with the level of acquiring competitive gym motor structures in elementary school female sixth-graders. Latent structure of predictor (morphological and motor) systems was determined first, followed by assessment of relations between these structures, i.e. latent morphological and motor variables, with the level of acquiring competitive gym motor structures.

Subjects and Methods

Subject sample

The study sample included 126 clinically healthy female sixth-graders from three elementary schools (Bijaći from Kaštel Novi, Kman-Kocunar from Split, and Knez Mislav from Kaštel Sućurac), chronological age 12 years (±3 months), having attended physical education and health culture classes on a regular basis and included in extracurricular activities other than competitive gymnastics.

Variable sample

The sample of variables used to assess morphological characteristics consisted of 17 standard anthropometric measures taken according to International Biological Program recommendations[20,21]: body height, leg length, arm length, shoulder width, knee diameter, elbow diameter, wrist diameter, pelvis width, body weight, triceps circumference, forearm circumference, upper leg circumference, triceps skinfold, subscapular skinfold, abdomen skinfold, and lower leg circumference.

Basic motor abilities were assessed by use of 16 standard motor measuring instruments considered to cover the following latent movement dimensions: coordination (bar agility, polygon backwards, side steps), flexibility (hip circle backwards with hands stretched out shoulder dislocation, side split, forward bow), movement frequency (hand tapping, foot tapping, foot tapping against wall) and various strength factors (explosive strength: standing long jump, supine med-ball throw, 20-m run; static strength: bent arm hang; and repetitive strength: sit-ups, modified test of semi-crouches in 30 s, modified bar hangs).

The scores allocated by six educated judges for performance of the gymnastics motor structures of cartwheel, handstand, front scale and double leg pirouette for 180°, squat vault, and backward pullover mount, as part of the official curriculum of physical education in elementary school sixth grade, were used as criterion variables.

Statistical analysis

The following statistical methods were used on data analysis: factor analysis to determine factor structure in the samples of morphological variables and motor variables (calculations: V1… – significant varimax factors according to Guttman-Kaiser criterion of $\lambda>1$; λ – characteristic values; Variance % – percentage of variance explained by each latent dimension); and canonical correlation analysis to determine relations between latent morphological and motor variables, and the set of variables for assessment of specific motor skills in competitive gymnastics (CAN – structure of canonical variable; CanR – canonical coefficient of correlation; $CanR^2$ – coefficient of canonical determination; p – level of significance).

Results and Discussion

Table 1 shows results of descriptive and factor analysis of the morphological variables measured in the study sample of female sixth-graders. Factor analysis of the morphological system yielded three significant varimax factors, which taken together explained 72.91% of the system variance.

First varimax factor of the morphological system analyzed (V1) defined 40.56% of the entire predictor space, and showed a statistically significant correlation with all variables hypothetically measuring body voluminosity and almost all variables hypothetically measuring subcutaneous adipose tissue. Therefore, this factor could be interpreted as a factor of mesoendomorphy and/or adipose body voluminosity.

Second varimax factor of the morphological system analyzed (V2) described 23.05% of total system variance, and showed a statistically significant correlation with the variables hypothetically measuring body longitudinality. Therefore, it could be interpreted as a factor of body longitudinality.

Third varimax factor of the morphological system analyzed (V3) explained 9.30% of total system variance, and showed a statistically highly significant correlation with the variables hypothetically measuring body transversality (elbow diameter and wrist diameter). Therefore, it could be interpreted as a factor of upper extremity skeleton transversality.

Results of descriptive and factor analysis of the motor variables applied are presented in Table 2. Factor analysis of the motor system (main component method – varimax rotation) yielded four significant varimax factors, which taken together explained 60.44% of the system variance.

First varimax factor of the motor system analyzed (V1) explained 28.81% of total system variance and showed a statistically highly significant correlation with the variables hypothetically assessing various motor abilities: body coordination, explosive strength of lower extremities, basic strength of upper extremities, movement frequency of upper extremities, and lower body flexibility. This factor primarily integrated whole body coordination with explosive strength of lower extremities, relative basic strength of upper extremities (overcoming resistance, i.e. own body weight) and movement frequency of

TABLE 1
DESCRIPTIVE STATISTICS (Mean±SD) AND RESULTS OF FACTOR ANALYSIS (VARIMAX ROTATION) OF VARIABLES ASSESSING MORPHOLOGICAL CHARACTERISTICS IN GIRLS (N=126)

Variable	Mean±SD	V1	V2	V3
Body height (cm)	159.26±6.43	0.16	0.85	0.27
Leg length (cm)	93.21±4.23	0.02	0.85	0.18
Arm length (cm)	67.65±3.62	0.06	0.91	0.15
Shoulder width (cm)	34.38±1.84	0.37	0.77	0.08
Knee diameter (cm)	8.85±0.60	0.68	0.21	0.15
Elbow diameter (cm)	5.93±0.42	0.30	0.23	0.70
Wrist diameter (cm)	4.88±0.30	0.14	0.32	0.79
Pelvis width (cm)	22.97±2.39	0.22	0.62	–0.26
Body weight (kg)	49.73±9.14	0.87	0.38	0.22
Upper arm circumference (cm)	24.14±2.59	0.89	0.14	0.14
Forearm circumference (cm)	22.00±1.58	0.81	0.29	0.30
Upper leg circumference (cm)	49.50±4.92	0.88	0.31	0.06
Lower leg circumference (cm)	32.90±2.82	0.84	0.30	0.24
Triceps skinfold (mm)	7.86±2.98	0.70	–0.03	–0.12
Subscapular skinfold (mm)	9.29±4.20	0.92	–0.10	–0.02
Abdomen skinfold (mm)	9.29±4.31	0.91	–0.12	–0.04
Lower leg skinfold (mm)	4.92±1.77	0.52	–0.12	–0.07
λ		6.92	3.92	1.57
Variance%		40.56	23.05	9.30

V – significant varimax factors, λ – characteristic values, Variance% – percentage of variance explained by a particular factor

TABLE 2
DESCRIPTIVE STATISTICS (Mean±SD) AND RESULTS OF FACTOR ANALYSIS (VARIMAX ROTATION) OF VARIABLES ASSESSING MOTOR ABILITIES IN GIRLS (N=126)

Variable	Mean±SD	V1	V2	V3	V4
Bar agility# (s)	14.77±3.75	–0.64	–0.16	0.45	0.09
Polygon backward# (s)	16.02±3.52	–0.80	–0.31	0.03	–0.10
Sidesteps#	11.44±1.28	–0.62	–0.21	–0.44	0.01
Shoulder dislocation# (cm)	77.48±13.69	–0.12	–0.13	–0.04	–0.69
Side split (cm)	154.92±14.19	0.03	0.06	0.31	0.70
Forward bow (cm)	66.53±10.74	0.52	0.13	0.11	–0.05
Hand tapping (f)	29.74±3.16	0.63	0.49	0.03	–0.29
Foot tapping (f)	19.59±2.74	0.23	0.80	0.24	–0.00
Foot tapping against wall (f)	19.85±2.84	–0.01	0.63	0.14	0.46
Standing long jump (cm)	159.58±20.11	0.75	0.08	0.30	0.15
Supine med-ball throw (dm)	47.19±7.62	0.03	0.18	0.82	0.20
High start sprint 20 m# (s)	4.34±0.40	–0.81	–0.11	–0.16	0.14
Bent arm hang (s)	17.60±12.54	0.70	0.00	–0.29	0.17
Sit-ups (f)	35.90±8.24	0.45	0.15	0.16	0.05
Semi-crouch in 30 s (f)	32.41±5.68	0.15	0.59	–0.31	0.20
Modified bar hangs (f)	7.78±5.61	0.73	–0.07	–0.22	0.30
λ		4.61	1.90	1.62	1.53
Variance%		28.81	11.94	10.13	9.56

V – significant varimax factors, λ – characteristic values, Variance% – percentage of variance explained by a particular factor; #variable with opposite metric orientation

upper extremities. Thus, it could be interpreted as a factor of general motor efficiency of the present subject sample. The percentage explained by this factor in the total percentage of system variance, i.e. significant reduction in variance % from the first to the second factor (from 28.81% to 11.94%) could be explained accordingly.

Second varimax factor of the motor system analyzed (V2) explained 11.94% of total system variance and showed a statistically highly significant correlation with the variables hypothetically assessing movement frequency (predominantly of lower extremities), thus it could be defined as a general factor of the speed of movements.

Third varimax factor of the motor system analyzed (V3) explained 10.13% of the predictor space variability and showed a statistically significant and predominant correlation with the variable hypothetically measuring explosive strength of upper extremities. Thus, it could be defined as a factor of explosive strength of upper extremities and shoulder girdle.

Fourth varimax factor of the motor system analyzed (V4) explained 9.56% of total system variance and showed a statistically significant correlation with the variables measuring upper and lower extremity flexibility (predominantly shoulder and hip joint flexibility). Therefore, it could be defined as a factor of upper and lower extremity flexibility.

Table 3 presents results of canonical correlation analysis of latent morphological and motor variables with the variables assessing specific motor skills in competitive gymnastics in the study sample of elementary school female sixth-graders. The results of canonical correlation analysis indicated the inter-relationship of latent morphological and motor characteristics and criterion variables of performing competitive gymnastics elements to be defined by quite high coefficients of correlation, while isolating three linear combinations, i.e. three pairs of canonical factors.

The first pair of canonical factors showed a significant correlation ($p<0.001$) with quite a high canonical coefficient of correlation of 0.69. According to the coefficient of canonical determination ($CanR^2$), this correlation explained 47% of variability of the set of variables analyzed.

First canonical factor of the predictor set of variables was predominantly defined by the very high projection of the general motor factor, which integrated the abilities of coordination, explosive strength of lower extremities, basic strength and movement frequency of upper extremities, and lower body flexibility into a unique motor structure upon which the students' motor efficiency was based. The factor of arm explosiveness also played a small but favorable role in the structure of this canonical factor. All this was accompanied by the above-average development of longitudinal skeleton dimensionality and to a lesser extent of arm skeleton transversality.

The structure of the canonical factor of the criterion set of variables was characterized by very high favorable

TABLE 3
CANONICAL RELATIONS BETWEEN THE SET OF LATENT MORPHOLOGICAL-MOTOR VARIABLES AND SET OF SITUATION-MOTOR VARIABLES

Morphological-Motor Factors	CAN1	CAN2	CAN3
Mesoendomorphy	–0.20	0.03	0.80
Body longitudinality	0.44	0.46	0.13
Upper extrem. skeleton tranversality	0.22	–0.47	–0.19
General motor factor	0.95	0.01	–0.04
General speed factor	0.05	–0.33	0.23
Upper extremity explosiveness	0.22	–0.37	–0.32
Upper and lower extremity flexibility	–0.01	–0.57	0.48
Competitive Gymnastics Elements	**CAN1**	**CAN2**	**CAN3**
Cartwheel	0.81	–0.49	0.21
Handstand	0.87	0.07	0.23
Front scale and double leg pirouette for 180°	0.55	0.40	0.40
Squat vault	0.32	–0.34	–0.41
Backward pullover mount	0.79	0.39	–0.37
CanR	0.69	0.48	0.35
$CanR^2$	0.47	0.23	0.12
p	0.00	0.00	0.02

CAN – structure of canonical variables, CanR – coefficient of canonical correlation, $CanR^2$ – coefficient of canonical determination, *p* – level of significance

projections of the following three criterion variables, in descending order: handstand, cartwheel and backward pullover mount.

Accordingly, a motor system appropriate for performance of gymnastics elements, predominated by the abilities of whole body coordination, lower extremity explosiveness and relative strength of upper extremities and shoulder girdle was formed, which to the greatest extent determined performance of all elements of competitive gymnastics, handstand, cartwheel and backward pullover mountin particular.

Of the morphological dimensions isolated, the dimension interpreted as body longitudinality showed a statistically significant correlation with the criterion set of variables, suggesting that students with higher numerical values of the manifest variables interpreting this dimension should demonstrate better performance of handstand, cartwheel and backward pullover mount. Upper extremity skeleton transversality, and wrist diameter in particular, should probably have a favorable on performing these elements impact in terms of better support.

The role of the general motor factor in performing cartwheel is related to the complex rules on its performance, i.e. requiring dynamic and rhythmical body weight transfer from the arms to the legs, to standing astride, stretching all body joints and standing astride in the vertical phase, with dynamic and rhythmical hand pushing from the floor (upper extremity explosiveness), movements of the legs and the whole body up to the final position. The role of the general motor factor in performing handstand and swing can be interpreted through hypothetical complexity of performing these elements, requiring a great number and high degree of motor ability development, coordination, explosive strength, speed and body flexibility in particular. On performing swing, above-average basic relative strength of upper extremities is an additional requirement to hold the body in the position of polygon or semi-polygon, closest to the center of rotation, i.e. bar.

A significant yet less pronounced correlation was recorded between the latent motor dimension interpreted as a general motor factor and performance of the motor structure of front scale and double leg pirouette for 180° and backward pullover mount. The result obtained suggested that proper performance of this motor structure demanded a higher level of a number of motor abilities. Coordination is necessary for timely and rhythmical connecting two motor structures (arabesque and swing) into a single structure, while strength of different parts of the body is needed to maintain the required body position in balance. Maintaining the bent position of the trunk, shoulders bent backwards in particular, and one of the defined positions of the arms (holding extended arms forward and backward) is substantial to maintain the body position in balance (the key point in performing this motor structure). Besides flexibility and strength of the trunk, strength of the upper extremities and shoulder girdle as well as the morphological structure describing athletic somatotype are important for this performance.

Second pair of canonical dimensions explained 23% of the common variability ($CanR^2$=0.23). Association of the structures of this pair of canonical dimensions could be attributed to the differentiating, i.e. opposing effects of skeleton longitudinality and upper extremity skeleton transversality, related to the motor abilities of flexibility, upper extremity explosiveness and movement frequency, on particular criterion variables. Thus, students with the above-average skeleton longitudinality but below-average transversality of upper extremity skeleton, flexibility, upper extremity explosiveness and movement frequency were superior on performing arabesque with 180° swing, and swing to those characterized by opposite morphological-motor features (i.e. with below-average skeleton longitudinality but above-average transversality of upper extremity skeleton, extremity flexibility, and upper extremity explosiveness and movement frequency); the latter were more successful on performing cartwheel and to a certain extent squat vault. Students of below-average body height but above-average transversality of upper extremities, wrist in particular, and upper and lower extremity flexibility showed better performance of the criterion variable of cartwheel. The greater support surface provided better stability of the upper part of the body, facilitating performance of cartwheel and jumping over the apparatus, i.e. squat vault, contributing to successful performance.

Third pair of canonical dimensions explained only 12% of the common variability ($CanR^2$=0.12). Association of the structures of this pair of canonical dimensions could be ascribed to the favorable impact of mesoendomorphy underlain by adipose body voluminosity, and to a certain extent of upper and lower extremity flexibility, on the front scale and double leg pirouette for 180° performance, and to the unfavorable effect on the performance of squat vault and to some extent backward pullover mount, which elements are favorably influenced by upper extremity explosiveness.

Considering the fact that adipose voluminosity is a limiting factor on performing any gymnastics elements, as demonstrated in a number of studies (Dzhafarov and Vasil'chuk, 1987; Claessens and Lefevre, 1998)[22,23], its unfavorable impact on the performance of these two criterion variables (squat vault and backward pullover mount) is logical and acceptable.

Conclusion

Factor analysis of the morphological system showed mesomorphy and endomorphy, i.e. a mesoendomorphic morphological structure, to predominate in elementary school female sixth-graders. This morphological structure explained more than 40% of the common variability and was the major feature of the study sample.

The second most relevant morphological feature was pronounced longitudinal skeleton dimensionality, followed by transverse dimensionality of trunk skeleton, recorded in 23% of the study subjects.

Transversality of upper extremity skeleton, wrist diameter in particular, was pronounced in a small but significant proportion of the study subjects (more than 9%), which significantly determined performance of particular gymnastics elements.

Factor analysis of the motor system yielded a motor structure that predominantly determined motor efficiency of the study subjects, thus also their performance of the elements of competitive gymnastics. This motor structure integrated whole body coordination, lower extremity explosiveness, basic relative strength of upper extremities, movement frequency of upper extremities and whole body flexibility, and as such it manifested high motor efficiency. This general motor factor was the basis of motor efficiency in more than 28% of the study subjects.

Other motor factors isolated explained a considerably smaller yet significant proportion of the sample variability. So, second varimax factor responsible for the development of movement frequency, of lower extremities in particular, was pronounced in nearly 12% of the sample subjects; third varimax factor responsible for the development of upper extremity explosiveness was pronounced in greater than 10% of the sample subjects; and fourth varimax factor responsible for the development of upper and lower extremity flexibility was pronounced in more than 9% of the study sample.

The isolated and characterized motor system (first varimax factor) predominantly determined the quality of gymnastics element performance, cartwheel, handstand and backward pullover mount in particular, and to a lesser extent front scale and double leg pirouette for 180° (Table 3). This demonstrated the striking complexity of motor skills in competitive gymnastics, where success depends on almost all relevant basic motor abilities: coordination, explosive strength, basic strength (of arms in particular), speed (of arms) and body flexibility, and their inter-relations. Relative to the characterized motor system, appropriate morphological system was defined, i.e. average and above-average longitudinal skeleton dimensionality including shoulder width, and transverse dimensionality of the upper extremity skeleton, along with below-average adipose body voluminosity (mesoendomorphy). Description of this morphological system reveals athletic somatotype that can be formed by gymnastics treatment and which would significantly determine performance in competitive gymnastics. Here we observe the relationship among morphological measures, i.e. morphological characteristics (proportions) rather than their absolute values, and which relationship is optimal for performance of all elements of competitive gymnastics in elementary school female sixth-graders. Adipose tissue reduction by competitive gym treatment would probably result in changes in the relations between morphological structures and competitive gymnastics performance. Therefore, integration of the optimal motor system into the optimal morphological system will only ensue in the next steps of selection in female competitive gymnastics.

Associations of the second pair of canonical factors indicated that subjects with greater upper extremity skeleton transversality and lower skeleton longitudinality, along with upper and lower extremity flexibility, upper extremity explosivity and movement frequency, of lower extremities in particular, would be superior on performing cartwheel and squat vault, as opposed to backward pullover mount, where subjects with the above-average skeleton longitudinality and below-average skeleton transversality would be more successful.

Associations recorded in the third pair of canonical factors showed the students with pronounced mesoendomorphy and above-average flexibility of upper and lower extremities to be superior on performing front scale and double leg pirouette for 180° but considerably inferior on performing squat vault and backward pullover mount. Thus, the second pair additionally explained the role of transverse dimensionality of upper extremity dimensionality, flexibility and explosiveness of upper extremities in performing cartwheel and squat vault, and the third pair explained the unfavorable impact of adipose voluminosity on the performance of squat vault and backward pullover mount, along with the favorable effect of mesoendomorphy on the performance of front scale and double leg pirouette for 180°.

The relations of motor abilities and morphological characteristics with gymnastics elements performance in elementary school female sixth-graders were similar to those found in elite female gymnasts[12,13,19,22,23].

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UTJECAJ BIOMOTORIČKIH STRUKTURA NA IZVEDBU ELEMENATA SPORTSKE GIMNASTIKE UČENICA ŠESTOG RAZREDA OSNOVNE ŠKOLE

SAŽETAK

U cilju identifikacije biomotoričkih sklopova koji determinaciju izvedbu gimnastičkih elemenata kod učenica 6. razreda osnovne škole, najprije su utvrđene faktorske strukture kako morfoloških karakteristika, tako i bazičnih motoričkih sposobnosti učenica kronološke dobi 12 godina ± 3 mjeseci (n=126), a zatim su utvrđene relacije dobivenih faktora morfološko-motoričkog prostora sa skupom kriterijskih varijabli, koje procjenjuju specifična motorička znanja iz sportske gimnastike. Faktorskom analizom 17 morfoloških mjera dobivena su tri morfološka faktora: faktor mezoendomorfije i/ili adipozne voluminoznosti tijela, faktor longitudinalne dimenzionalnosti tijela i faktor transverzalne dimenzionalnosti ruku, dok su faktorskom analizom 16 motoričkih varijabli dobivena četiri motorička faktora: generalni faktor motorike (motorički sklop), generalni faktor brzine, faktor eksplozivne snage tipa bacanja (eksplozivnost ruku) i faktor fleksibilnosti ruku i nogu. Tri značajne kanoničke korelacije, tj. linearne kombinacije, objasnile su povezanost između skupa od sedam latentnih varijabli morfološkog i bazično motoričkog prostora i pet varijabli za procjenu znanja iz sportske gimnastike. U osnovi prve kanoničke linearne kombinacije je pozitivan i dominantan utjecaj generalnog motoričkog faktora (sklop koji integrira koordinaciju cijelog tijela, eksplozivnost nogu, relativnu snagu ruku, frekvenciju pokreta ruku i fleksibilnost tijela) na kvalitetu izvedbe gimnastičkih elemenata i to posebno premeta strance, stoja na rukama i uzmaha jednonožnog, te u nešto manjoj mijeri vage s okretom sunožnim za 180^o. U relaciji drugog para kanoničkih faktora se dodatno objašnjava važnost transverzalne dimenzionalnosti skeleta ruku, fleksibilnosti i eksplozivnosti ruku na realizaciju premeta strance i zgrčke, a u relaciji trećeg para kanoničkih faktora negativni utjecaj adipozne voluminoznosti na izvedbu zgrčke i uzmaha jednonožnog.