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THE EFFECT OF PILATES ON PHYSICAL FITNESS PARAMETERS IN GIRLS: A NON-RANDOMIZED CONTROLLED STUDY

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Original research:

Abstract
Improvement of parameters of physical fitness in children by application of different programs of exercising is important kinesiology task. The aim of this study was to establish potential transformational efficiency of Pilates program in 16-week period on parameter of physical fitness in female high school students (2nd and 3rd grade of female boarding school) Total of 110 school girls were divided in two groups: control group (CG) and experimental group (EG), (n= 55 subjects in each group). Both groups attended physical education lesson (PE) according to plan and program for high school students (90 minutes; 1x week). Experimental group in in warm-up section of the PE class did Pilates exercises in 40-minute time, while controlled group performed conventional approach to PE warm-up exercises (40 minutes). Parameters of physical fitness were evaluated by 9 tests, which covered latent area of repetitive strength: push-ups (MSKL) raising torso from lying position (MPTL) and deep squad 30 s (MCUC; flexibility; rotation with a bat (MISK); leaning forward multi-legged (MPRR), leaning forward on the bench; and evaluation of balance of standing on the bench longitudinally on both legs (MU2N), longitudinally on one leg (MU1N), diagonally on both legs (MP2N). After the Pilates exercise program, the experimental group showed a significant improvement in the balance (Sig = 0.00) and in repetitive strength (Sig = 0.00). There were no significant differences in tests of flexibility due to the fact that development of flexibility is achieved by the volume of Pilates training (weekly). This study showed that Pilates exercises can be useful additional method in physical education class in school, because significant quantity changes in physical fitness of balance and repetitive strength were obtained.

Key words: Pilates, physical fitness, women, exercise

Introduction

Regular physical activity is an important factor in establishing and maintaining health. Is it is practiced in early age it remains as a habit in function of health for the rest the life. Physical activity has positive effects on children and adolescents in various aspects, such as preventing obesity, increasing the quality of life, and improving physical and mental health (Andermo et al., 2020). According to certain studies (Badrić and Prskalo, 2011) boys in puberty are more physically active than girls, therefore it is necessary to examine methods of exercising which are efficient and continuative. Promotion of fitness exercise that has a positive effect on women's overall health is an important strategy of health policy (Ljubojevic, et. al., 2022). Reduced activity of women in puberty and partially post-puberty period can be caused by intense physiological changes and it is very important that physical exercising is adjusted to development abilities of an exerciser.

Explosive tempo of growth and development of young female body due to development of secondary gender features is commonly followed by stagnation in development of motor skills and it is very useful to find programs of body exercising suitable for young female body, in this sensitive period, which stimulate psycho-motor skills. Promotion of physical activity in this sensitive period of growing up is very important. Motor development includes continuous changes of motor behavior in a certain time period, cause by interaction between demands of motor task, biology of an individual and conditions of environment (Hernandez, et. al., 2020). In its original form, Pilates method, as a concept of gradient and therapy impact on musculature was developed by German trainer Joseph H. Pilates in 20ties of the last century, who joined exercises, movement, philosophy, gymnastics, martial arts, yoga and dance using this type of activity as a healthy way of living. It is considered that this system of exercising

strengths and shapes muscles, corrects posture, improves flexibility and balance, unites body and mind and improves body shape, as a whole. Concept of exercising of all muscles, simultaneously, with constant movement shifting is the most efficient way to increase muscle endurance. Exercises are specific by number of repetitions, series of exercises and their name. Program includes 34 basic and more than 500 other exercises. Rhythm of breathing is precisely defined for each exercise. All exercises are performed in a simple way, without sudden moves with constant support of a mat. Physiological loading during Pilates lesson can be compared with medical yoga or aerobic of low intensity (Jago et al. 2006). Results of some studies (Hernandez et al 2020) show that application of Pilates method at children age have positive effect on motor development, where significant improvements in quotient of general motor skills, are identified. Pilates methods at child's age showed positive effects on motor development, where significant improvements in overall motor skills, balance, body and space organization of movement and quotient of general motor skills, were identified, after 28 sessions of Pilates trainings (Montanez and Lara, 2015). This exercise program includes techniques of conscious control of all muscle body movement where the concept of exercising is based on six fundamental principles: center (main bridge of method and "powerhouse") concentration (important for performance of exercises, "mental guidance for the body"), control (awareness of all movements during exercising), breathing (achieved in all movements, with rhythm), fluidity (coordination, flow of movements in time frame), integrated isolation (inclusion of muscles into movement). The essence of Pilates is development of spirit and body, team work and healthier lifestyle (Brignell, 2004). Pilates includes great spectrum of exercises, which are suitable, regardless the level of physical shape, for completely unprepared individuals, children and top-level athletes, as well. Pilates method showed significant improvements in the area of strength, flexibility, posture control and reduce of pain in children with muscular pathology (Hornsby & Johnston, 2019). Pilates is also very important component in training preparation of girls in esthetic sports (Ljubojevic et. al., 2008). Although increase of number of publications, which include Pilates method in different contexts and populations, is evident, (Bergamin, 2015), its approach to healthy school kids is limited. At the same time, school curriculum of P.E. doesn't follow the trends of exercising, which from day to day show scientifically based evidence on benefits of such approach. Therefore, the aim of this study is to examine effects of Pilates exercises on improvement of certain motor skills in female high school students as potentially new methods of exercising, which will provide bigger participation of female population in programs of organized physical activities.

Methods

Study design

A non-randomized controlled trial with 2x2 statistical designs was provide in this study. It included one experimental group (Pilates intervention) and one controlled group (regular PE activities) and two moments of evaluation: (1) at baseline and (2) after 16 weeks of post intervention period. The strength, flexibility and balance in each group were recorded. All participant volunteered in this study and provided informed consent prior to participation. This study was conducted according to the guidelines laid down in the Declaration of Helsinki for research of human subjects.

Participants

The survey was conducted on a sample subject of 110 female high school students of second and third grade of boarding school Gazi Husref begov madrasah in Sarajevo. The study was conducted within P.E. lessons, where 4 classes participated (only female students). Inclusion criteria states that the participants must be female, physically inactive (less than 120 min of moderate-to-vigorous physical activity per week), inexperienced at Pilates, healthy and musculoskeletal injury free. The Pilates program was done during the months of September and December. The test subjects were divided into 2 groups: The control group (CG) members had no addition physical activities (usual PE activities) during the duration of the experimental program. Women who attended 95 percent of the training sessions during the 16-week duration of the Pilates program made up the experimental group. 60 girls began the Pilates program, and of those, 55 met the requirements to be counted in the final measurement because they attended regularly. The participants in the experimental group did not engage in any other forms of physical activity during experimental program out of school facility. The test was carried out at the school gym by professors from the Faculty of Physical Education and Sports before and after the Pilates program. The temperature of the room was around 20°C. All participants volunteered in this study and provided informed consent prior to participation. This study was conducted according to the guidelines laid down in the Declaration of Helsinki for research of human subjects.

Procedures

Physical fitness

3 variables in the field of flexibility, repetitive strength and balance, were selected for evaluation of motor

skills (physical fitness). Each variable was defined by 3 tests. Variable of repetitive strength includes tests: push-ups (MSKL), raising torso from lying position (MPTL) and deep squad 30 s (MCUC); flexibility; rotation with a bat (MISK); leaning forward multi-legged (MPRR), leaning forward on the bench (MPNK); and evaluation of balance of standing on the bench longitudinally on both legs (MU2N), longitudinally on one leg (MU1O), diagonally on both legs (MP2N). Applied tests are standardized and satisfy necessary metric features (Metikoš et. al 1989).

Table 1. Description of applied Pilates program

N0	name of the exercise	Rep.	N0	name of the exercise	Rep.
1	Hundred	100x	18	Nek pull	6-8x
2	The roll-up	5-6x	19	The scissors	10-12x
3	The rollover	6-8x	20	The bicycle	10-12x
4	Leg circles	8-10x	21	Shoulder bridge	8-10x
5	Rolling like a ball	6-8x	22	Spine twist	10-12x
6	Single leg stretch	8-10 x	23	The jack knife	6-8x
7	Double leg stretch	8-10x	24	Side kicks	12-15x
8	Leg stretch	8-10x	25	Teasers	5-8x
9	Legs stretch	6-8x	26	Hip circles	5-8x
10	Crisscross	6-8x	27	Swimming	12-16x
11	Spine stretches forward	5-6x	28	The leg pulls down	6-8x
12	Open - leg rocker	6-8x	29	Leg pulls up	6-8x
13	The corkscrew	6-8x	30	Kneeling side kicks	8-10x
14	The saw	10-12x	31	Mermaid side bends	5-6 x
15	Swan dive	8-10x	32	The boomerang	8-10x
16	Single leg kicks	10-12x	33	The seal	8-10x
17	Double leg kicks	8-10x	34	Push-ups	3-6x

Pilates exercise intervention

Pilates program lasted for 4 months, one session of Pilates a week, for 40 minutes (16 sessions, in total). In introductory-preparation part of the lesson classical set of exercises was conducted, in controlled group and program of Pilates exercises was conducted in experimental group. Pilates is defined as unique and specific system of combined exercises of stretching, strength and balance (Siler, 2005). Program was conducted by teacher of P.E. and licensed Pilates instructor and it was conducted according to series of exercises from the book "The Pilates® Body" (Siler, 2005). 34 Pilates exercises (table 1), which were performed in a precisely defined order and number of repetitions, where quality is the most important than quantity, are used in each session. Breathing is precisely defined in each exercise and the whole body is treated (there were no isolated exercises of strength). At the same time, in each exercise's muscles were built and stretched. All exercises were performed in ground position on the mat i.e., mat Pilates technique. In the first 8 sessions all exercises were performed in simpler beginner's version, and the following 8 sessions included the same exercises but in more advanced version of performance. It Is insisted on concentrations (kinesthetic consciousness) in performance of each exercise. Between each exercise there was enough time (15-20 sec) and explanation of the following exercise and the constant correction and insisting on proper, conscious and slower performance of the exercise. Table 1 displays Pilates program.

Statistical analysis

The obtained results were analyzed with the statistical package SPSS 20.0 (IBM, Armonk, NY). The basic descriptive parameters of the initial and final measurements (arithmetic mean-M and standard deviation-SD) were calculated for three variables that tested physical fitness: repetitive strength, flexibility and balance. Descriptive parameters were calculated for the complete sample, then individually for the experimental (EG) and control group (CG). The Kolmogorov-Smirnov test (K-S) was used to determine whether the analyzed results of the initial and final measurements had a normal distribution, and the results were found to be normal ($p>0.05$). An independent t-test at the level of $p<0.05$ was used to establish significant differences in repetitive strength, flexibility and balance between the experimental and control groups at the initial measurement. The dependent t-test at the level of $p<0.05$ was used to determine a significant difference between the groups' final measurement for the parameters of physical fitness. All results are presented in tables and graphs.

Results and Discussion

Table 1 displays results of tests of repetitive strength, balance and flexibility of girls in initial measurement in both control and experimental group. Based on means of p-value it is noticed that there is no statistically significant difference between control and experimental group in initial measurement, which indicates that groups of subjects are homogeny, before the beginning of experimental program and it is assumed that positive effects of experimental program will be shown due to absence of differences in initial measurement. In order to determine partial differences between of results of measured motor quality between experimental and control group of examinees in the final state, T-test for independent of samples (Table 2) was applied. Means of T-test were significant on the level (Sig = or < .05). It is noticed that in all variables for evaluation of balance there are statistically significant differences on the level (Sig. 0.00). There are no statistically significant differences in variables for evaluation of flexibility. Statistically significant differences appear in variables for evaluation of repetitive strength; push-ups ($Sig.<0.01$).

Table 2. The difference between the experimental and control groups at the initial measurement

	Total sample (n=110)		CG (n=55)		EG (n=55)		
Variable	M	SD	M	SD	M	SD	*p-Value*
Repetitive strength							
MSKL	5.59	4.36	4.56	4.41	6.62	4.318	.08
MPTL	19.81	9.11	20.58	8.827	19.05	9.390	.39
MČUČ	24.45	10.86	26.85	9.995	22.05	11.726	.07
Flexibility							
MISK	116.57	17.24	118.87	20.309	114.27	14.170	.17
MPRR	54.68	8.31	54.25	8.959	55.11	7.969	.59
MPRK	35.54	4.81	35.64	4.893	35.45	4.733	.84
Balance							
MU20	17.31	13.94	23.67	18.702	10.95	9.187	.08
MU10	21.52	15.35	31.89	20.639	11.15	10.062	.09
MP20	11.36	10.17	16.45	16.394	6.27	3.956	.56

Legend: EG-experimental group; CG – control group; push-ups (MSKL), raising torso from lying position (MPTL) and deep squad 30 s (MCUC); flexibility; rotation with a bat (MISK);
leaning forward multi-legged (MPRR)
leaning forward on the bench (MPNK);
and evaluation of balance of standing on the bench longitudinally on both legs (MU2N), longitudinally on one leg (MU1O),
diagonally on both legs (MP2N);
M-arithmetic mean, SD-standard deviation.

After conducted experimental program, results of the study showed that there are statistically significant differences between control and experimental group in all variables for evaluation of balance, where better results had examinees that did Pilates. In order to achieve posture control, harmonic interaction between nervous system through vestibular, visual, kinesthetic and muscular bone system, which includes bio-mechanic and neuro-functional relations (Shumway-Cook, 2003). Building muscles, which make center of the body through principle of centering, Pilates exercises activate sensor motor systems, responsible for balance and dynamic posture control. Integration i.e. inclusion of all muscles in movement, Pilates exercises help with better location of center of gravity of body, stabilize torso and pelvis during movement, maintain suitable leveling spinal column against impact of gravitation, giving important support base of movement of the whole body. Considering relation between center of gravity, posture and balance it is assumed that Pilates improves posture compliance and motor coordination which conditioned effect of improvement of maintenance of balance position of examinees of experimental group. It is possible that these effects are connected to specific exercises, that are used in this study protocol, such as: spine stretching " vertebrae- one by one", "rolling like a ball", "rolling with open legs", "corkscrew", because these exercises improve body awareness and therefore students become aware of mobilization of each segment of every vertebrae, including cervical part of the spine (vestibular position) and integration of all information which come from the environment (visual system) , as well. Results of previous studies (Thalia 2019) show that Pilates is efficient in: improving posture balance in children, increase of integration and use of visual and vestibular system. Pilates improves strength of core and flexibility (Kloubec, 2010), posture and balance (Alves de Araújo et.al, 2012).

Table 3. The differences between the experimental and control groups at the final measurement

Variable	N	Group	M	SD	t	SIG.	ES
REPETITIVE STRENGTH							
MSKL	55	E	8.07	4.59	2.52	.01	0.47
MSKL	55	K	5.95	4.24			
MPTL	55	E	21.42	9.36	-0.34	.73	0.06
MPTL	55	K	22.02	8.88			
MCUC	55	E	24.65	11.44	-1.80	.07	0.34
MCUC	55	K	28.36	10.01			
FLEXIBILTY							
MISK	55	E	113.58	14.07	-1.40	.16	0.26
MISK	55	K	118.24	20.164			
MPRR	55	E	54.45	8.11	0.40	.68	0.07
MPRR	55	K	53.80	8.88			
MPRK	55	E	36.09	4.65	-0.13	.89	0.02
MPRK	55	K	36.22	4.94			
BALANCE							
MU2O	55	E	12.24	8.73	-4.39	.00	0.83
MU2O	55	K	24.31	18.38			
MU1O	55	E	12.96	9.59	-6.46	.00	1.23
MU1O	55	K	32.45	20.18			
MP2O	55	E	8.47	3.73	-4.14	.00	0.79
MP2O	55	K	17.67	16.03			

Legend: EG-experimental group; CG – control group; push-ups (MSKL), raising torso from lying position (MPTL) and deep squad 30 s (MCUC); flexibility; rotation with a bat (MISK); leaning forward multi-legged (MPRR), leaning forward on the bench (MPNK);
and evaluation of balance of standing on the bench longitudinally on both legs (MU2N), longitudinally on one leg (MU1O),
diagonally on both legs (MP2N);
M-arithmetic mean, SD-standard deviation;
SIG. – statistical significance; ES-effect size

Pilates method integrates principles that demand that all exercises are performed with maximal concentration, coordinated breathing and bigger fluidity and precision, which is very important in achieving better perceptive sense of one's own body in space and therefore maintaining better balance. The principle, which is applied in performance of all exercises demands maximal focus on proper performance of movement and awareness of body position in space, which is additional advantage of application of this program in female high school students, that are in intense phase of growth and development and can be psychological instable, which has negative effect on maintenance of balanced position. Also, in Pilates exercises the emphasize is on continuous control of "longed body position" and spine stretch upwards, which significantly contributes to improvement of body posture, where position of head dictates position of the whole body and influences on better maintenance of balance position. Proper use of muscles and dynamic balance, respectively, between

the ones that bend and the ones that straighten out the body, we keep straight position and balanced position. Statistically significant differences in test of flexibility between control and experimental group were not measured. The question arises why there were no significant differences in the area of tests of flexibility. Increase of flexibility hasn't occurred because the volume of training once a week is not sufficient for improvement of this motor skill. In order to maintain the level of achieved flexibility of exercise of stretching, it is necessary to perform it at least three times a week, and in order to achieve flexibility of the exercise, it needs to be done every day. Group of authors (Cibinello, de Jesus Neves, Carvalho, Valenciano, & Fujisawa, 2020) came to similar data. They observed effects of Pilates on flexibility of the back kinetic chain and mobility of torso in school children aged from 8 to 12, two times a week, in 4-month period. Their results showed that there were no differences in flexibility of the last chain and mobility of the torso between school children, that were subjected to Pilates exercises and the control group. However, children that participated in Pilates program had improvements in flexibility results. Pilates treats the whole body (there are no isolated exercises of strength) and exercises in this study caused strengthening pectoral girdle and torso, which is an important factor of improvement of repetitive strength at this age of female students. This is especially important because it is known that school children spend a lot of time in front of the screen /computers, tablets and mobile phones) therefore head position to the front is very common and it is defined as anterior position of cervical spine, which is connected to bad posture, tiredness, muscle misbalance and neck pain. Practice shows that the most common exercise for strengthening muscles of upper part of the body that are performed by female students in P.E. lessons are push-ups, that most of female population perform less in relation to men. Prskalo (2016) states that gender becomes a factor which needs to be respected, in terms of dozing and loading and selection of the content. It is not recommended to prescribe a recipe of male training to women, which is featured by gracile built and specific body structure, which limits possibilities. Differences are increased with the puberty, because muscles of girls are less developed than in boys, bones are gentler and body fat is more massive and differently distributed (Prskalo, Sporiš 2016). With its integral approach Pilates gives opportunities in selection of the contents and dosage of loading especially in the contexts of development of repetitive strength of upper part of the body of girls in relation to classical shape exercises. Comparing Pilates with classical shape exercises, that are used in preparation part of the lesson of P.E., we can conclude that Pilates can be excellent substitute or complement to classical program of shape exercises. The advantage reflects in exercises that treat the whole body and strengthen and stretch musculature with maximal consciousness of correct performance of movements and increase concentration and therefore establishes better balance position. This type of exercising is desirable in period of growth and development of women population because it enables development of balance and strength of muscles. It would also be good to examine effects of the group programs of fitness in introductory-preparation part of the lesson, especially the ones that are performed with music. Also, teachers should be additionally educated and trained. Disadvantage of the study is relatively small number of female subjects.

Conclusion

Although Pilates is present for long period of time, it has taken a leading role among group fitness programs in the last few years and tendency of its growth is constantly rising and its application in P.E. lessons. Each exercise of Pilates activates a great number of muscles; therefore, results are shown quickly. Results of this study confirm positive effects of Pilates exercises on improvement of posture balance and repetitive strength in female students of experimental group. When comparing two groups it is noticed that effects of Pilates method were more pronounced in relation to classical exercises and it is suggested that Pilates exercises should be used in as additional tool in P.E lessons. This study proves that female students can improve their muscle endurance and balance by using Pilates exercises, which do not demand additional equipment or high-level skills or previous knowledge. With its integral approach to the body, Pilates enables smarter exercise selection and thus a more efficient approach to load dosage, especially for female population. There were no significant differences in flexibility because development of flexibility requires greater volume of Pilates exercises on weekly basis.

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