IMPACT OF MOTOR ABILITIES ON PERFORMANCE OF GYMNASTIC ELEMENTS ON FLOOR IN GIRLS

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Original scientific paper

Abstract
The goal of this research was to determine motor abilities that have the biggest impact on girls' performance of gymnastic floor elements. Sample consisted of 103 girls from fifth and sixth grades. They were subjected to the experimental program which included learning of gymnastic elements in the regular physical education classes. Quality of performing "Straddle forward roll", "Handstand" and "Round off" was evaluated by the competent gymnastic judges and their mark represented a dependent variable. Battery of 12 motor ability tests was applied as a system of independent variables. The relation between a system of independent variables and a dependent variable was estimated by linear regression analysis. Results showed that applied motor variables as a system of independent variables have statistically significant impact ($p \leq 0.05$) on performance of all 3 gymnastic elements in girls. Observed individually, 5 motor ability variables had statistically significant impact on dependent variable, i.e. *variables "Seated straddle stretch" and "Leg lifting lying aside", which evaluates flexibility, variables "Sit-ups in 60 seconds" and "Handgrip strength" for general strength evaluation and variable "20 meters dash" for explosive strength evaluation. Based on the results, the authors concluded that physical preparation is necessary before learning mentioned gymnastic elements. Thus, improving general and explosive strength and flexibility should be primary.*

Key words: *gymnastics, physical education, school, floor exercises.*

Introduction

Physical activity in childhood is of a great importance, as well as acquired motor skills and abilities, because they offer an opportunity for children to develop a life style where physical activity is primary and also to develop adequate motor skills and abilities (Fisher et al., 2005; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006). High level of motor abilities is highly correlated with high level of physical activity (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009; Lopes, Rodrigues, Maia, & Malina, 2011). On the other hand, physical inactivity in childhood has negative influence on motor learning and it prevents further development of motor skills and abilities (Lubans, Morgan, Cliff, Barnett, &Okely, 2010). The mastery of certain fundamental motor skills is a prerequisite if we are to function on a daily basis and participate in later physical or sport-specific activities. The motor development is very important because of its influence on intellectual, social and emotional characteristics of the children, and through the development of motor abilities, children's cognitive, emotional, and social skills will be developed (Živčić, Trajkovski-Višić, & Sentdderdi, 2008). One of the main goals of gymnastics in elementary school curriculum, as well as physical activity in general, is to ensure proper biological growth and development of children and overall health (Madić, 2000; Madić, & Popović, 2005; Popović 2010). That is the reason why it is interesting to analyze how students, at mentioned age, adopt new and complex moving patterns. It is necessary to observe complete anthropological status of students to ensure learning quality of gymnastic exercises in PE classes. Information of motor abilities level could be an excellent starting point which determines the learning approach. The aim of this research was to define motor abilities that have the biggest influence on girls' performance of gymnastic elements on floor.

Methods

Sample consisted of 103 girls from fifth and sixth grades of primary school "Petefi Šandor" from Novi Sad, aged 11 and 12. They were subjected to the experimental treatment in period of 9 weeks which included learning of gymnastic elements in the regular physical education classes. Only healthy students who attended PE classes continuously were tested. Quality of performing 3 gymnastic elements on floor: 1) Straddle forward roll; 2) Handstand; and 3) Round off, was evaluated by the competent gymnastic judges, according to (Madić, 2000) on the scale 1 to 7 with following requirements:

Mark 1 – exercise was not performed, not even with assistance;
Mark 2 – exercise performed with significant assistance;
Mark 3 – exercise performed with minor assistance;
Mark 4 – exercise performed independently with poor technique and poor aesthetic;
Mark 5 – exercise performed independently with slight deviation in technique and good aesthetic;

Mark 6 – exercise performed with good technique and good aesthetic, but with small amplitude;
Mark 7 – exercise performed with excellent technique and good aesthetic with great amplitude.

Judges' marks represented a dependent variable and a battery of 12 motor ability tests was applied as a system of independent variables. Based on previous researches related to motor abilities and their impact on learning gymnastic elements (Madić, 2000; Popović, 2002) and with standardization of measuring instruments by Metikoš, Prot, Hofman, Pintar and Oreb (1989), authors chose following model of basic motor abilities tests:

Tests estimating coordination of the whole body:
- Obstacle course backwards;
- Passing through and jumping over;

Tests estimating speed of alternative moves:
- Arm plate tapping;
- Foot tapping;

Tests estimating flexibility:
- Seated straddle stretch;
- Leg lifting lying aside;
- Dislocation with a stick;

Tests estimating explosive strength:
- Standing long jump;
- 20 meters dash;

Tests estimating general strength:
- Bent arm hang;
- Sit-ups in 60 seconds;
- Handgrip strength.

Statistical analysiswas performed by "IBM SPSS Statistics 20" software package. Descriptive statistics was calculated for both dependent and independent variables and the relation between a system of independent variables and a dependent variable was estimated by linear regression analysis with statistical significance of $p \leq 0.05$.

Results

Descriptive statistics of a system of independent variables and "Straddle forward roll" as dependent variable are shown in Table 1, as well as the results of linear regression analysis.

Table 1. Descriptive statistics and results of regression analysis for "Straddle forward roll" as dependent variable

	VARIABLE	M	S	Min	Max	β	t	p
1.	Obstacle course backwards (0.1s)	173.19	39.52	96	288	-0.087	-0.771	0.442
2.	Passing through and jumping over (0.1s)	197.80	45.04	127	354	-0.180	-1.456	0.149
3.	Arm plate tapping (freq)	30.49	3.85	17	42	0.008	0.078	0.938
4.	Foot tapping (freq)	18.86	1.87	14	23	-0.086	-0.951	0.344
5.	**Seated straddle stretch (cm)**	63.08	11.19	36	91	0.225	2.151	**0.034**
6.	**Leg lifting lying aside (^{0})**	75.87	9.43	51	94	0.274	3.101	**0.003**
7.	Dislocation with a stick (cm)	71.85	15.58	25	123	0.022	0.256	0.799
8.	Standing long jump (cm)	165.60	20.51	113	208	-0.109	-0.921	0.360
9.	20 meters dash (0.1s)	44.81	3.12	38	52	-0.152	-1.752	0.083
10.	Bent arm hang (0.1s)	200.50	157.48	0	918	0.114	1.104	0.272
11.	**Sit-ups in 60 seconds (freq)**	38.52	6.78	8	53	0.283	3.084	**0.003**
12.	**Handgrip strength (kg)**	24.92	4.66	15	39	-0.212	-2.326	**0.022**
13.	*Straddle forward roll (mark)*	*4.34*	*1.35*	*1*	*7*			

R = 0.716 R^2 = 0.513 F = 7.904 p = 0.00

M – arithmetic mean, S – standard deviation, Min – minimum result, Max – maximum result, β – standardized coefficient, t – t test for β, R – coefficient of multiple correlation, R^2 – coefficient of determination, F – F test for R, p – statistical significance level.

Table 2. Descriptive statistics and results of regression analysis for "Handstand" as dependent variable

	VARIABLE	M	S	Min	Max	β	t	p
1.	Obstacle course backwards (0.1s)	173.19	39.52	96	288	-0.191	-1.429	0.157
2.	Passing through and jumping over (0.1s)	197.80	45.04	127	354	-0.236	-1.607	0.111
3.	Arm plate tapping (freq)	30.49	3.85	17	42	0.005	0.039	0.969
4.	Foot tapping (freq)	18.86	1.87	14	23	-0.112	-1.048	0.298
5.	Seated straddle stretch (cm)	63.08	11.19	36	91	-0.055	-0.442	0.659
6.	Leg lifting lying aside (^{0})	75.87	9.43	51	94	0.109	1.038	0.302
7.	Dislocation with a stick (cm)	71.85	15.58	25	123	-0.144	-1.406	0.163
8.	Standing long jump (cm)	165.60	20.51	113	208	-0.240	-1.708	0.091
9.	**20 meters dash (0.1s)**	44.81	3.12	38	52	-0.281	-2.731	**0.008**
10.	Bent arm hang (0.1s)	200.50	157.48	0	918	0.078	0.638	0.525
11.	Sit-ups in 60 seconds (freq)	38.52	6.78	8	53	0.061	0.557	0.579
12.	Handgrip strength (kg)	24.92	4.66	15	39	0.098	0.908	0.366
13.	*Handstand (mark)*	*3.53*	*1.24*	*1*	*6.25*			

R = 0.558 R^2 = 0.311 F = 3.384 p = 0.00

M – arithmetic mean, S – standard deviation, Min – minimum result, Max – maximum result, β – standardized coefficient, t – t test for β, R – coefficient of multiple correlation, R^2 – coefficient of determination, F – F test for R, p – statistical significance level.

Results in table 1 showed that applied motor variables as a system of independent variables had statistically significant impact ($p \leq 0.05$) on performance of "Straddle forward roll" in girls.

Observed individually, 4 motor ability variables had statistically significant impact ($p \leq 0.05$) on dependent variable, *i.e.* variables "Seated straddle stretch" and "Leg lifting lying aside", which evaluates flexibility and variables "Sit-ups in 60 seconds" and "Handgrip strength" for general strength evaluation. Table 2 shows descriptive statistics of a system of independent variables and "Handstand" as dependent variable, as well as the results of linear regression analysis. Results in table 2 showed that applied motor variables as a system of independent variables had statistically significant impact ($p \leq 0.05$) on performance of "Handstand" in girls. Observed individually, only one motor ability variable had statistically significant impact ($p \leq 0.05$) on dependent variable, *i.e.* variable "20 meters dash", which evaluates explosive strength. Descriptive statistics of a system of independent variables and "Round off" as dependent variable are shown in Table 3, as well as the results of linear regression analysis.

Table 3. Descriptive statistics and results of regression analysis for "Round off" as dependent variable

VARIABLE		M	S	Min	Max	β	t	p
1.	Obstacle course backwards (0.1s)	173.19	39.52	96	288	-0.203	-1.687	0.095
2.	Passing through and jumping over (0.1s)	197.80	45.04	127	354	-0.196	-1.486	0.141
3.	Arm plate tapping (freq)	30.49	3.85	17	42	0.001	0.008	0.994
4.	Foot tapping (freq)	18.86	1.87	14	23	0.121	1.254	0.213
5.	Seated straddle stretch (cm)	63.08	11.19	36	91	0.080	0.713	0.478
6.	Leg lifting lying aside (^{0})	75.87	9.43	51	94	0.106	1.122	0.265
7.	Dislocation with a stick (cm)	71.85	15.58	25	123	-0.048	-0.515	0.608
8.	Standing long jump (cm)	165.60	20.51	113	208	-0.048	-0.380	0.705
9.	20 meters dash (0.1s)	44.81	3.12	38	52	-0.163	-1.757	0.082
10.	Bent arm hang (0.1s)	200.50	157.48	0	918	0.039	0.355	0.723
11.	Sit-ups in 60 seconds (freq)	38.52	6.78	8	53	0.149	1.509	0.135
12.	Handgrip strength (kg)	24.92	4.66	15	39	0.018	0.179	0.858
13.	*Round off (mark)*	*3.47*	*1.63*	*1*	*7*			

$R = 0.664$ $R^2 = 0.441$ $F = 5.915$ $p = 0.00$

M – arithmetic mean, S – standard deviation, Min – minimum result, Max – maximum result, β – standardized coefficient, t – t test for β, R – coefficient of multiple correlation, R^2 – coefficient of determination, F – F test for R, p – statistical significance level.

Results in table 3 showed that applied motor variables as a system of independent variables had statistically significant impact ($p \leq 0.05$) on performance of "Round off in girls".

Observed individually, none of motor ability variables had statistically significant impact on dependent variable ($p > 0.05$).

Discussion and conclusion

This research examined an impact of motor abilities on performance of gymnastic elements on floor in 11-12 years-old girls. As the results showed, there was a statistically significant impact of motor abilities on performance of all 3 gymnastic elements. Similar results confirming a great impact that motor abilities have on performance of gymnastic routines on floor, as well as on the other apparatus, can be found in many studies (Madić, Popović, Tumin, Obradović, & Radanović, 2011; Radanović, Štajer, Popović, & Madić, 2013; Popović, Madić, Aleksić-Veljković, Radanović, Spasić, Pantović, & Stupar, 2014; Delaš-Kalinski, Milić, Padulo, Maras, & Erceg, 2016). Observed individually, 4 motor ability variables had statistically significant impact ($p \leq 0.05$) on dependent variable "Straddle forward roll", *i.e.* variables "Seated straddle stretch" and "Leg lifting lying aside", which evaluates flexibility and variables "Sit-ups in 60 seconds" and "Handgrip strength" for general strength evaluation. Trunk flexors as the most engaged muscles in performing "Sit-ups in 60 seconds" test are also highly engaged while performing straddle forward roll, especially in seated straddle position trying to do a maximum bend. On the other hand, high flexibility level of hamstring muscle and leg adductors is crucial to do an exercise correctly. Many studies examined an importance of strength and flexibility of different body segments in gymnastics (Madić, 2000; Radanović, Štajer, Popović, & Madić, 2013). Variable "20 meters dash", which evaluates explosive strength, was the only motor ability variable that had statistically significant impact ($p \leq 0.05$) on dependent variable "Handstand". High explosive strength level of leg and hip extensors is important to maintain correct biomechanical pattern, which leads to optimal technique. Results of motor ability test, estimating explosive strength "20 meters dash", support this claim, as well as similar studies exploring relations of explosive strength and gymnastics (Madić, 2000; Popović 2010; Delaš-Kalinski, Milić, Padulo, Maras, & Erceg, 2016). None of the motor ability variables had statistically significant impact on dependent variable "Round off". The closest one was "Obstacle course backwards" which estimates coordination ($p = 0.095$). Higher level of coordination may implicate to students with better technique. Round off was the most complex gymnastic element with

the lowest marks and obviously too hard to learn. It could be the reason why, observed individually, motor abilities didn't show statistically significant impact on "Round off". Perhaps, if some more time was spent on learning and mastering round off; motor abilities could show greater impact. Based on the results, the authors concluded that motor abilities have great influence on performing gymnastic elements. Therefore, physical preparation is necessary before learning any of gymnastic elements, which turned out to be quite difficult for students.

Thus, improving general and explosive strength, as well as flexibility should be primary. Values of coefficients of determination showed that motor abilities explained a big part of dependent variables, which was somehow expected. More studies should be conducted regarded to some other anthropological dimensions, such as morphological characteristics, cognitive abilities, conative characteristics, which could have impact on performance of gymnastic elements. Also, it would be interesting to include more gymnastic elements on different apparatus.

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UTJECAJ MOTORIČKIH SPOSOBNOSTI NA IZVEDBU GIMNASTIČKIH ELEMENATA NA TLU KOD DJEVOJČICA

Sažetak

Cilj ovog istraživanja je da se definiraju motoričke sposobnosti koje imaju najveći utjecaj na izvedbu gimnastičkih elememata na tlu kod djevojčica. Uzorak su činile 103 djevojčice, učenice petih i šestih razreda. Ispitanice su bile uključene u eksperimentalni program koji je obuhvaćao obučavanje gimnastičkih vježbi na redovnim satima tjelesnog odgoja. Kvalitet izvođenja „Koluta naprijed raznožno", „Stoja na rukama" i „Rondata" procijenjena je od kompetentnih gimnastičkih sudaca, a njihova ocjena predstavljala je ovisnu varijablu. Baterija od 12 motoričkih testova primijenjena je kao sustav neovisnih varijabli. Povezanost između sustava neovisnih varijabli i ovisne varijable izračunata je pomoću regresijske analize. Rezultati su pokazali da primijenjene motoričke varijable, kao sustav neovisnih varijabli, imaju statistički značajan utjecaj($p \leq 0.05$) na izvedbu sva 3 gimnastička elementa kod djevojčica. Promatrane pojedinačno, 5 motoričkih varijabli su imale statistički značajan utjecaj na zavisnu varijablu. To su varijable "Pretklon u sijedu raznožno" i "Odnoženje ležeći na boku" koje procjenjuju gibljivost, varijable "Trbušnjaci za 60 sekundi" i "Stisak šake" za procjenu opće snage i varijabla „20 metara sprint" za procjenu eksplozivne snage. Na temelju rezultata, autori su zaključili da je tjelesna priprema neophodna prije obuke pomenutih gimnastičkih elemenata, a pozornost prije svega treba usmjeriti na razvoj opće i eksplozivne snage i gibljivosti.

Ključne riječi: *gimnastika, tjelesni odgoj, škola, vježbe na tlu.*

Received: August 18, 2016
Accepted: September 5, 2016
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