**INFLUENCE OF SOME MOTOR ABILITIES ON THE BASIC GYMNASTICS SKILLS PERFORMANCE THROUGH THE LEARNING PROCESS**

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**Abstract**

In order to determine the influence of some motor abilities on the performance of basic acrobatic elements of artistic gymnastics, in various stages of their acquisition, this study evaluated a sample of 44 first graders. ANOVA, with Fisher post hoc test, revealed significant differences in measured variables, at various stages of the learning process. Multiple regression analysis was used to assess the influence of some motor abilities on the gymnastics skills in all phases of the learning process. Results confirmed a statistically significant effect of predictor variables on all analyzed skills in the initial point of the learning process, on four skills in the transitive point of the learning process and statistically significant influence on two skills in the final point of the learning process. The percentage of explained criteria variability ranged from 43% to 64%. It can be concluded that the application of the proper kinesiological treatment, which results with higher level of learned skills, reduces statistical reliability of the influence of motor abilities on the performance of some skills.

**Key words:** motor skills, artistic gymnastics, first graders, ANOVA, acrobatics

**Introduction**

According to the basic definition artistic gymnastics is a sport of aesthetically designed, acyclic movement structures, which are evaluated according to the previously prescribed convention of momentum, defined by the Code of Points. In order to learn hundreds, and possibly thousands of elements and their combinations (at six apparatus in men's gymnastics and on the four apparatus in women's gymnastics) it is indispensable to implement a process of motor learning. Numerous theories and studies about the motor learning process have been generated since the end of the 18th century. As a synthesis of many theories and analyzed aspects of the motor learning process Schmidt and Lee (2005) have defined it as a set of internal processes associated with practice and experience that lead to relatively permanent changes in an individual's ability in performing the motor task. According to the same authors, the ultimate goal of every motor learning process, particularly in sport, is to achieve the highest level of the skill- *automatization level*. With the aim of reaching *automatization* level of the skill, except proper application of "learning process" and accepting several factors (such as cognitive and conative characteristics, motivation, prior knowledge and difficulty of the task that is taught), the authors point out that achieving a certain level of knowledge demands a certain (as higher) level of motor abilities which stands out in the equation of sports specification. According to researches, it was found that best ranked gymnasts, for who is presumed that have the highest quality and highest level of gymnastic skills, have very high levels of almost all motor abilities (Faria and Faria, 1989). The importance of the high level of motor abilities is even more emphasized if perceived through the theories and reviews of the previous studies. According to these, *those who learn* and have a higher level of motor abilities are more capable to quickly reach the highest (*automatization*) level of the skill (Neljak, 2009).

Considering the presented facts it is obvious that the effect of motor abilities on the performance of motor skills in different stages of the learning process is not specified and explained. Such information would be very valuable for the process of motor learning.

The aim of this study was to determine the influence of motor abilities on the basic gymnastics skills performance at different stages of the learning process.

**Methods**

The sample consisted of 44 first graders (schoolgirls) from Bijaći elementary school in Kaštel Novi, chronological age 7 years (± 0.5 years). They attended an experimental kinesiological treatment 3 times a week for 45 minutes during 6 months. The program included a number of skills from the current curriculum and some gymnastics skills. Gymnastics skills were selected due to the material conditions of the school and according to schoolgirl’s abilities and prior knowledge.

The sample of variables consisted of the variables that estimate motor abilities and from the variables of gymnastics skills. Motor abilities have been estimated with 10 motor variables: 6 that are usually applied in the school system and additional 4 which also estimate motor abilities and have a significant impact on the performance of gymnastic skills (Delaš, 2005). In accordance with the foregoing, selected motor abilities variables are: *hand tapping* (MTR) and *foot tapping on the wall* (MTAZ) for frequency of movement assessment; *sit-ups* (MPT) for repetitive power assessment; *standing long jump* (MSD) and *20 meters running from standing start* (M20M) for explosive power assessment; *pull-up hang hold* (MIV) for static power assessment; *straddle forward bent* (MPR) and *bent forward on a bench* (MPRK) for flexibility assessment and *polygon backwards* (MPN) and *step aside* (MKUS) for coordination assessment. Gymnastics skills have been represented with five basic acrobatic elements: *candle stick* (CS), "*bridge"* (BR), *forward roll* (FR), *backward roll* (BR) *and cartwheel* (CW).The levels of performance of these skills have been evaluated by five judges through the video, according to the prescribed criterias (Delaš Kalinski, 2009.)

Descriptive statistic parameters (mean (AM) and standard deviation (SD)), the average correlation between test items (IIR) and the Cronbach alpha coefficient (Cα) have been calculated for all variables. Burt method of simple summation was used to calculate the total score for each skill in each measurement point. The analysis of variance (ANOVA) with Fisher post-hoc test has been used to determine the differences in measured variables at various points of the learning process. Regression analyses have been used to determine the influence of motor abilities on gymnastics skills in the initial, transitive and final point of the learning process.

**Results**

Table 1: Descriptive statistic parameters (AM ± SD) of gymnastics skills and motor abilities and their metric characteristics (IIR, Cα) determined in different stages of the learning process

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **INITIAL POINT** | | | **TRANSITIVE POINT** | | | **FINAL POINT** | | |
|  | **AM±SD** | **IIR** | **Cα** | **AM±SD** | **IIR** | **Cα** | **AM±SD** | **IIR** | **Cα** |
| **CS** | 2,93 ± 1,02\*\*\* | 0,85 | 0,96 | 3,63 ± 0,94 | 0,85 | 0,96 | 3,97 ± 0,73**³** | 0,76 | 0,93 |
| **BR** | 2,82 ± 1,24\*\*\* | 0,92 | 0,98 | 3,60 ± 1,11**††** | 0,89 | 0,97 | 4,19 ± 0,73**³** | 0,68 | 0,89 |
| **FR** | 2,73 ± 0,84\*\*\* | 0,83 | 0,96 | 3,37 ± 0,70**†††** | 0,76 | 0,93 | 4,03 ± 0,69**³** | 0,72 | 0,92 |
| **BR** | 2,48 ± 0,91\*\* | 0,81 | 0,95 | 3,01 ± 0,83**†††** | 0,86 | 0,96 | 3,85 ± 0,74**³** | 0,79 | 0,94 |
| **CW** | 2,31 ± 1,15\* | 0,93 | 0,98 | 2,82 ± 1,15**†** | 0,90 | 0,98 | 3,36 ± 1,02**³** | 0,91 | 0,98 |
| **MTR** | 15,20 ± 2,10\*\*\* |  |  | 20,47 ± 3,05**††** |  |  | 21,94 ± 2,65**³** |  |  |
| **MTAZ** | 12,39 ± 1,83\* |  |  | 13,27 ± 1,74**††** |  |  | 14,39 ± 2,01**³** |  |  |
| **MPT** | 19,77 ± 7,97\*\*\* |  |  | 25,95 ± 8,81 |  |  | 27,09 ± 9,01**³** |  |  |
| **MSD** | 104,73 ± 16,63 | 0,82 | 0,93 | 107,67 ± 15,36 | 0,81 | 0,92 | 107,88 ± 13,64 | 0,70 | 0,87 |
| **M20M** | 5,53 ± 0,39\*\*\* | 0,74 | 0,88 | 5,20 ± 0,29**†††** | 0,81 | 0,93 | 4,52 ± 0,33**³** | 0,81 | 0,93 |
| **MIV** | 13,92 ± 11,10 |  |  | 15,47 ± 11,21 |  |  | 12,46 ± 7,81 |  |  |
| **MPR** | 53,06 ± 7,78 | 0,90 | 0,96 | 53,27 ± 6,97**††** | 0,88 | 0,95 | 58,41 ± 10,40**²** | 0,97 | 0,99 |
| **MPRK** | 0,16 ± 5,18\*\*\* | 0,93 | 0,97 | 4,63 ± 4,76 | 0,92 | 0,97 | 5,35 ± 5,25**³** | 0,94 | 0,98 |
| **MPN** | 23,30 ± 4,57\*\*\* | 0,79 | 0,91 | 18,96 ± 3,83 | 0,87 | 0,94 | 19,35 ±3,64**³** | 0,86 | 0,94 |
| **MKUS** | 15,34 ± 2,03\*\*\* | 0,90 | 0,96 | 14,17 ± 1,20 | 0,77 | 0,90 | 13,81 ±1,01**³** | 0,63 | 0,83 |

Legend: One Way ANOVA with Fischer LMSD post-hoc test: \*p<0,05; \*\*p<0,01; \*\*\*p<0,001 – significant difference between initial and transitive measurement point; **†**p<0,05; **††**p<0,01; **†††**p<0,001 – significant difference between transitive and final measurement point; **¹**p<0,05; **²**p<0,01; **³**p<0,001 – significant difference between initial and final measurement point;

Variables legend: MTR*- hand tapping*, MTAZ - *foot tapping on the wall*, MPT *- sit-ups*, MSD *- standing long jump*, M20M - *20 meters running from standing start*, MIV *- pull-up hang hold*, MPR *- straddle forward bent*, MPRK*- bent forward on a bench,* MPN -*polygon backwards*, MKUS *- step aside*, CS- *candle stick*, BR - "*bridge"*,FR - *forward roll*,BR - *backward roll,* CW *– cartwheel.*

According to the results of ANOVA post-hoc Fisher test numerical increase in the average values of all skills (AS) can be determined between initial and transitive, and transitive and final point of the learning process. Differences between the average values of all skills between the initial and transitive measurement point have been determined. For four skills (BR, FR, BR and CW) statistical difference in average value was determined between transitive and final point of the learning process. Statistically significant differentiation between their initial and final point of the learning process, have been determined for all skills.

For all skills, from the initial to the final point, Cronbach Alpha coefficient ranged from 0.87 to 0.98 and IIR ranged from 0.68 to 0.93. In the area of motor abilities, increase of numerical value have been determined from initial to transitive and to final point of measurement for all variables except for the MIV (which hypothetically estimated static strength of arms and shoulders). According to ANOVA results, increase of average results, through the learning process, have been determined as significant.

Table 2: Results of regression analysis between the set of predictor variables and criterion variables in initial, transitive and final point of learning process

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **INITIAL POINT** | | | | | **TRANSITIVE POINT** | | | | | **FINAL POINT** | | | | |
|  | **CS** | **BR** | **FR** | **BR** | **CW** | **CS** | **BR** | **FR** | **BR** | **CW** | **CS** | **BR** | **FR** | **BR** | **CW** |
| **MTRR** | 0.17 | 0.01 | 0.07 | -0.11 | -0.01 | -0.06 | 0.11 | 0.06 | 0.04 | 0.04 | 0.36 | 0.33 | 0.20 | ***0.47\**** | -0.23 |
| **MTAZ** | -0.12 | -0.03 | -0.01 | 0.13 | 0.07 | -0.09 | -0.05 | -0.26 | -0.20 | -0.16 | -0.05 | 0.05 | -0.23 | -0.31 | 0.14 |
| **MPT** | ***0.34\**** | 0.06 | 0.28 | ***0.39\**** | 0.25 | 0.30 | 0.10 | 0.19 | 0.14 | 0.11 | 0.17 | -0.10 | 0.18 | 0.19 | 0.21 |
| **MSD** | 0.18 | -0.13 | 0.05 | 0.24 | 0.17 | 0.01 | -0.13 | 0.08 | 0.13 | 0.06 | 0.35 | 0.21 | 0.26 | ***0.43\**** | 0.09 |
| **M20M** | -0.32 | -0.10 | -0.27 | -0.27 | -0.26 | -0.28 | -0.01 | -0.29 | -0.13 | -0.30 | 0.20 | 0.21 | 0.36 | ***0.44\**** | -0.22 |
| **MIV** | 0.28 | 0.24 | 0.21 | 0.08 | 0.00 | 0.10 | 0.14 | 0.26 | 0.19 | 0.14 | 0.16 | 0.09 | 0.13 | 0.28 | 0.10 |
| **MPRK** | -0.14 | 0.16 | 0.25 | 0.20 | 0.32 | -0.06 | 0.26 | -0.09 | 0.04 | ***0.44\**** | -0.39 | 0.11 | -0.14 | -0.21 | 0.10 |
| **MPR** | 0.03 | 0.12 | -0.21 | -0.06 | 0.01 | -0.09 | -0.03 | 0.13 | 0.00 | -0.04 | 0.18 | 0.21 | 0.06 | 0.10 | 0.06 |
| **MPN** | -0.03 | -0.29 | -0.05 | -0.01 | 0.03 | ***-0.40\**** | -0.30 | -0.09 | ***-0.40\**** | -0.04 | -0.16 | -0.25 | -0.15 | -0.23 | -0.29 |
| **MKUS** | -0.08 | -0.33 | -0.01 | -0.13 | -0.05 | -0.02 | -0.36 | 0.08 | -0.02 | -0.18 | 0.22 | 0.31 | 0.10 | 0.25 | -0.10 |
| **R** | 0.73 | 0.71 | 0.67 | 0.76 | 0.67 | 0.72 | 0.67 | 0.58 | 0.71 | 0.80 | 0.55 | 0.56 | 0.40 | 0.66 | 0.72 |
| **R²** | 0.53 | 0.51 | 0.45 | 0.58 | 0.44 | 0.52 | 0.45 | 0.33 | 0.51 | 0.64 | 0.30 | 0.31 | 0.16 | 0.43 | 0.51 |
| **p** | **0.00** | **0.00** | **0.01** | **0.00** | **0.02** | **0.00** | **0.02** | 0.14 | **0.00** | **0.00** | 0.22 | 0.18 | 0.78 | **0.02** | **0.00** |

\*statistically significant coefficients p<0, 05

Variables legend: CS- *candle stick*, BR - "*bridge"*,FR - *forward roll*,BR - *backward roll,* CW –*cartwheel,* MTR*- hand tapping*, MTAZ - *foot tapping on the wall*, MPT *- sit-ups*, MSD *- standing long jump*, M20M - *20 meters running from standing start*, MIV *- pull-up hang hold*, MPR *- straddle forward bent*, MPRK*- bent forward on a bench,* MPN -*polygon backwards*, MKUS *- step aside*

The results of multiple regression analysis between the set of motor variables and criterion variables *candle stick* (CS), *bridge* (BR), *forward roll* (FR), *backward roll* (BR) and *cartwheel* (CW), in initial, transitive and final point of the learning process, are presented in Table 2. The results obtained revealed that the applied set of motor variables has an impact on all criterion variables in the initial point of the learning process. It was found that values of correlation between the predictor variables, described by multiple correlation coefficient, with all criteria variables range from 0.67 to 0.73, that is that a set of motor variables, as predictors, explain between 44% and 58% variance of criterion variables (R2). It can be determined that MPT has a statistically significant effect on the criterion variables *candle stick* (CS) and *backward roll* (BR).

In the transitive point of the learning process statistically significant influence of all predictor variables have been determined on the *candle stick* (CS), *bridge* (BR), *backward roll* (BR) and *cartwheel* (CW). The values of coefficients of multiple correlations between the set of predictor and criterion variables (R) ranged between 0.67 and 0.80, while the percentage of variance ranged from 45% to 64%. MPN had a significant influence on the criterion variables *candle stick* (CS) and *backward roll* (BR) while MPRK was a significant predictor for s *cartwheel* (CW). Statistically significant influence of applied set of motor variables has not been determined for the *forward roll* (FR).

In the final point of the learning process the applied set of motor variables had a statistically significant effect on the *backward roll* (BR) and *cartwheel* (CW). MTR, MSD and M20M had statistically significant influence on the variable *backward roll* (BR). The influence of the set of predictor variables on all other criterion variables (CS, BR and FR) was not determined.

**Discussion and conclusions**

Summarizing the results of the ANOVA, for variables that assess motor abilities and basic acrobatic elements from the field of artistic gymnastics, it is possible to conclude that statistically significant differences were found in the results of majority of analyzed variables from the initial to the final point of the learning process. Such results suggest that the applied treatment had a positive impact on the increase of the motor abilities level, but also on the increase of the level of performance of the basic acrobatic elements. Statistically significant influence of the MPT on the *candle stick* (CS) and *forward roll* (FR), in the initial point of the learning process, is considered logical and expected if the structure of the performance of these criterion variables is perceived. The strength of the abdominal muscles is important in retaining the position of *candle stick* but also in lifting and holding legs in a pike position during the rolling -the key stage in performing *backward roll*. Results from the transitive point of the learning process can be explained through the characteristics of artistic gymnastics as a sport. In artistic gymnastics the goal, and one of the criteria for evaluation of gymnast’s skills, is to perform many parts of one skill and/or many skills as one routine with a wide range of movement. In the final point of the learning process, the entire set of predictor variables was identified as important for the performance of *cartwheel* and confirmed the complexity of this skill. For the performance of *backward roll* the importance of dynamic performance (which can be observed through the synergy of the variables that hypothetically estimate the frequency of movement and explosive leg strength) was determined as statistically significant.

Summarizing all results of the regression analysis at various points of the learning process, it is possible to conclude that the influence of motor variables on skill performance was reduced through the process of motor learning. At the end of the learning process the impact of predictors remained statistically significant only for those skills that were determined as "difficult" to learn and probably more complex than others (Delaš, 2009). Skills that are determined as structurally easier to learn, and which have been learned at a higher level in the earlier stages of the learning process, have become independent from motor abilities as opposed to the more complex motor skills.

The obtained results confirm the results of previous studies (Faria and Faria, 1989) which determined that better performance of gymnastic skills requires higher level of motor abilities. At the same time results of the study’s lead to the conclusion that the application of adequate kinesiological treatment and high frequency of repetition of certain skill makes the impact of motor abilities on skills statistically insignificant.

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