FACTA UNIVERSITATIS
Series: **Physical Education and Sport**, Vol. 22, No 1, 2024, pp. 33 - 47
https://doi.org/10.22190/FUPES231206004A

Research article

ADAPTIVE CHANGES IN BODY COMPOSITION UNDER THE INFLUENCE OF THE CORE BODY BALL PILATES TRAINING

UDC 796.012.1:613.71

Ashrf Nouri Abohllala, Nataša Branković, Nebojša Trajković, Nenad Stojiljković, Stevan Stamenković, Sreten Marković, Suzana Branković, Uroš Nikolić

Faculty of Sport and Physical Education, University of Niš, Serbia

ORCID iDs: Ashrf Nouri Abohllala (N/A)
Nataša Branković https://orcid.org/0000-0001-9340-1310
Nebojša Trajković https://orcid.org/0000-0001-6276-3052
Nenad Stojiljković https://orcid.org/0000-0002-8064-4388
Stevan Stamenković https://orcid.org/0000-0002-3835-4838
Sreten Marković (N/A)
Suzana Branković (N/A)
Uroš Nikolić (N/A)

Abstract. *Body composition is a fitness component closely associated with health and the efficiency of sports performance, making it an integral aspect of research in sports medicine sciences. Implementing appropriate training programs results in suitable physiological adaptations and a notable enhancement in body composition. This study determined the effectiveness of a 10-week body core training conducted on a Pilates ball on the body composition of adolescent non-athletes. The sample of 48 respondents was randomly divided into an experimental (n=24) and a control group (n=24.) The experimental group performed the ball Pilates program twice a week during regular physical education classes, while the control group carried out a standard physical and health education program. The experimental program consisted of balanced sitting exercises, stabilization endurance exercises, and dynamic exercises on a Pilates ball to strengthen the trunk stabilizer muscles. Before the beginning and at the end of the experimental period, the absolute and relative values of the body fat mass and the absolute values of the skeletal muscle mass were measured in both groups of participants. Statistically significant improvements and moderate effects were determined in all body composition parameters within the experimental group when the final measurements were compared to the initial ones. In the control group of respondents, improvements were only numerical and did not reach statistical significance. At the final measurement, statistically significant differences and moderate effects of the experimental treatment in skeletal muscle and body fat mass were determined. The findings of the study confirm the effectiveness of core body training on a Pilates ball in enhancing the body composition of adolescent non-athletes.*

Key words: *effects, adolescents, lean body mass, fat body mass, core stability, Pilates ball*

Received December 6, 2023 / Accepted April 1, 2024
Corresponding author: Nebojša Trajković
Faculty of Sport and Physical Education, University of Niš, Čarnojevićeva 10A, 18000 Niš, Serbia
E-mail: nele_trajce@yahoo.com

INTRODUCTION

Pilates on a ball is a conditioning and body-shaping method rooted in stretching and strengthening exercises designed to enhance body posture, joint health, and core stability and mobility. The core, or the body's center, encompasses the musculoskeletal structures comprising the lumbo-pelvic-hip complex (LPHC) and the muscles that connect the pelvis to the upper and lower extremities (Clark, Lucett, McGill, Montel, & Sutton, 2018). Core muscles play a pivotal role in stabilizing the LPH complex and transmitting force from the core to the extremities, ultimately enhancing neuromuscular efficiency throughout the entire kinetic chain's system of motion (Gurtner, 2014). This is why their development is crucial and integral to most training programs.

Core training encompasses exercises performed in different training zones, leading to physiological adaptations in various body tissues. As exercise intensity and volume progress throughout the training period, Pilates ball training includes exercises in low (60–70% of maximum heart rate [HRmax], moderate (70–80% of HRmax), and high-intensity zones (80-90% of HRmax)), especially when performing more complex plank exercises. During aerobic exercise in the low and moderate-intensity zones, which dominate during warm-up and dynamic exercises on the Pilates ball, energy is sourced from the combustion of glucose and free fatty acids. Stabilization endurance exercises, such as plank exercises, prevent the loss of lean body mass resulting from physical inactivity and effectively enhance the muscular tone of the entire body, particularly the core muscles. Numerous studies have demonstrated that regular engagement in plank exercises significantly increases lean body mass (Buttichak, Leelayuwat, Bumrerrajand, & Boonprakob, 2019; Raj & Pramod, 2012; Ružić, 2020) while notably reducing body fat mass (Anant & Venugopal 2021; Buttichak et al., 2019; Cakmakçi, 2011; Prakash, James, Sivakumar, & Dharini, 2021; Raj & Pramod, 2012; Ružić, 2020; Srinivasulu & Amudhan, 2018; Welling & Nitsure, 2015; Wrotniak, Whalen, Forsyth, & Taylor, 2001). Although the established decrease in body fat mass can generally be attributed to increased oxidation of fatty acids during exercise in the low to moderate intensity zone, the application of plank exercises is also associated with a tendency to decrease the fat component of body composition and increase the basal metabolic rate (Park, Lee, Heo, & Jee, 2021).

Maintaining an optimal level of fat and lean components of the body is vital for a healthy body composition and, thus, for the overall health form of an individual (Ayers & Sariscsany, 2010). On average, the fat-to-muscle mass ratio in females is 28:39%, and in men 18:42% (Pavlica & Rakić, 2019, p. 80). Increased values of body fat mass are highly correlated with increased cardiovascular morbidity and mortality, type 2 diabetes, and lipid and lipoprotein disorders (Badimon, Padró, & Vilahur, 2012; Heyward & Wagner, 2004; Pavlica & Rakić, 2019). In addition, studies indicate health consequences due to low lean body mass values, especially in physically inactive and obese people. A four times increased prevalence of cardiometabolic diseases such as dyslipidemia, cardiovascular disease, and type 2 diabetes was found in persons with low compared to persons with lean body mass reference values (Khazem et al., 2018). Decreased muscle mass values are also closely related to decreased physical functions and quality of life and are considered significant predictors of morbidity and mortality (Pavlica & Rakić, 2019; Prado et al., 2018).

In addition to physical activity, physiological adaptations in body composition are conditioned by numerous endogenous and exogenous factors, such as genetic factors, lifestyle, gender, age, caloric intake, food quality, sleep quality, stress, and other factors. Generally, regular physical activity with proper nutrition is considered a dominant factor determining body composition (Welling & Nitsure, 2015; Wrotniak et al., 2001). An optimal dosage of training stimuli, such as frequency, duration and intensity of applied exercises according to the exercisers' initial fitness and age, is very important (Jakičić et al., 2001). According to Olson et al. (2004), the minimum exercise duration to burn fat should not be less than 30 minutes.

Although some studies show that an 8-week period with a frequency of two training sessions per week lasting for 45-60 minutes is an adequate training stimulus for causing adaptive changes in body composition in obese children and adolescents (Wrotniak et al., 2001), most studies show that high frequency of training sessions is required for achieving similar training effects (Anant & Venugopal, 2021; Cakmakçi, 2011; Prakash et al., 2021; Vispute, Smith, LeCheminant, & Hurley, 2011; Welling & Nitsure, 2015) or longer duration of the training period (Buttichak et al., 2019; Khajehlandi & Mohammadi, 2021; Prakash et al., 2021; Raj & Pramod, 2012; Srinivasulu & Amudhan, 2018). At the same time, it should be considered that the increase in bone density and quality depends on nutrition to a significant extent.

In contrast to most studies, some research findings challenge the effectiveness of Pilates ball exercises in inducing adaptive changes in body composition (Vispute et al., 2011; Yaprak, 2018; Yaprak & Küçükkubaş 2020). Such results often stem from insufficiently addressing the components of training, encompassing frequency, intensity, duration, and the selection of training activities (Segal, Hein, & Basford, 2004). It is worth noting that individuals with a normal weight tend to experience slower weight loss than those who are overfed or obese (Jakicic et al., 2001).

Given the observed disparities in the results of various studies, there is a need for further research to provide a more comprehensive understanding of this issue. The primary objective of this study is to investigate the effect of core body training on a Pilates ball on the adaptive changes in the body composition of young adolescent non-athletes.

METHOD

The sample of participants

The sample of participants consisted of 48 clinically healthy female adolescents, first-grade high school students from Niš. The participants attended only regular physical and health education classes at school, prescribed by the Institute for the Advancement of Education and Upbringing of the Republic of Serbia. They were not additionally involved in any training activities for the previous six months.

Following a comprehensive introduction outlining the objectives and concept of this longitudinal research, which received approval from the Ethics Committee of the Faculty of Sport and Physical Education in Niš, the participants willingly provided their parents' written consent to participate in the study. To uphold ethical standards, the study maintained the anonymity of the participants, following the guidelines for clinical research outlined in the World Medical Association's Declaration of Helsinki (WMA, 2013). Statistical data analysis was based on the test results of the participants who did not exceed a 10% absence rate during the experimental period.

The participants were randomly assigned to either the experimental or control group, with each group consisting of 24 participants (Table 1).

Table 1 Basic anthropometric characteristics of the experimental and control group of participants (mean values ± standard deviation)

Respondents	N	A	BH (cm)	BM (kg)	BMI (kg/m^2)
EG	24	15.28 ± 0.48	162.76 ± 2.33	56.77 ± 4.08	21.43 ± 1.10
CG	24	15.06 ± 0.29	163.13 ± 2.25	54.04 ± 4.77	20.68 ± 1.54

Legend: N - number of participants; A - age (years);
BH - body height; BM - body mass; BMI - body mass index.

The sample of measuring instruments

The anthropometric characteristics of the experimental and control group of participants were determined by measuring body height, body mass and the body mass index. All measurements were carried out according to the recommendations of the International Biological Program - IBP (Weiner & Lourie, 1981).

Body height was measured using the Martin anthropometer, which measures with an accuracy of 0.1 cm. Body mass and the body mass index were measured using the body structure analyzer “Inbody 720” (Inbody 720, Tetrapolar; 8-Point Tactile Electrode System - Biospace Co. Ltd). Using the most precise methods, the body structure analyzer segmentally analyzed and determined the following body composition parameters: skeletal muscle mass (kg), body fat mass (kg) and body fat percentage (%).

The initial and final measurements of anthropometric characteristics and body composition parameters were carried out in the morning by previously trained measurers. Both measurements were carried out using the same measuring instruments and techniques. During the measurements, the participants were minimally dressed and barefoot. The participants were told not to engage in strenuous exercise for at least two days before the measurement and not to consume food or drink for three hours before the measurement.

Experimental design

The experiment was conducted in regular physical and health education classes twice a week for 45 minutes. The experimental group carried out a ball Pilates program to strengthen the muscles of the body core (Table 2) and the control group a standard physical and health education program.

The physical education classes for the control group of participant followed a traditional four-part structure, comprising an introductory (3-5 min), preparatory (8-10 min), main (25-30 min) and final phase (5 min). The participants engaged in physiological warm-up activities in the introductory phase, primarily running. The preparatory phase involved a variety of shaping exercises, some utilizing props and others not. During the main phase of the class, the regular physical education curriculum was delivered, covering topics such as volleyball, track and field, and artistic gymnastics. The final phase of the class focused on static stretching exercises targeting all major muscle groups.

The training sessions of the experimental group of participants consisted of: a) a standard warm-up, applying jogging and dynamic stretching exercises (10 minutes); b) a ball Pilates exercise program to strengthen the body’s core muscles (30 minutes); and c) a five-minute cool-down using static stretching exercises with an emphasis on stretching the core muscles. The basis of the ball Pilates program was endurance exercises on the Pilates ball and trunk flexion, extension, and rotation dynamic exercises (Table 4). The periodization of ball Pilates training was carried out through three phases, according to the guidelines taken from Clark, Lucett, McGill, Montel, & Sutton (2018):

1. the Phase of Neural-Adaptation, aimed at establishing motor control using one-dimensional exercises. In this phase, the participants performed exercises to develop static stability of the body core, and the flexion, extension, and trunk rotation exercises necessary to improve the functional training outcomes;

2. the Developmental Phase of Accumulation, aimed at improving the dynamic stability of the trunk stabilizers by applying more complex and more intense exercises;

3. the Advanced Phase of Specialization, aimed at increasing the force production of trunk stabilizers by applying structurally more complex and more energy-demanding exercises.

Table 2 Experimental program

Phase 1 / Week 1 /Pace: Slow				Phase 1 / Week 2 /Pace: Slow			
Exercises	S	REP	Time (s)	Exercises	S	REP	Time (s)
Balanced Sitting	1	/	:60 el	Balanced Sitting	1	/	:60 el
Ball Prone Bridge	2	/	:60	Ball Prone Bridge	3	/	:45
Ball Side Bridge	2	/	:60 es	Ball Side Bridge	3	/	:45 es
Ball Supine Bridge	2	/	:60	Ball Supine Bridge	3	/	:45
Ball Forward Bend	3	10	/	Ball Reverse Crunch	3	10	/
Ball Trunk Hyperextension	3	10	/	Ball Reverse Hyperextension	3	10	/
Ball Supine Hip Rotation	2	8	/	Ball Supine Hip Rotation	3	8	/
Phase 1 / Week 3/Pace: Slow				Phase 2/ Week 4/Pace: Medium			
Exercises	S S	REP	Time (s)	Exercises	S	REP	Time (s)
Balanced Sitting	2	/	:45 el	Balanced Sitting – one leg off	1	/	:60
Ball Prone Bridge	3	/	60	Single-Leg Ball Prone Bridge	2	/	:35 el
Ball Side Bridge	3	/	:60 es	Ball Side Bridge - upper leg up	2	/	:30 es
Ball Supine Bridge	33 3	/	:60 es	Ball Supine Bridge- one leg up	2	/	:30 el
Ball Forward Bend	2	10	/	Ball V-Pass	3	10	/
Ball Reverse Crunch	2	10	/	Ball Lateral Crunch	2	8 es	/
Ball Trunk Hyperextension	2	10	/	Ball Diagonal Crunch	2	8 es	/
Ball Reverse Hyperextension	2	10	/	Superman on a Ball Exercise	2	8	/
Ball Supine Hip Rotation	3	8-10	/	Ball Single-leg Hip Rotation	1	10 el	/
Phase 2 Week 5 /Pace: Medium				Phase 2 Week 6 /Pace: Medium			
Exercises	S	REP	Time (s)	Exercises	S	REP	Time (s)
Balanced Sitting – one leg off	2	/	:40 el	Balanced Sitting – one leg off	3	/	:30
Ball Single Leg Prone Bridge	2	/	:40 el	Ball Single Leg Prone Bridge	3	/	:30
Ball Side Bridge - upper leg up	2	/	:40 es	Ball Side Bridge - upper leg up	3	/	:30 es
Ball Supine Bridge - one leg up	2	/	:40 el	Ball Supine Bridge - one leg up	3	/	:30 el
Ball Pike	1	6	/	Ball Pike	1	10	/
Ball Lateral Crunch	2	10 es	/	Ball Lateral Crunch	3	8 es	/
Ball Diagonal Crunch	2	10 es	/	Ball Diagonal Crunch	3	8 es	/
Superman on a Ball Exercise	2	10	/	Superman on a Ball Exercise	2	12	/
Ball Single-leg Hip Rotation	2	7 el	/	Ball Single-leg Hip Rotation	2	10 el	/
Phase 2/ Week 7/Pace: Medium				Phase 3 / Week 8 /Pace: Medium			
Exercises	S	REP	Time (s)	Exercises	S	REP	Time (s)
Balanced Sitting – one leg off	3	/	:35	Ball 4-point Kneeling	2	/	:30
Ball Single Leg Prone Bridge	2	/	:50 el	Ball Forearm Plank	3	/	:30
Ball Side Bridge - upper leg up	2 es	/	:50 el	Ball Side Plank – elbow on ball	3 es	/	:30 es
Ball Supine Bridge - one leg up	2	/	:50 el	Ball Supine Bridge - one leg up	3	/	:35 el
Ball Pike	2	6	/	Ball Pike	2	8	/
Ball Lateral Crunch	3	10 es	/	Ball Lateral Crunch	3	12 es	/
Ball Diagonal Crunch	3	10 es	/	Ball Diagonal Crunch	3	12 es	/
Superman on a Ball Exercise	3	10	/	Superman on a Ball Exercise	3	10	/
Ball Single-leg Hip Rotation	3	8 el	/	Ball Single-leg Hip Rotation	3	10 el	/
Phase 3 / Week 9 /Pace: Medium				Phase 3/ Week 10 /Pace: Medium			
Exercises	S	REP	Time (s)	Exercises	S	REP	Time (s)
Ball 4-point Kneeling	2	/	:45	Ball 4-point Kneeling	1	/	:25
Ball Forearm Plank	3	/	:45	Ball Forearm Plank	2	/	:30
Ball Side Plank – elbow on ball	3 es	/	:45 es	Ball Side Bridge - upper leg up	3 es	/	:45 es
Ball Supine Bridge - one leg up	3	/	:45 el	Ball Supine Bridge - one leg up	3	/	:50 el
Ball Pike	2	10	/	Ball V-Pass	3	15	/
Ball Lateral Crunch	3	15 es	/	Pike	3	8	/
Ball Diagonal Crunch	3	15	/	Superman on a Ball Exercise	3	15	/
Superman on a Ball Exercise	3	12 es	/	Ball Hip Rotation	3	10 es	/
Dumbbell Russian Twist	3	10 es	/	Ball Diagonal Crunch	3	10-12 es	/
Ball Single-leg Hip Rotation	3	12 es	/	Ball Side Crunch	3	15 el	/

Legend: el - with each leg; es - on both sides; REP - the number of repetitions; S -the number of sets.

Statistical Analysis

The software package for social sciences, SPSS Statistics, version 23.0, was used for statistical data processing. The level of statistical significance was set at $p<0.05$.

Basic descriptive parameters were calculated for all the sample characteristics and body composition variables. Due to the relatively small sample of participants, the normality of data distribution was checked using the Shapiro-Wilk test (Marques de Sà, 2007).

Differences in body composition between the groups at the initial and final measurements were examined using the t-test for independent samples. To determine differences within the experimental and within the control group between the initial and final measurements, the t-test for dependent samples was used.

The effect size was estimated using the partial eta-squared (η^2p), whose values, according to Ferguson (2009), denote small effects when $0.05\leq\eta2p< 0.26$, medium effects when $0.26\leq\eta^2p<0.64$ and large effects when $0.64\leq\eta^2p$.

RESULTS

Table 3 Descriptive body composition parameters of the experimental and control groups at the initial and final measurement

		Experimental group			Control group		
	Parameter	Mean	SD	S-W	Mean	SD	S-W
IM	SMMi (kg)	22.08	3.86	.584	22.74	3.22	.588
	BFMi (kg)	17.23	4.29	.569	18.59	4.70	.591
	BFPi (%)	30.35	5.08	.772	32.38	4.96	.534
FM	SMMf (kg)	23.98	3.93	.687	23.44	3.85	.604
	BFMf (kg)	15.32	4.52	.559	17.89	4.52	.665
	BFPf (%)	27.83	5.66	.790	31.72	4.64	.586

Legend: IM - initial measurement; FM - final measurement; SMMi - skeletal muscle mass; BFM - body fat mass; BFP- body fat percentage; Mean - mean value; SD - standard deviation; S-W - the significance of Shapiro-Wilk coefficient.

Table 3 indicates the descriptive data of the body composition of the experimental and control group at the initial and final measurements. For each body composition parameter, the following parameters were calculated: mean value, standard deviation and normality indicators of results distribution *(S-W).*

At the initial and final measurement, the Shapiro-Wilk test of the skeletal muscle mass, body fat mass in kilograms and percentages did not show a significant deviation from normal distribution (*S-W* > 0.05).

Given that the distribution of the results of the body composition parameters did not significantly deviate from normal distribution in either group either at the initial or at the final measurement, one of the conditions for applying parametric statistical tests for body composition data was fulfilled.

Table 4 Differences in body composition between the experimental and control group at the initial measurement

Parameter	Group	Mean	SD	t	p	η^2_p
SMMi (kg)	EG	22.08	2.86	-0.117	0.907	0.00
	CG	22.74	2.82			
BFMi (kg)	EG	17.23	4.29	0.023	0.982	0.00
	CG	18.59	4.30			
PBFi (%)	EG	30.35	6.48	0.038	0.314	0.01
	CG	32.38	4.76			

Legend: SMM - skeletal muscle mass; BFM - body fat mass; PBF - body fat percentage; EG - experimental group; CG-control group; Mean - mean value SD - standard deviation; t - value of t-test coefficient; p - coefficient of significance of t-statistics; η^2_p - partial squared eta (measure of effect size).

The coefficients of statistical significance of the t-test for independent samples (Table 4) showed that the experimental and control group did not differ statistically significantly in any body composition parameter at the initial measurement.

Table 5 Differences in body composition between the initial and final measurements of the experimental group

Parameter	Group	Mean	SD	t	p	η^2_p
SMM (kg)	IM	22.08	2.86	7.078	0.042*	.522
	FM	23.98	1.93			
BFM (kg)	IM	17.23	4.29	-8.507	0.047*	.610
	FM	15.32	4.52			
BFP (%)	IM	30.35	6.48	-7.249	0.039*	.545
	FM	27.83	6.66			

Legend: SMM - skeletal muscle mass; BFM - body fat mass; BFP - body fat percentage; IM - initial measurement; FM- final measurement; Mean - mean value; SD - standard deviation; t - the value of the coefficient (statistics) of the t-test; p - coefficient of significance; t - statistics; η^2_p - partial squared eta (measure of effect size); * - statistical significance at the level of p<.05.

Table 5 indicates the results of the univariate differences between the initial and final measurements of the experimental group in the body composition parameters.

Upon reviewing the t-test results for dependent samples, it becomes evident that there are statistically significant differences in the body composition between the initial and final measurements of the experimental group (t_{SMM} = 7.078, p < .05; t_{BFM} = -8.507, p <.05; t_{BFP} = -7.249, p < .05).

The partial squared eta coefficient values suggest medium effects in the skeletal muscle mass (η^2p=.522), body fat mass in kilograms (η2p =.610) and body fat percentage (η^2p=.545).

Table 6 Differences in body composition between the initial and final measurements of the control group

Parameter	Measurement	Mean	SD	t	p	η^2p
SMM (kg)	IM	22.74	1.83	- 0.117	.052	.232
	FM	23.44	1.85			
BFM (kg)	IM	18.59	4.30	- 0.122	.057	.235
	FM	17.89	4.33			
BFP (%)	IM	32.38	5.76	- 0.097	.059	.228
	FM	31.72	5.79			

Legend: SMM - skeletal muscle mass; BFM - body fat mass; BFP - body fat percentage; IM - initial measurement; FM- final measurement; Mean - mean value SD - standard deviation; t - the value of the t-test coefficient (statistics); p - coefficient of significance of t - statistics; η^2_p - partial squared eta (measure of effect size).

The t-test results for dependent samples (Table 6) indicate no statistically significant differences in mean values of the body composition parameters between the initial and final measurements of the control group (t_{SMM} = - 0.117, p > .05; t_{BFM} = - 0.122, p > .05; t_{BFP} = - 0.097, p > .05). The effects size measures indicate small effects in the skeletal muscle mass (η^2p = .232), body fat mass η2p = .235) and body fat percentage (η^2p = .228).

Table 7 Differences in body composition between the experimental and control group at the final measurement

Parameter	Group	Mean	SD	t	p	η2p
SMM (kg)	EG	23.98	1.93	5.220	0.00^{**}	.497
	CG	23.44	1.85			
BFM (kg)	EG	15.32	4.52	-6.180	0.00^{**}	.526
	CG	17.89	4.10			
BFP (%)	EG	27.83	5.66	-5.623	0.00^{**}	.513
	CG	31.72	4.05			

Legend: SMM - skeletal muscle body mass; BFM - body fat mass; BFP - body fat percentage; E - experimental group; K-control group; Mean - arithmetic mean; SD - standard deviation; t - value of t-test coefficient; p - coefficient of significance of t-statistics; η^2_p - partial squared eta (measure of effect size); ** - statistical significance at the level of .01.

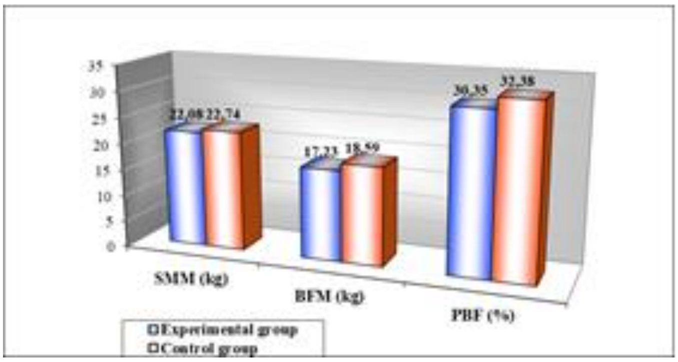
At the final measurement, the t-test for independent samples (Table 7) indicated that the groups of participants differed statistically significantly in all body composition parameters (t_{SMM}= 5.220, p <.01; t_{BFM}= - 6.180, p <.01; t_{BFP}= -5.623, p <.01) in favor of better results in the experimental group. The medium effects of the applied experimental treatment in skeletal muscle mass (η^2_p = .497), and body fat mass in kilograms (η^2_p =. 526) and percentages (η^2_p = .513) were determined.

DISCUSSION

This study aimed to compare the effectiveness of an experimental Pilates ball program and a standard Physical Education program in inducing adaptive changes in the body composition of young female adolescents. The experimental program included static and dynamic exercises on a Pilates ball, primarily focusing on strengthening the core muscles, while the standard program comprised volleyball, track and field and artistic gymnastics activities.

The findings demonstrated that the experimental program significantly improved all body composition parameters, whereas the standard program resulted in numerical improvements that did not reach statistical significance. Furthermore, at the final measurement, the experimental program exhibited significantly greater effects on enhancing body composition parameters than the standard Physical Education program.

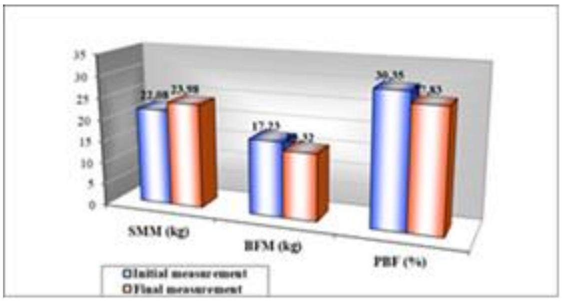
Before commencing the experiment, it was established that the groups of participants did not exhibit statistically significant differences in any body composition parameter (Graph 1). Only on a numerical level were slightly higher average values of all body composition parameters observed in the control group compared to the experimental group.



Graph 1 Intergroup differences in body composition at the initial measurement

According to McCarthy, Samani-Radia, Jebb, and Prentice (2013), the average values of skeletal muscle mass in both groups of participants were within the reference values for age and gender. However, according to Ayers and Sariscsany (2010), the average body fat mass of the control group of participants slightly increased, while the experimental group were at the upper limit of reference values. Other studies involving non-athlete participants also observed increased body fat mass values at the initial measurement (Buttichak et al., 2019; Cakmakçi, 2011; Lee, Kim, &, Lee, 2016; Vispute et al., 2011). On the contrary, lower initial body fat values than in this study were registered in studies that involved athletes (Aksen-Cengizhan, Onay, Sever, & Doğan, 2018; Anant & Venugopalb, 2021; Srinivasulu & Amudhan, 2018; Yaprak, 2018).

After the 10-week experimental period, significant improvements and moderate effects resulting from the applied experimental program were observed. These improvements were associated with an increase in skeletal muscle mass (t_{SMM}= 7.078, $p <.05$, η^2p= .522) and a reduction in body fat mass, both in terms of absolute values (t_{BFM}= -8.507, $p < .05$, η^2p = .61) and the relative ones. (t_{PBF} = 7.249, $p < .05$, η^2p= .545). The Pilates ball exercises, in conjunction with appropriate load progression throughout the experimental period, led to substantial adaptations in the experimental group's skeletal muscle mass and body fat mass (Graph 2).



Graph 2 Differences in body composition between the initial and final measurements of the experimental group

In addition to the training process, skeletal muscle mass values increase physiologically along with the increase in body height and, to a lesser extent, with the increase in body mass (Forbes, 1987; McCarthy et al., 2014) Plank exercises, which engage the whole body's musculature and not only the body core, have greatly contributed to the established adaptations of the skeletal muscle mass, increasing muscle mass even in a relatively short period (Akuthota, Ferreiro, Moore, & Fredericson, 2008; Behm, Drinkwater, Willardson, & Cowley, 2010; Park et al., 2021; Park & Park, 2019).

The obtained results align with other studies in which the participants significantly increased lean body mass (Anant &Venugopal, 2021; Buttichak et al., 2019; Raj & Pramod, 2012) and reduced body fat mass (Anant & Venugopal, 2021; Buttichak et al., 2019; Cakmakçi, 2011; Lee et al., 2016; Prakash et al., 2021; Raj & Pramod, 2012; Srinivasulu & Amudhan, 2018; Welling & Nitsure, 2015; Wrotniak et al., 2001; Yaprak, & Küçükkubaş 2020). Such results are expected considering that Pilates exercises, depending on the applied stimuli, cause adaptations of different body tissues.

Along with the increase in skeletal muscle mass, a significant decrease in body fat mass in absolute and relative values was found in the experimental group. Warm-up exercises in the introductory-preparatory phase of training and dynamic exercises on a Pilates ball were mostly performed in a low to moderate intensity zone, suitable for burning body fat. Increased consumption of calories to create energy also occurs during plank exercises (Park & Park, 2019; Park et al., 2021), especially in the later stages of training when there is an accelerated oxidation of fatty acids after carbohydrate reserves have been used up. Therefore, for getting into the lipolysis process, the optimal duration of exercise is important, which, according to evidence from the available literature, should not be shorter than 30 minutes. Thus, Bayrakdar, Demirhan, and Zorba, (2019), who conducted an 8-week high-frequency weekly training on a sample of adolescent swimmers, did not find significant changes in the reduction of body fat because the training sessions lasted only 20 minutes, so the energy for exercise was mainly obtained from carbohydrate stores and to a lesser extent due to the lipolysis process. Similar to the results of Bayrakdar et al. (2019), Yaprak and Küçükkubaş (2020) also did not find a significant decrease in the body fat mass of college students after eight weeks of body core training on an unstable surface. As the reason for the absence of significant changes in body composition, the authors mentioned above cite the training program concept in which isometric endurance exercises such as plank exercises prevailed and an inadequate number of sets and repetitions of each exercise. Even though performing plank exercises increases the consumption of calories to create energy, it is necessary to combine them with activities of low to moderate intensity for more efficient fat burning. Apart from the choice of training stimulants, adequate dosing of all other training stimuli and adequately dosed load progression are also important.

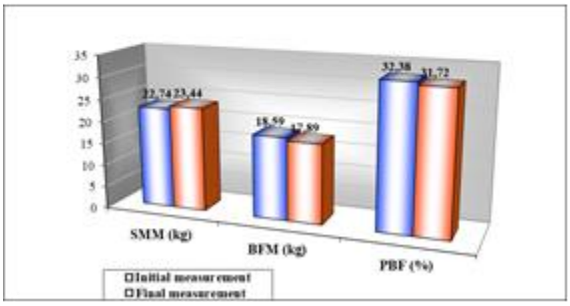
In the study mentioned above, the load progression during the training period was not as gradual or timely as in this study. Still, two training variables (the number of sets and repetitions) simultaneously increased significantly and only once, just in the middle of the training period. Such load dosage is in contrast to FITT training principles because after initial adaptations, stagnation occurs, and overtraining syndrome occurs after a sudden increase in load.

In addition, unlike the results of this study, the study conducted by Vispute et al. (2011) on a sample of non-athlete students did not confirm the effectiveness of ball Pilates on decreasing body fat mass. Namely, Vispute et al. (2011) found only numerical and not statistically significant decreases in body fat mass at the end of the 6-week experimental period. In their study, the participants were older than in this study, so the expected adaptations to training loads were less than in untrained younger participants (Bompa, 2009). Although their study lasted only six weeks, training sessions were performed five times a week, so the total number of training sessions was larger than in this study. Among other things, significant effects were not achieved due to the program concept, which in their study contained only dynamic exercises on a Pilates ball and not stabilizing endurance exercises, the performance of which leads to increased calorie consumption. This was confirmed by the 6-week study conducted by Anant and Venugopal (2021), who, in addition to dynamic exercises on a Pilates ball, also performed stabilizing endurance exercises and found significant effects in reducing body fat. The results of their study are consistent with our study and the results of other studies that combined less intense dynamic exercises with more intense stabilization endurance exercises in their program concept.

Significantly greater effects in reducing body fat than in our study were achieved in the study conducted by Srinivasulu and Amudhan (2018) on a sample of young volleyball players who decreased body fat by 25.98% at the end of the experiment. However, the authors mentioned above conducted the ball Pilates training in combination with plyometric exercises and the usual volleyball training. It is evident that these additional activities, predominantly aerobic, contributed to the established effects to a certain extent.

Generally, differences in the effectiveness of training programs applied in different studies are conditioned by the choice of exercises following the initial fitness and functional capabilities of the respondents, the intensity and duration of exercise, and the adequately dosed load progression throughout the training period. It would be preferable to perform low to moderate-intensity exercises in combination with strength training and obligatory changes in the diet regime. It is important to emphasize that variations in the degree of fat tissue adaptation certainly depend on numerous other factors, such as genetic factors, gender, age, nutrition quality and caloric intake, sleep quality, stress, status of certain hormones, and other factors that were not monitored in this study, but which would enable a more complex understanding of this issue.

In the control group of participants that implemented a standard physical education program, the determined effects of increasing skeletal muscle mass and decreasing body fat mass were small and insignificant. Although the recommended Physical Education teaching contents defined various activities, the control group did not realize them in practice but favored the volleyball and, to a lesser extent, gymnastics contents, only from the floor exercise program. Namely, the recommended Physical Education content defined contents for the development of motor and functional abilities, athletics contents, the program chosen by the students and in accordance with the school facilities, apparatus and floor exercises, the sports game program chosen by the students and following the school possibilities and corrective gymnastics exercises. Contents for developing motor and functional abilities, exercises on apparatus, and corrective gymnastics exercises were not realized, at least not during the 10-week experimental period. At the same time, it is important to emphasize that the school did not have a beam or a vaulting gymnastics horse so the exercises on the beam and vaulting gymnastics horse could not even be realized. For the reasons above, the implemented program of the control group was not in the function of improving body composition, so significant effects were not achieved. The applied exercises, frequency, duration, and intensity in regular Physical Education classes did not represent adequate training stimuli for causing significant changes in body composition (Graph 3).

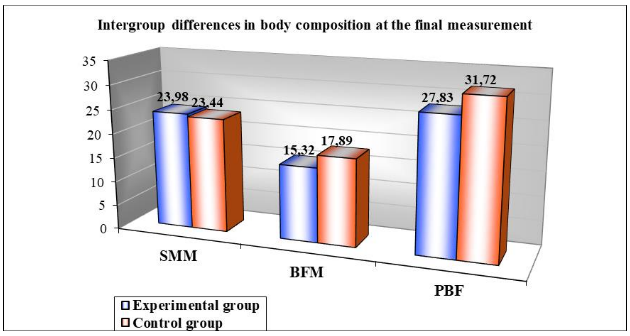


Graph 3 Differences in body composition between the initial and final measurements of the control group

At the final measurement, the groups of participants differed statistically significantly in all body composition parameters. Intergroup differences in body composition favored better results in the experimental group of participants because they had statistically significantly larger average values of skeletal muscle mass and lesser average values of body fat mass.

Medium effects of the applied experimental treatment were determined, which explain 49.7% of the variance in the results of the skeletal muscle mass, 52.6% of the variance in the results of body fat mass in kilograms, and 51.3% of the variance in the results of body fat percentage values.

The results confirmed the superiority of the 10-week body core program on a Pilates ball compared to the standard physical education program in adapting the skeletal muscle mass and body fat mass in the experimental group of participants. The obtained results are in line with the results of the study conducted by Srinivasulu and Amudhan (2018) and Prakash et al. (2021), in which the experimental group that performed ball Pilates achieved significantly greater effects in reducing body fat mass than the control group that performed usual training activities.



Graph 4 Differences between the experimental and control groups in body composition at the final measurement

However, in the study conducted by Lee et al. (2016) on a sample of obese students divided into an experimental group that performed ball Pilates in addition to aerobic training and a control group that performed only aerobic training, the groups of participants at the final measurement did not differ significantly in percentage values of body fat. The training programs of both groups of participants were carried out for eight weeks with a frequency of three training sessions per week, which lasted for 60 minutes and led to a significant reduction in body fat at the final measurement. Still, intergroup differences at the final measurement were not statistically significant. Such results were expected considering that the aerobic training carried out by the control group of participants is based on the exercise programmed to decrease body fat mass.

Conclusion

Exercising on a Pilates ball evokes appropriate physiological and structural adaptations of the various tissues in the human body. Comparing the effectiveness of the standard physical education program and the experimental core body program on a Pilates ball, the study confirmed the superiority of the experimental program in transforming skeletal muscle mass and body fat mass in adolescent girls. The findings of this study are significant primarily from the health aspect and then in the fitness field. Future studies should determine adaptive changes in body composition under the influence of training on a Pilates ball with an appropriate diet and monitor the psychological and motivational factors.

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ADAPTIVNE PROMENE U TELESNOJ KOMPOZICIJI ADOLESCENATA POD UTICAJEM TRENINGA JEZGRA TELA NA PILATES LOPTI

Telesna kompozicija je fitnes komponenta usko povezana sa zdravljem i efikasnošću sportskog performansa pa je njeno proučavanje sastavni deo istraživanja u sportsko medicinskim naukama. Primenom adekvatnih trenažnih programa dolazi do odgovarajućih fizioloških adaptacija i značajnog poboljšanja telesne kompozicije. Ovim istraživanjem je utvrđivana efikasnost desetonedeljnog treninga na pilates lopti na telesnu kompoziciju adolescentkinja, učenica prvog razreda gimnazije. Uzorak od 48 ispitanica, nasumično je bio podeljen na eksperimentalnu (n=24) *i kontrolnu grupu* (n=24)*. Eksperimentalna grupa je na časovima redovne nastave fizičkog vaspitanja dva puta nedeljno sprovodila program pilatesa na lopti dok je kontrolna grupa sprovodila standardni program fizičkog i zdravstvenog vaspitanja. Eksperimentalni program se sastojao od vežbi balansiranog sedenja, vežbi stabilizacione izdržljivosti i dinamičkih vežbi na pilates lopti za jačanje mišića stabilizatora trupa. Pre početka i na kraju eksperimentalnog perioda kod ispitanica obe grupe su izmerene apsolutne i relativne vrednosti masne mase tela i apsolutne vrednosti skeletno-mišićne mase. Na finalnom u odnosu na inicijalno merenje, kod eksperimentalne grupe su utvrđena statistički značajna poboljšanja i srednji efekti u svim parametrima telesne kompozicije. Kod ispitanica kontrolne grupe, utvrđena poboljšanja su bila numerička, a ne i statistički značajna. Na finalnom merenju utvrđene su statistički značajne razlike i srednji efekti primenjenog eksperimentalnog u skeletno-mišićnoj i masnoj masi tela. Nalazi ove studije su potvrdili efikasnost treninga stabilizatora trupa na pilates lopti u poboljšanju telesne kompozicije adolescentkinja nesportista.*

Ključne reči: *efekti, adolescenti, nemasna masa tela, masna masa tela, stabilnost jezgra tela, pilates lopta*