RELATIONS OF NON-SPECIFIC MOTOR ABILITIES AND PERFORMANCES OF FLOOR EXERCISE IN ARTISTIC GYMNASTICS

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Abstract
In a relatively short athletic career of women gymnasts, multilateral development of motor abilities, with the aim of quality performance of complex skills, is crucial to win a competition. Out of the four apparatuses of women's gymnastics All Around Event, the floor exercise is, in energy terms, the most demanding. Comparatively, this study raises the question which motor abilities are required for more efficient performance of the floor exercise. The research was carried out on 26 female competitors of the Croatian "C" national program from the South region, aged 6-8 years, cadet competition category. Some of their non specific motor abilities have been analyzed by standing long jump, 20 m dash, straight arm hang, sit-ups, arm plate tapping, obstacle course backwards and sit and reach test. By regression analysis, significant impact of the standing long jump (B=-0.63; p=0.01), obstacle course backwards (B=-0.57; p=0.02) and sit and reach test (B=0.42; p=0.02) on the floor exercise performance was determined. Significant differences were determined by ANOVA in the sit-ups (F=0.0.38; p=0.02), arm plate tapping (F=0.86; p=0.02) and obstacle course backwards test (F=-0.73; p=0.01) between more efficient and less efficient competitors. In accordance with the demands put upon the competitors by the analyzed exercise, but also by the Code of Point, the obtained results are considered logical.

Key words: competitive program, ANOVA, Croatian Code of Points, performance analysis

Introduction

Artistic gymnastics is a sport in which the progress, from initial participation to higher gymnastics levels, is extremely complex (Pion, Lenoir, Vandorpe & Segers, 2015). Artistic gymnastics is a sport in which athletic maturity and peek occur much sooner than in other sports and, as a consequence, there is a demand for achieving the art of movement, development of complex motor skills and a high level of flexibility at a very early age (Pion, Lenoir, Vandorpe & Segers, 2015). Given that a certain period of time is necessary to achieve this, early selection, specialization and training processes are essential and are therefore carried out earlier than in other sports (Kvasina & Delaš Kalinski, 2013). The process of learning gymnastics skills, with all respect paid to the didactic principles usually begins around the age of 5 (Arkaiev & Suchilin, 2009). The learning of the most complex gymnastics forms and variations should be completed or mostly completed by the time of reaching puberty - at the latest by the age of 14 (Erceg, Delaš Kalinski & Milić, 2014). The model of long-term sports periodization suggested by Bompa (2000) involves two basic periods of athletic development: the period of multilateral development and the period of specialization of athletes. Within the multilateral training character, from age 6 to 10, athletes need to get used to a regular, systematic and hard training, and to start engaging in professional sports. It is a period of ensuring quality development of non-specific and specific motor abilities, as well as basic technical-tactical skills. Only on the "good foundations", sports specialization should begin (age 10 to 14 years). It should include full development of the non-specific and specific abilities and characteristics, as well as stabilization and automatization of skills (Schmidt & Wrisberg, 2005) that are necessary for the efficient performance of technical-tactical elements. Only processes set in such a manner can produce elite athletic performances on a larger number of competitions which are more demanding and begin after the age of 15. Accordingly, together with the results of previous researches on the factors of success in each sport, training processes for the young athletes should be planned and programmed. Prescot (1999) conducted a study to determine tests that are suitable for conducting the selection processes in Women Artistic Gymnastics (WAG). She analysed a large number of previous studies conducted in artistic gymnastics and concluded that, together with certain anthropometric characteristics of children (gymnasts), it is important to conduct the tests that assess gymnasts' strength, flexibility, perceptual-motor characteristics and psychological characteristics. Based on the previously described findings, it can be assumed that children in the youngest competition categories, who achieve better results in motor tests that assess the aforementioned anthropological dimensions, will also achieve better results in artistic gymnastics (Morucci et al. 2014). Subsequently, tests for assessing non-specific

motor abilities of young selected women gymnasts will be the objective of this research. In accordance, the aim of this research is to determine the impact of non-specific motor abilities on efficiency of floor exercise performance in artistic gymnastics, i.e. to determine the differences between more efficient and less efficient women gymnasts in tests assessing non-specific motor abilities.

Methods

The subject sample includes 26 selected Croatian women gymnasts, competitors in the "C" national program of the South region , aged 6-8 years, cadet competition category. During the observed period, the participants were clinically healthy. They practiced for 2.5 hours × 4 times per week, i.e. 10 hours per week in total. All the participants were informed about experimental procedures and their consequences and they gave a free signed consent for participation in this study which was formerly announced. The protocol was approved by the Ethical board for research of the institution which hosted the study (Faculty of Kinesiology, University of Split, Croatia). The participants executed the floor exercise prescribed for that age and category by the Croatian Gymnastics Federation (CGF, 2015). The execution of the floor exercise was chosen because it proved to be the most energy demanding of all the apparatuses in artistic gymnastics (Rodriguez et al., 1999; in Jemni et al., 2011). Each routine was recorded and subsequently scored by 3 licensed judges according to the Code of Points of the „C" programme (CGF, 2015). According to their scores, the participants were divided into two groups: more efficient and less efficient. In the more efficient group, gymnasts were classified according to their possibility to qualify for the Cup Finals (minimum score had to be 14.00P). According to this criterion, 15 gymnasts were categorised in the more efficient group and 12 in the group of less efficient. Also, measurements were conducted to assess motor abilities. Variables that were used to determine non-specific motor abilities were selected out of the battery of tests designed by Grdelj, Metikoš, Hošek & Momirović (1975) and Metikoš, Prot, Hofman, Pintar & Oreb (1989), and the following motor areas were assessed: coordination, flexibility, movement frequency and power. The obstacle course backwards test was used to assess coordination. The sit and reach test was used to assess flexibility. The arm plate tapping test was used to assess movement frequency. The following tests were used to assess power: standing long jump, 20 m dash, bent arm hang and sit-ups. All measurements were taken by the same 3 measurers during morning hours (from 9 am to 12 am) at the gym of Public institution Sports objects Split. The order of measurements relied on test loads (on nerve-muscle innervations and on the energy system of the body), with breaks for the rest. Accordingly, the measurements were carried out as follows: 1) sit and reach test; 2) standing long jump; 3) arm plate tapping; 4) obstacle course backwards; 5) sit-ups; 6) bent arm hang. All the tests were performed by following the standardized procedures applied in the Republic of Croatia (Findak, Metikoš, Mraković & Neljak, 1996; Neljak, 2013.). Methods of data analysis included calculation of descriptive statistical parameters: mean (M), minimum and maximum result (Min and Max), standard deviation (SD), values of Skewness (Skew) and Kurtosis (Kurt) of result distribution and calculation of MaxD value for determining normal distribution of variables by KS-test (KS). Cronbach's alpha coefficient (Cα) was used to determine reliability and objectivity of the judges. Regression analysis was applied to determine the impact of non-specific motor abilities on success in performance of the floor exercise. The difference between the more efficient and less efficient women gymnasts in the variables applied was determined by univariate analysis of variance (ANOVA). Data analysis was performed by software package STATISTICA ver. 12 (StatSoft, Tulsa, USA).

Results and discussion

The results of descriptive parameters of the applied variables are presented in Table 1.

Table 1. Descriptive indicators of test results of non-specific motor abilities of the selected women gymnasts

Variables	M	Min	Max	SD	Skew	Kurt	KS
Standing long jump (cm)	158.94	105.00	200.00	20.17	-0.06	1.37	0.09
20 m dash (sec)	4.38	3.76	5.25	0.41	0.69	-0.19	0.14
Straight arm hang (sec)	40.63	7.60	88.29	20.71	0.79	0.05	0.16
Sit-ups (frequency in 30	41.07	26.00	56.00	7.17	-0.18	-0.17	0.09
Arm plate tapping (frequenc	24.88	18.00	31.00	3.49	-0.32	-0.84	0.16
Obstacle course backward	11.45	6.89	21.12	2.65	1.91	6.46	0.15
Sit and reach (cm)	65.73	54.00	77.00	7.15	-0.08	-1.08	0.09
				Cα=0.98	KS test = 0.26		

Legend: M - mean, Min – minimum result, Max – maximum result, SD - standard deviation, Skew – coefficient of distribution asymmetry, Kurt – coefficient of distribution peakeness. , KS - Kolmogorov-Smirnov test, d<.26 (for N=26).

Basic descriptive parameters of motor abilities tests of the selected women gymnasts are presented in Table 1. The Cronbach's alpha coefficient indicates high reliability and objectivity among the judges' scores for the execution of the floor exercise (Cα = 0.98). High values for the Cronbach's alpha coefficient (Cα = 0.98), higher than the value of the same coefficient determined in similar studies (Miletić, 2003; Delaš, 2005; Delaš Kalinski, 2009) lead to a conclusion that the evaluators (judges)

were competent and familiar with the criteria set for the evaluation of the floor exercise. Judges' high objectivity at major competitions in the WAG has been found in previous studies (Bučar Pajek et al., 2011; Bučar, Čuk, Pajek, Karácsony & Leskošek, 2012; Bučar Pajek et al., 2013; Atiković et al., 2014). However, it is important to emphasize how, on the analysed competitions from the aforementioned studies, in comparison with the other apparatuses in WAG, the objectivity of the floor trials had slightly lower values. Accordingly, in comparison with the result of this research, we can conclude that the higher objectivity in judges' occurs when they judge structurally simple floor exercises, rather than when they judge structurally more complex floor exercises. The coefficient of result dispersion of the measured sample was higher in the *standing long jump* and *straight arm hang* test than in other tests. The reason for this probably arises from the wide range between minimum and maximum value. These data indicate that there are extremely good and extremely poor test results in the sample. The *obstacle course backwards* test showed to be the most difficult test for the measured sample, which is indicated by its coefficients of Skewness and Kurtosis. The mentioned results can be attributed to: a) not being familiar with the motor task; b) morphological characteristics of the girls at this age; c) most likely to the inappropriate height of obstacles in the *obstacle course backwards* for this age group. According to the KS test (d<0.26), the results found in all the variables showed no significant deviations from normal distribution. Therefore, parametric methods were applied in further analyses. The results of regression analysis of impact of non-specific motor abilities on efficiency in floor exercise performance are presented in Table 2.

Table 2. Results of regression analysis (R =0.89; R^2 =0.79*; F* (7.18) = 10.26*; p* = 0.0004)

VARIABLES	B	p
Standing long jump (cm)	-0.63	0.01
20 m dash (sec)	0.06	0.73
Straight arm hang (sec)	0.11	0.44
Sit-ups (frequency in 30 sec)	0.26	0.16
Arm plate tapping (frequency in 30 sec)	0.38	0.01
Obstacle course backwards (sec)	-0.57	0.01
Sit and reach (cm)	0.42	0.02

Legend: B- relative coefficient of impact, p- level of statistical significance

Based on the regression analysis results, it can be concluded that the predictor variable set has a significant impact on performance of the floor exercise (R=0.89; p=0.0004). For the *standing long jump*, *arm plate tapping*, *obstacle course backwards* and *sit and reach* test it was determined that they have a significant impact on performance of the floor exercise in women gymnasts of the youngest categories (Table 2). Significant impact of the *standing long jump*, *obstacle course backwards* and *sit and reach* test, which are assumed to assess explosive power, coordination and flexibility, can be interpreted by relying on general characteristics of the floor exercise. Namely, the floor exercise itself (of the observed sample of gymnasts), requires maximum correct (technical/biomechanical) basic acrobatic and dance elements performances. Only such performances present the core foundation for further upgrading of acrobatic and dance elements in older age and heavier competition programmes, both on the floor and the balance beam. Since these are skills that include different: a) starting positions; b) rotations around different body axes; c) speed; d) push off from an apparatus; multilateral development of explosive power, coordination and flexibility make a logical result. Significant impact of the *arm plate tapping* test, which hypothetically represents movement frequency, emphasizes the importance of movement frequency, within which there is a rhythmical movement, in the floor exercise performance. The importance of developing rhythm through dance structures becomes even more important if we consider two facts: 1) that gymnastics belongs to the group of aesthetic sports; 2) according to the Code of Points (Federation de Internationale de Gymnastique (FIG), 2013), there is a deduction for artistry. Artistic performance in artistic gymnastics is defined as one in which the gymnast shows her ability to transform her floor exercise, from a well-structured acrobatic and dance composition, into an artistic performance. The design, structure and composition of an exercise include: a rich and varied selection of elements from different structure groups, changes of direction, changes of rhythm and tempo and creative movements and elements which follow the chosen music (FIG, 2013). The aforementioned leads to the conclusion that children in artistic gymnastics, from the youngest age, as well as from the initial competition programmes, need to learn not only acrobatic elements but different dance structures as well. Apart from the difference between the youngest competitors, at the levels of non-specific motor abilities, Čuljak et al. (2011) have determined that there is a difference in these abilities (explosive strength, frequency of motion and flexibility), between the competitor beginners and the untrained children. Accordingly, the introduction statements can be confirmed: from the youngest age it is important to develop basic motor skills of each sport, as well as, through the multilateral impact, to develop the whole spectrum of motor abilities in young athletes. In particular, it relates to the development of the non-specific, as well as the specific motor abilities that stand out as predictors of successful performance in WAG

(Prescott, 1999; Delaš, 2005; Delaš Kalinski, 2009). Results of univariate analysis of variance of the applied variables between the two subgroups which were predetermined based on the criterion of efficiency.

Table 3: Analysis of variance of women gymnasts according to the criterion of efficiency

VARIABLES	F	p
Standing long jump (cm)	0.35	0.56
20 m dash (sec)	0.03	0.32
Straight arm hang (sec)	0.32	0.14
Sit-ups (frequency in 30 sec)	0.38	0.02
Arm plate tapping (frequency in 30 sec)	0.86	0.02
Obstacle course backwards (sec)	-0.73	0.01
Sit and reach (cm)	0.13	0.29

Legend: F – test value, ratio of variance between and within the groups; p – level of statistical significance.

The results of analysis of variance show a statistically significant difference between more efficient and less efficient gymnasts in 3 out of the total 7 tests: *sit-ups*, *arm plate tapping* and *obstacle course backwards*. The significant difference of women gymnasts in the *sit-ups* test (hypothetically estimate trunk repetitive strength) can be explained through prescribed, technically very demanding, key moments of almost all acrobatic elements that are performed in the floor exercise, in this competitive category. The key moments are: specific starting position, handstand and finishing positions.

Through all of them gymnasts should hold hollow position of the body: arms parallel and up by the ears, chin tucked down towards chest and rounded inward, chest and abdominal muscles slightly flexed, hips tucked downwards. Because the performance of this position primarily requires the strength of the trunk, determined result is logical.

Significant difference between more efficient and less efficient gymnasts in the floor exercise performance in the *arm plate tapping* test emphasize the importance of the rhythm and frequency of movement development, from the youngest competition categories, and the size of their transfer on the performance of dance structures within the floor exercise.

The importance of the aforementioned is emphasized by the existence of the musicality deduction (in the Code of Points, HGS; 2013) in the group of deductions for artistry.

Since artistry does not represent only a gymnast's ability to interpret music, demonstrate rhythm and speed, but also to demonstrate the flow of music and musical theme with movement (FIG, 2013), it is logical to point out this test, i.e. motor ability as significant for efficient performance of the floor exercise. The *obstacle course backwards* test, as a representative of motor ability of coordination, was also determined as significant in differentiating more efficient and less efficient gymnasts. Since coordination is defined as the ability to carry out complex motor structures synchronised in time and space and speed of learning those structures, the obtained results are not surprising given the complexity of the floor exercise even at the youngest age categories. The obtained results can be related to similar investigations (Prescott, 1999; Delaš, 2005; Delaš Kalinski, 2009), which proved that precisely coordination is one of important predictors of success in artistic gymnastics.

Conclusion

The results of this study showed significant impact of non-specific motor abilities on floor exercise performance in selected Croatian women gymnasts of "C" program, cadet competition category.

By regression analysis, significant impact of the test that hypothetically represents power (*standing long jump)*, coordination *(obstacle course backwards)* and flexibility (*sit and reach)* was determined.

Significant differences were found in the *sit-ups*, *arm plate tapping* and *obstacle course backwards* test between more efficient and less efficient selected gymnasts of "C" program.

Following the aforementioned results, it can be concluded that the successful performance of the floor exercise, from the youngest age categories, relies on motor abilities which have been as significant at senior gymnasts (Prescott, 1999).

Subsequently, it is necessary to develop them. Repetitive core strength and coordination, also known as "motor intelligence", have been determined as necessary (for success) in other complex sports such as karate (Vando et al., 2013; Vando et al., 2014; Alesi et al., 2014; Padulo et al, 2014(a); Padulo et al., 2014(b); Ouergui et al., 2014).

Only on the well-developed non-specific motor abilities it is possible to develop specific motor abilities and learning processes of the structurally more complex motor skills.

Authors believe that the results of this study should serve to the professional teams in: a) designing selection tests for the youngest age categories, which are still lacking at a national level; b) processes of the talent identification in competitive artistic gymnastics; c) in planning and

programming of the training process of the young competitors.

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ODNOSI NESPECIFIČNIH MOTORIČKIH SPOSOBNOSTI I IZVEDBE VJEŽBI NA PODU KOD UMJETNIČKE GIMNASTIKE

Sažetak

U relativno kratkoj atletičkoj karijeri gimnastičarki, višestran razvoj motoričkih sposobnosti, s ciljem kvalitetne izvedbe složenih vještina, presudan je za pobjedu u natjecanju. Od četiri pomagala ženske gimnastike All Around Eventa, vježba na podu je, po pitanju energije, najzahtjevnija. Usporedno s tim, ovo istraživanje postavlja pitanje koje motoričke sposobnosti su potrebne za učinkovitiju izvedbu vježbi na podu. Istraživanje je provedeno na 26 natjecateljica hrvatskog ''C'' nacionalnog programa iz južne regije, dobi 6-8 godina, u natjecateljskoj kategoriji kateda. Neke od njihovih nespecifičnih motoričkih sposobnosti su analizirane skokom u dalj iz mjesta, trčanjem na 20 metara, visom u zgibu, tapping testom, utrkom s preprekama unatrag i podizanjem trupa. Regresijskom analizom je utvrđen značajan utjecaj na skok u dalj iz mjesta (B= -0,63; p=0,01), utrku s preprekama unatrak (B= -0,57; p=0,02) i dohvat u sjedu (B=0,42; p=0,02) na izvjedbu vježbi na podu. Značajne razlike su utvrđene ANOVA testom kod trbušnjaka (F=0,0,38; p=0,02), tapping testa (F=0,86; p=0,02) i testom utrke s preprekama unatrag (F= -0,73; p=0,01) između više i manje učinkovitih natjecatelja. U skladu sa zahtjevima koji su predstavljeni natjecateljima od analizirane vježbe, ali također od Kodeksa točaka, dobiveni rezultati se smatraju logičnima.

Ključne riječi: *natjecateljski program, ANOVA, Hrvatski kodeks točaka, analiza izvedbe*

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