EFFECTS OF ISOKINETIC RESISTANCE TRAINING ON STRENGTH KNEE STABILIZERS AND PERFORMANCE EFFICIENCY OF ACROBATIC ELEMENTS IN ARTISTIC GYMNASTICS

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Abstract

The aim of this study was to examine whether additional training protocol of isokinetic training results in increased biomechanical values of certain parameters and whether it increases functional correlation between speed and strength leading to improved performance of acrobatic elements in floor exercises. Additional training protocol, which lasted for one semester, was performed on Biodex 3 apparatus (60°·s^{-1}). Examinees participating in this research were (N = 80) male students from Faculty of Sport and Education (mean age, 19.8 ± 1.7 year; weight, 75.2 ± 2,9 kg; height 179.7 ± 6.4 cm). Control group (N = 40), between two measurements, conducted only regular practical teaching program of artistic gymnastics. Experimental group (N = 40), besides regular practical teaching program of artistic gymnastics, also had additional program of isokinetic practice on Biodex 3 apparatus. Experimental group showed obvious structural changes that can be dominantly registered through variables assessing the maximum strength of the dynamic knee stabilizers (the maximum moment of force, overall work and average strength) and reciprocal relationship between agonist and antagonist muscles. In variables assessing the performance of elements of floor exercises in artistic gymnastics we obtained statistically significant differences in elements requiring changes of the maximum strength of the dynamic knee stabilizers: dive roll, back handspring, salto forward and backward tucked.

Keywords: *isokinetic, peak torque, power, work, acrobatic elements.*

INTRODUCTION

Sport gymnastics is classified in the group of conventional sports (Čuk, 1996), considering that the aesthetic component and acyclic movement are based on strict rules of the Code of Points (Fédération Internationale de Gymnastique, 2013). Acrobatics is acyclic sport characterized by a great diversity of movement and with its many and varied elements have a very positive impact on the development of the overall coordination of movement (Bolkovič, & Kristan, 1998). Acrobatic elements have a significant influence on the ability to move the body in space (Bressel, Yonker, Kras, & Heath, 2007), which improves overall coordinative motor ability of the entire body and its parts (Bolkovič, & Kristan, 1998). Also, very accurate and fast work and alternating activation of individual muscles and muscle groups, acrobatics develop all forms of strength, where the explosive and static strength is the most important especially in the take off phase and landing (Marinšek, 2010).

As an example, in artistic gymnastics requires a high level of physical fitness and skill to succeed: speed (Lindner, Caine, & Johns, 1991), strength (Lindner, Caine, & Johns, 1991; Bradshaw, & Le Rossignol, 2004), endurance (Bradshaw, & Le Rossignol, 2004), agility (Daly, Bass, & Finch, 2001), flexibility (Delaš, Babin, & Katić, 2007), balance (Lindner, Caine, & Johns, 1991) and power (Delaš, Babin, & Katić, 2007) are all physical abilities that play a role in the success of a competitive gymnast.

In artistic gymnastics on floor exercies some phases like run, take off, flight and landing phase success depends on the physical preparation and motor control of the gymnast. Physical preparation refers to the gymnast's ability to cope with the load to which they are exposed during the take off and landing. Motor control refers to the control the gymnast has over the skill they perform (Marinšek, 2010). During take-offs and landings in artistic gymnastics can be very high. Forces measured at landings can range from 3.9 to 14.4 times the gymnast's body weight (Panzer, 1987; Karacsony, & Čuk, 2005). Based on previous studies by Karacsony and Čuk (2005) found that forces at take off at different somersaults can be up to 13.9 times the participant's body weight.

Different preparation drills using modern props for the development of motor skills are used. They have to emulate as authentically as possible the movement structure of an element that is learned and practiced. They have to influence development and improvement of motor abilities that are necessary for its performance and therefore are performed with the same or similar amplitude and direction of muscle contraction. Majority of preparation drills are done individually, with the help of a training prop or a coach. Therefore, all coaches as well as gymnasts have to be experts in the movement structure they teach and they have to know which muscle groups are specific for certain acrobatic elements.

Isokinetic training requires a special machine that keeps the muscle contracting at a constant pace. Isokinetics combine isometric and isotonic contractions. This kind of training allows for maximal strength improvements and is usually combined with other types of strength training. Because the equipment used in isokinetic training constantly monitors the exertion of the user, the resistance can be altered to keep a constant contraction on the muscles without risk of overtraining or injury. This type of training is especially helpful in rehabilitation scenarios where the person is at high risk for re-injury. Isokinetic dynamometers are used widely for trening, testing and rehabilitation in various sports and injuries (Dvir, 2004). Reliability (Siqueira, Pelegrini, Fontana, & Greve, 2002) and validity (Siqueira, Pelegrini, Fontana, & Greve, 2002; Pincivero, Dixon, & Coelho, 2003) of isokinetic torque measurement were reported good to excellent while reliability in lower velocities reached high (Pincivero, Dixon, & Coelho, 2003). Popular isokinetic velocities are $60°\cdot s^{-1}$, $180°\cdot s^{-1}$, and $300°\cdot s^{-1}$; these are often referred to as slow, medium, and fast speeds, respectively. Selecting low strength speed ($60°\cdot s^{-1}$), medium fast speed ($180°\cdot s^{-1}$) and high endurance speed ($300°\cdot s^{-1}$) isokinetic testing speeds is essential for optimal strength evaluation, given that in slow muscle action the vast majority of motor units are recruited, while faster testing velocities enrich the force-velocity spectrum of the acting muscles (Baltzopoulos, & Brodie, 1989).

In this article (Benson, 2008), the term “resistance training” is defined as a type of exercise that requires the musculature to contract against an opposing force generated by some type of resistance (e.g., body weight, barbells, dumbbells, weight, isokinetics machine).

However, motor performance increases observed during resistance training are: vertical jumping ability, sprinting speed, balance, coordination, throwing velocity, kicking performance, running economy, bat swing velocity, wrestling performance, tennis service velocity, etc. (Kraemer, Ratamess, & French, 2002). The key quality to an individualized resistance training program is the acute manipulation of program variables targeting certain areas of muscular fitness. The program variables are: 1) intensity (or loading), 2) volume (the number of sets and repetitions), 3) exercises selected, 4) the order of the exercises, 5) rest intervals between sets, 6) velocity of contraction, and 7) frequency (Kraemer, Ratamess, & French, 2002).

METHODS

This investigation was designed to assess the possible beneficial effects of isokinetic training on students who attend practical classes from artistic gymnastics. During gymnastic exercises on floor, considerable force output is required in the knee muscles. Isokinetic performance of the knee muscles in students population, has not been examined. Our study provides important information related to adaptations of this group muscle training that occur in students population of Physical Education and Sport. The reason why we decided to try this kind of study is to compare our results resistence traning with other similar studies (Calmles et al., 1995; Teng et al., 2008; Piazza et al., 2014). So far we have not found studies showing the effect of short-term exercise on the student population and that would help students when adopting new motor skills.

The study was performed in accordance with the ethical standards. Moreover, the local Ethics Committee, in accordance with the Helsinki Declaration, approved all procedures prior to the start of this investigation. All volunteers completed a medical screening questionnaire and provided written informed consent prior to participation. The participants in this research consisted of (N=80) male students of the Faculty of Sport and Physical Education, University of Sarajevo, (mean age, 19.8 ± 1.7 years; weight, 75.2 ± 2.9 kg; height, 179.7 ± 6.4 cm). The participants were divided, using accidental sampling method, into two groups: control C (N=40) and experimental E (N=40). The entire experiment was conducted during one semester of the academic year.

Strength test on knee joint extensor an flexor was conducted using Biodex System 3 (Biodex Corporation, Shirley, New York, USA) isokinetic dynamometer (Fig. 1). Reliability of the system expressed in coefficient of variation is 3 % (Drouin, Valovich-mcLeod, Shultz, Gansneder, & Perrin, 2004). Short and brief introduction to Biodex Pro 3 system and its software (Biodex System 3, 2009). In this additional programmed kinesiology treatment the machine was used for exercise in experimental group.

Examiners in this study are University professors (N=3) with more than 30 years of experience of work in various sports clubs and Faculty of Physical Education and Sport. Before the assessment, they carefully read the description of task and criteria (Table 1). Only better performance of performed acrobatic elements was used in the analysis. After evaluation of better performance, we calculated the final grade for each examinee in each task as the arithmetic average of the ratings assigned by the examiner. For evaluation, they used points from 6 to 10 point measuring scale, according to the criteria, where grade 10 is the highest/best.

Anthropometric tests: Body height – BH was measured using Martin's anthropometer with precision of 0.1 cm.

Examinees were on the horizontal surface standing on one leg, with body weight equally balanced on both legs, shoulders relaxed, heels placed together, while the head was in so called „frankfurt plane“. Total body weight – BW (kg), was measured using a Tanita TBF-300A Pro Body Composition analyzers scales with precision of 0.1 kg. Students and students were barefooted during measurements.

All measurements of the strength of knee joint extensors and flexors were performed from sitting position with 90° average angle of body and upper leg. Bands for stabilization were positioned over body, hips and distal part of upper leg for the leg that was tested. During the whole procedure of isokinetic training examinees held their hands crossed on their chests. Also, during the test examinees were given instructions that they have to give their maximum effort for each exercise. Dominant leg was always the first one to be tested. Dominant leg was considered to be the one that examinees chose to be the leg they would use to kick the ball. By this way leg dominance was determined in other studies as well (Wei, Housh, Housh & Weir, 1997.)

Table 1
Criteria for acrobatic elements knowledge evaluation.

Measurement scale (points)	Description of standards - Acrobatics
Points 10	The exercise (element) is performed optimally in such a way that there were no mistakes in the initial position, body position, leg and/or hand positions. There were no mistakes in the aesthetic part of the exercise, in the coordination of performance, technical performance, range of motion, in the speed and pace and lastly no mistakes in the final position.
Points 9	The exercise (element) was performed optimally with minor errors found in certain technical requirements of the initial position, body position, and position of the legs and/or hands. Possible minor errors found in the aesthetic part of the exercise, range of motion, speed and pace and final position. Total maximum number of minor faults 1 to 2.
Points 8	The exercise (element) is still well-performed with a small number of errors noticed in certain technical requirements of the initial position, body position, and position of the legs and/or hands. Possible errors found in the aesthetic part of the exercise, coordination of performance, range of motion, speed and pace and final position. However these errors did not impair the whole structure of the movement. The total maximum number of minor errors 3 to 4.
Points 7	The performance of the exercise (element) was flawed. There were errors in almost all the above mentioned technical requirements. There was also a noticeable distortion in the structure of the movement.
Points 6	The exercise (element) is poorly performed with a large number of errors. There are major deficiencies in all of the abovementioned technical requirements. The structure of the movement was significantly impaired.

Table 2
Resistance training programme.

Exercise	Sets/Repetitions/Rest	Speed
Warming up on byciclogometer 10 min (75 RPM, 50 WATT)		
Static stretching muscles of lower extremities (10 min)		
3 sets	4 - 6 repetitions pauses of 30 s between the series	with the left leg on the angular speed of $60°\cdot s^{-1}$
3 sets	4 - 6 repetitions pauses of 30 s between the series	with the right leg on the angular speed of $60°\cdot s^{-1}$
	Pause between exercises of 3 min	

Table 3
Artistic gymnastics elements.

DRL – dive roll	
CAR – cartwheel	
FHS – front handspring	
BHS – back handspring	
SFT – salto forward tucked	
SBT – salto backward tucked	

A standardized testing routine improves the operator's control of several variables that influence tests: testing of uninvolved side first, alignment of axis of rotation, warm-ups, subject stabilization, verbal commands, visual feedback, test position, system calibration, angular velocity selection, system stabilization, skill, training of tester, gravity compensation, rest intervals, test repetitions, collection of data (print - out) for future analysis, analysis of data through the use of statistical software (Biodex 3, 2009).

Testing protocol for isokinetic assessment in this research:

Body height and weight was measured for each participant before initial and final measurement.

Warm-up and overall body stretching – 20 min.

Positioning examinee in optimal stabilization.

Alignment of joints and dynanometric axis of rotation.

Positioning pad for resistance.

Verbal introduction into isokinetic concept of exercises.

Gravitation correction.

Warm-up (3 submaximal, 1 maximal repetitions).

Maximal test with the test speed 60 (5 repetitions).

Rest (30 seconds).

Testing contralateral extremity.

Recording test detail to make sure that repeatability on a repeated test is possible.

The experimental group of subjects had an isokinetic program (Table 2) of exercise 3 times a week x 40 min for 12 weeks. All subjects had a knee range of motion (ROM) 90 degrees. Testing speeds for the knee were set at $60°\cdot s^{-1}$ for concentric and eccentric muscle action.

Variables to assess maximum muscle strength of the dynamic knee stabilizers

The following section will define the test data, and describe what may affect each variable (Biodex System 3, 2009). Peak torque (PT) highest muscular force output at any moment during a repetition expressed in (Nm). Peak Torque indicates the muscle's maximum strength capability. Variables show results separately for extension and flexion and for left and right leg. Total work (TW) the amount of work accomplished for the entire set. This represents the muscle's capability to maintain torque throughout the test bout. If the ROM is smaller on one side, the total work will be affected even if the peak torque is the same.

Average power (AVG power)

AVG power = amount of total work divided by the time to complete that total work. This value is used to provide a true measure of work rate intensity defined as total work divided by time. Power represents how quickly a muscle can produce force. It expresses the muscle's ability to do the work for a specified period of time and intramuscular ratio (agonist to antagonist ratio) is expressed in percentages for both legs (Biodex System 3, 2009).

Maximum muscle strength of knee extensors

EXTLEF60 (Nm) – peak torque of the knee extensors of the left leg

EXTRIG60 (Nm) – peak torque of the knee extensors of the right leg

EXLFTW60 (J) – total work of the knee extensors of the left leg

EXRGTW60 (J) – total work of the knee extensors of the right leg

AVGEXLF60 (W) – average power of the knee extensors of the left leg

AVGEXRG60 (W) – average power of the knee extensors of the right leg

Maximum muscle strength of knee flexors

FLXLEF60 (Nm) – peak torque of the knee flexors of the left leg

FLXRIG60 (Nm) – peak torque of the knee flexors of the right leg

FXLFTW60 (J) – total work of the knee flexors of the left leg

FXRGTW60 (J) – total work of the knee flexors of the right leg

AVGFLLF60 (W) – average power of the knee flexors of the left leg

AVGFLRG60 (W) – average power of the knee flexors of the right leg

Ratio between knee extensors and flexors

AGANLF60 – intramuscular ratio (hamstring/quadriceps) of the left leg

AGANRG60 – intramuscular ratio (hamstring/quadriceps) of the right leg

Variables to assess the efficiency of the performance of floor exercises elements of artistic gymnastic

The participants did not have prior knowledge of applied artistic gymnastics; therefore the initial assessment of the performance of the artistic gymnastics was not carried out. However after the basic program of 12 weeks of regular practical training – a final evaluation of the experimental and control groups was conducted by the University professors (N=3) with more than 30 years of experience of work in various sports clubs and Faculty of Physical Education and Sport. The acrobatic tests, with description of movements and certain mistakes, were used by authors (Mujanović, Atiković, & Nožinović Mujanović, 2014). Evaluation of motor knowledge of acrobatic elements was carried out at gym hall with set-up of six mats placed one behind the other touching along shorter side. Each mat was 2 m long and 1 m wide with height/thickness of 6 cm. The sample of variables to assess the efficiency of the performance of floor exercises elements of competitive gymnastics is represented in this research by six elements (Table 3).

Statistical analyses

Descriptive statistics (means and standard deviation) was calculated for all variables separately for each group. ANOVA was performed to determine whether there were significant differences. Data were analyzed using oneway ANOVA with repeated measures. All variables in each sample had normal disrubition which is tested by Kolmogorov – Smirnov test. There were no significant differences between control and experimental gymnastics group. Significant level was defined as ($P < 0.05$). The SPSS version 21.0 was used for all analyses (SPSS Inc., Chicago, Illinois).

RESULTS

All the participants completed the study and no injuries or health complains were reported. In (Table 4) contains results of arithmetic means and standard deviation for variables body height and body weight for examinees from control and experimental group in initial and final measurement. By going through the results, one can conclude that there are no differences of artihmetic means in results of the applied variables. Average values of body height for control and experimental group were calculated, and they were within the following range (C: 179.13 ± 5.97; E: 180.20 ± 7.01) while the values for body weight was (C: 74.90 ± 3.13; E: 75.80 ± 2.85). The same calculation was done before the second measurement, with the value for body height being (C: 179.24 ± 5.95; E: 180.43 ± 6.91), and body weight (C: 74.76 ± 2.93; E: 75.55 ± 3.00). From a statistical point of view, there were no differences between the two groups.

Table 4
Comparison two variables after the first and second measurement (Mean ±SD).

Variable	Control Group Mean ± SD (N=40)	Experimental Group Mean ± SD (N=40)	*P* Value for Group Difference	Control Group Mean ± SD (N=40)	Experimental Group Mean ± SD (N=40)	*P* Value for Group Difference
	Fisrt measurement			Second measurement		
Height (cm)	179.13 ± 5.97	180.20 ± 7.01	.46	179.24 ± 5.95	180.43 ± 6.91	.41
Weight (kg)	74.90 ± 3.13	75.80 ± 2.85	.18	74.76 ± 2.93	75.55 ± 3.00	.24

Data are presented as the Mean ± SD. *P* values based on comparisons of groups using ANOVA.

Table 5
ANOVA dynamic stabilizer knee control and experimental groups in the initial and final measurements (speed 60°·s⁻¹).

Variable	First measurment	Second measurment	ANOVA	First measurment		Second measurment	
	Mean ± SD		df	F	P Value for Group Difference	F	P Value for Group Difference
	Maximum muscle strength of knee extensors						
EXTLEF60	216.46 ± 38.62 219.94 ± 37.78	266.17 ± 41.37 231.43 ± 39.82	1.00	0.17	.69	14.64	.00*
ETRIG60	209.14 ± 32.70 221.67 ± 35.48	258.35 ± 41.94 223.83 ± 36.17	1.00	2.70	.10	15.55	.00*
EXLFTW60	890.20 ± 175.01 950.89 ± 182.91	1141.22 ± 206.32 969.57 ± 147.09	1.00	2.30	.13	18.36	.00*
EXRGTW60	874.13 ± 121.97 911.66 ± 113.00	1130.36 ± 215.46 942.15 ± 156.70	1.00	2.04	.16	19.96	.00*
AVGEXLF60	134.04 ± 19.68 137.08 ± 17.45	176.49 ± 40.90 147.04 ± 26.90	1.00	0.54	.47	14.48	.00*
AVGEXRG60	125.18 ± 11.87 128.76 ± 15.03	172.09 ± 44.51 143.80 ± 27.07	1.00	1.40	.24	11.80	.00*
	Maximum muscle strength of knee flexors						
FLXLEF60	120.33 ± 13.03 123.98 ± 10.88	150.32 ± 23.84 131.79 ± 23.98	1.00	1.85	.18	12.02	.00*
FLXRIG60	131.42 ± 20.82 135.38 ± 23.59	149.57 ± 25.15 131.50 ± 24.97	1.00	0.63	.43	10.40	.00*
FXLFTW60	511.10 ± 57.91 498.47 ± 64.84	790.87 ± 142.74 664.45 ± 134.15	1.00	0.84	.36	16.66	.00*
FXRGTW60	557.72 ± 70.75 541.70 ± 78.80	800.44 ± 137.64 657.00 ± 146.93	1.00	0.92	.34	20.30	.00*
AVGFLLF60	91.29 ± 6.56 92.77 ± 6.98	115.76 ± 23.83 94.93 ± 21.13	1.00	0.96	.33	17.10	.00*
AVGFLRG60	93.18 ± 17.22 91.69 ± 12.99	118.44 ± 26.19 94.18 ± 20.83	1.00	.19	.66	21.03	.00*
	Ratio between knee extensors and flexors						
AGANLF60	55.06 ± 4.07 56.54 ± 6.58	59.21 ± 3.27 57.33 ± 7.21	1.00	1.47	.23	2.27	.14
AGANRG60	59.03 ± 6.43 61.24 ± 8.00	61.13 ± 3.68 58.98 ± 7.39	1.00	1.86	.18	2.71	.10

Data are presented as the Mean ± SD. *P* values based on comparisons of groups using ANOVA.
*. The mean difference is significant at the .05 level

Table 6
ANOVA elements of acrobatics for control and experimental group.

	ANOVA					
Variable	Mean ± SD	Sum of Squares	df	Mean Square	F	*P* Value for Group Difference
DRL – dive roll	8.28 ± 0.96 7.00 ± 0.68	32.51	1.00	32.51	46.98	.00
CAR – cartwheel	8.20 ± 0.72 8.03 ± 0.70	.61	1.00	.61	1.21	.27*
FHS – front handspring	7.85 ± 0.74 7.78 ± 0.70	.11	1.00	.11	.22	.64*
BHS – back handspring	7.90 ± 0.78 6.90 ± 0.67	20.00	1.00	20.00	37.86	.00
SFT – salto forward tucked	7.80 ± 0.72 6.58 ± 0.71	30.01	1.00	30.01	58.27	.00
SBT – salto backward tucked	7.70 ± 0.76 6.45 ± 0.64	31.25	1.00	31.25	63.64	.00

Data are presented as the Mean ± SD. *P* values based on comparisons of groups using ANOVA.
*. The mean difference is significant at the .05 level

The first analysis was done on the results of control and experimental group in the initial measurement, in other words before the program was conducted. In (Table 4.) one can see the results which show that from a statistical point of view examinees are not significantly different in all strength variables of flexor muscle and dynamic knee stabilizer. Based on this one can conclude that differences are statistically insignificant or in other words that the two groups of examinees belong to the same population. ANOVA showed that significant difference was found for all variables the maximum muscle strength of knee extensors and the maximum muscle strength of knee flexors between unspecific and specific training program on Biodex 3 ($P < 0.05$). Results ANOVA showed that there were no statistically significant changes after the second measurement in the two variables that were treated (Ratio between knee extensors and flexors) in AGANLF60 ($F_{1.80} = 2.27$; $P < 0.14$), and AGANRG60 ($F_{1.80} = 2.71$; $P < 0.10$).

In two variables (Table 6) assessing the success in performing elements of floor exercises in artistic gymnastics: CAR – cartwheel and FHS – front handspring, we obtained no statistically significant differences in relation to control and experimental group CAR ($F_{1.80} = 1.21$; $P < 0.27$), and FHS ($F_{1.80} = 0.22$; $P < 0.64$). Reason for this may be the fact that in elements cartwheel and front handspring, take off is performed from arms to legs, with arms being more important in the performance of the element in comparison to other elements performed by a take off using lower extremities.

DISCUSION AND CONCLUSION

Our wish was to determine not only whether additional training protocol results in the increased biomechanical values of certain parameters but also to determine whether isokinetic training or resistance training increases functional correlation between speed and strength leading to improved performance of acrobatic elements in floor exercises. We designed and evaluated training protocol and found that it is effective in increasing the strength of knee extensors and flexors. Design of isokinetic dynamometer on apparatus Biodex 3 allows continuous resistance in all angles of movement that other training simulators don't possess. This characteristic is important not just for a significant increase in muscle strength but also to balance the relationship between flexor and extensor muscles of the dynamic knee stabilizers.

Control group had more unfavourable position than experimental group because between the two measurements for control group only regular program of practical teaching from competitive gymnastics was conducted without additional training program. In the program which entities from control group were subjected to there were no additional stimuli such as training on apparatus Biodex 3, which made the whole process completely directed to regular practical teaching on college. Therefore, structural changes of the maximum strength of the dynamic knee stabilizers with lower intensity occurred for control group. Experimental group showed obvious structural changes which could be dominantly registered through variables for the assessment of the maximum strength of the dynamic knee stabilizer (the maximum moment of force, overall work and average strength) and reciprocal relationship between agonist and antagonist muscles.

In the initial measurement, before we started conducting the program, the groups practically show no differences, which is an excellent indicator of balanced position for possible application of specific additional training program for muscles of the dynamic knee stabilizers under two applied transformational procedures. However, in the second measurement (at the end of program) the groups show significant differences in the assessment of the maximum strength of the dynamic knee stabilizers as well as in the assessment of the performance of floor exercise elements in competitive gymnastics.

In variables assessing the maximum strength of the dynamic knee stabilizers and variables assessing the performance of floor exercise elements in competitive gymnastics we obtained statistically significant differences in almost all applied variables.

Our findings determined that for elements of floor exercises in artistic gymnastics it can be concluded that more significant were the changes obtained for elements that required changes of the maximum strength of dynamic knee stabilizers: dive roll, back handspring, salto backward and forward. Explosive strength, which is defined as the ability to activate the maximum number of muscle units in the unit of time, in majority of researches has significant correlations with the success in performing floor exercise elements and elements of other sports (Mujanović, Atiković, & Nozinović Mujanović, 2014; Lešnik, Glinsek, & Žvan, 2015). Above mentioned facts lead to a conclusion that for a successful performance of applied elements in floor exercises for this type of performance, more significant engagement of musculature is necessary on the principle of transitory activation of the maximum number of muscle units in the unit of time (explosive strength of lower extremities).

Preparing additional training on the dynamic knee stabilizers (but probably on many other types of muscles) through training protocols on isokinetic equipment would prove to be the best solution, first of all because of the possibility of optimum training load for a performer and continuous resistance which is allowed by this equipment (Cools, Geerooms, Van den Berghe, Cambier, & Witvrouw, 2007; Teng, Keong, Ghosh, & Thimuryan, 2008).

Certainly, precise defining of sorts and types of protocol, number of repetitions about dependence on transformation stages and aims of work, overall volume and specific content, should all be developed in accordance with the characteristics of muscle groups, which is a topic for future researches, but it is completely certain that the applied training in this research eventually proved to be an important method for improving muscle strength of the dynamic knee stabilizers, as well as significant influence on the improvement of effectiveness in performing elements of floor exercises in competitive gymnastics. Controlling, managing and distributing training load is an important factor not just in terms of intensifying teaching process, but also in bringing the process of additional training closer to authentic problems of students. This happens mostly due to the fact that the influence of adequate kinesiological operators in appropriate time and space (which implies conducting defined control, management and distribution of the load) leads to positive changes in motor abilities and motor skills occur. In other words, adaptational changes in part occur in muscles. This also has a positive influence on creating favorable adaptational structures, and on better overall functional state of students' bodies. It is clear that such students adapt better on the load during the teaching process, but also that the injury chances due to low muscle strength would decrease. Therefore, the overall effects of solving various motor tasks would be larger. Recent findings (Piazza et al., 2014), conversely, have demonstrated that resistance training can be an effective tool to increase strength in children and adolescents, when appropriately prescribed and supervised (Payne, Morrow, Johnson, & Dalton, 1997; Harries, Lubans, & Callister, 2012). The main finding of this study (Piazza et al., 2014), was that both tested resistance training protocols affected positively the jumping performance in young rhythmic gymnasts, with anincrease of 6-7% in lower limb explosive strength and with no side effects. Results are in agreement with other studies which reported statistically significant increases in explosive strength ranging from 5% to 24% as assessed by vertical jumps, after resistance training (Alves, Rebelo, Abrantes, & Sampaio, 2010).

Other reports indicated that resistance training may improve motor performance; strength of the muscles, ligaments and bones in youth. In addition, resistance training helps to prevent or reduce injuries in sports and recreational activities and may favourably alter selected anatomic and psychosocial variables (Faigenbaum, Westcott, Loud, & Long, 1999). Resistance training has become popular among prepubescent and adolescents over the last decade and has received attention as an important component of youth fitness programme (Picosky, Faigenbaum, Westcott, & Rodriguez, 2002).

Some studies have reported that loads of 45-50% of 1 repetition maximum (1RM) in adults, young men and women, has lead to an increase in dynamic muscular strength following 7 to 20 weeks of resistance training at a rate of 3 days per week (Weiss, Coney, & Clark, 1999). It appears that resistance training frequency of twice per week was sufficient to can induce strength gains in adolescents.

This studie (Amato, Lemoine, Gonzales, Schmidt, Afriat, & Bernard, 2001) reported a significant influence of age and physical activity on isokinetic characteristics of hamstring and quadriceps muscles of young gymnasts and soccer players. The isokinetic values of soccer players were significantly higher ($P < 0.0001$) than those of the the gymnasts. The isokinetic values of the oldest gymnasts were significantly higher ($0.005 < P < 0.05$) for the quadriceps than those of the younger gymnasts. The muscular maturation improves the absolute strength of the older sportsmen in comparison to the younger. Soccer favor most the absolute strength of the inferior member in comparison to the gymnastics.

Based on previous study by (Calmels, vanDenBorne, Nellen, Domenach, Minaire, & Drost, 1995) analyzed the effects of intensive training on young national competition gymnasts have not been established with precision. This, using an isokinetic dynamometer at speeds $60°·s^{-1}$ and $120°·s^{-1}$, the concentric and eccentric isokinetic muscle strength of knee flexors and extensors in a population of nine young national caliber gymnasts. In results authors present eccentric strength is greater than concentric strength, there's no significant difference between dominant and non-dominant limb, and a significant increase of the flexor/extensor peak torque ratio was observed with increasing speed, due to the concentric ratios. These results provide information about the relationship between angular velocity and eccentric muscle strength already reported in previous studies and, in particular, the fact that the knee flexors and extensors behave differently during eccentric and concentric work as the angular velocity increases. Analysis of the flexor/extensor ratio also indicated the absence of specific differentiation of muscle activity despite the intensive level of sports activity and suggests the role of age, or even puberty, in these young gymnasts. This analysis encourages annual follow-up of this population and specific studies concerning the role of hormones and muscle maturation.

Previous research by (Procopio, 2014) highlighted that, impact resistance training performed on nonconsecutive days, following non-linear periodization for 1.5 to 2 hours per week for ten weeks is sufficient to obtain bone mineral density and performance improvements in competitive female adolescent gymnasts. Resistance training resulted in significant improvements in bone mineral density, power and jump height, as well as maximal strength ($P \leq 0.05$).

Previous research investigated the isokinetic variables comparing the right and left body side in two sports group, with dominance on one or both legs, did not differ. No differences were recorded in the H/Q between the right and left legs for any of the subject groups (Zakas, 2006).

Research findings suggest that a majority of resistance training-related injuries in children and adolescents are the result of accidents, improper exercise technique or lack of qualified supervision and instruction (Jones, Christensen, & Young, 2000).

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