Research Paper

PILATES OR A FASCIA PROGRAMME TRAINING TO IMPROVE THE SIZE OF MUSCLES AND PHYSICAL ABILITIES IN HEALTHY ADULTS?

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Abstract

The objectives of this research were to evaluate two different functional training programmes with body weight, «Flowbility» (FB) which promote the fascial health and «Authentic Pilates» (AP), on physical abilities of muscles, in healthy adult students. Participants (n=58) were randomly divided into three groups, the «FB», that performed a pre-choreographed programme, the «AP», that applied the authentic series of Pilates exercises on mat, and the «Control» group, that rested. The load was increased progressively. The intervention lasted 6 weeks, with frequency 3 sessions of 45 min. per week, for each group. Three measurements were carried out (initial, final and detraining one month after the intervention). Functional tests were used to measure: strength, flexibility-mobility and functionality-balance, as an ultrasound device to measure transverse abdominal and multifidus muscle thickness. Used ANOVA analysis of variance of repeated measurements, the degree of significance was set at p=0.05. The analysis of results showed that there is statistically significant difference in performance from initial to final and retention measurement. In conclusion, practicing with «Flowbility» and «Authentic Pilates» significantly improved the physical abilities of adults, at the same level and contributed to reduction of TrA thickness at the resting phase and increased its activation.

Keywords: Pilates, body weight training, core, ultrasound, fascial system.

Introduction

Functional exercise promotes, with precision and efficiency, the ability to produce and maintain both the agility and the stability of the joints along the motor chain while performing fundamental motor patterns (Okada et al., 2011). In functional training is preferred to include many closed chain exercises (Gottschall et al., 2018), as well as multi-joint movements performed at multiple levels, thus emphasizing more on the quality of the movement and not so much on the targeted improvement of strength (Stensdotter et al., 2003). Initially, the exercises are taught with only body weight and gradually, additional resistances and unstable surfaces are used, by changing lever arm, balancing on one or two ends of upper or lower body (Stensdotter et al., 2003). Exercise with body weight has been widespread in sports and rehabilitation in recent years and applies at exercise programmes of strength, flexibility and coordination, mainly to enhance the muscle control required around the lumbar and whole spine, to maintain functional balance and effective movement (Cayot et al., 2017; Dinç & Ergin, 2019; Mills at al., 2005; Okada et al., 2011). Furthermore, it is suggested that exercise programmes aimed at stabilization of the thoracic spine, may improve the strength of the core muscles and posture (Toprak Çelenay & Özer Kaya, 2017). Also, deep muscle training programmes, contribute significantly to improve the posture (Szczygieł et al., 2018). A variety of exercise methods, which enhance the core muscles, have been recorded and used by athletes to improve their performance. In addition, these exercise methods are being used from the general population, including all ages, for a better physical health (Dinç & Ergin, 2019). Specifically, Pilates mat (PM) programme brings about an increase in the thickness of the transverse abdominal (TrA) at the contraction phase compared to the rest (Critchley et al., 2011; Endleman & Critchley, 2008) as it increases (Wang et al., 2012).

While a greater increase in thickness of the multifidus muscle (LM) and TrA, is caused when performing exercises with bodyweight, such as «superman» exercise, used the abdominal activation technique "draw-in maneuver", when not in use (Hwang & Park, 2018) that is to say causes increased activation of muscle, since according to researchers increased thickness of LM and TrA, also means increased activation of muscles (Djordjevic et al., 2015; Kiesel et al., 2007; Hodges et al., 2003). In addition to boosting strength in young adults as mentioned above, PM exercise also contributes to other functional abilities of young adults, such as improving back muscle strength and flexibility of lumbar spine and hamstrings (Wang et al., 2012). It has also been proved to be suitable for older people, as recent evidence supports, that it improves the physical performance of elderly, such as dynamic balance, lower extremity strength, hip and lumbar spine flexibility, and cardiovascular endurance (Bueno de Souza et al., 2018).

In addition to sports and rehabilitation, the general population seems to prefer to participate in body weight training programmes, which take place indoors such as gyms or homes (home workout) and outdoors such as in park. One of the most popular with greater participation exercise programme is the PM programme, created by Joseph Pilates in 1920. This is a body weight exercise that does not require equipment or highly developed abilities and it is easy to implement in a personal or group fitness routine, which can perform anywhere, e.g. home, gym etc. PM is a training method, which refers to general population of all ages including professional athletes, rehabilitation specialists and simple practitioners for a better body and mind health.

In recent years, many training programmes that use similar principles of Pilates practice have been created. The Flowbility exercise programme (FB), created by George Samiotis Physical Education Teacher in 2015, seems to be gaining popularity and has great participation at gym's classes in Greece. The name of the programme is a two-word synthetic flow and mobility. The FB includes 5 parts:

- warm- up,
- mobility of joints and muscles,
- balance,
- supports (like handstands) and
- specific core and stretching exercises.

The first 4 parts of the training programme are performed from an upright position with a set of exercises at all levels and directions and the last part performed (or take place) mainly on the ground from a sitting or lying position. The FB is described as an exercise program structured in a circular manner, with only the body weight as charge and movements performed at a slow, moderate and fast pace. Includes exercises with or without bouncing that are repeated cyclically in the session with flow (muscle-motor flow) and aim to improve mobility and balance, in different directions and with rhythmic changes. The aim of this training method is to activate the entire body in positions and angles that it is not used to receiving in everyday life, with an emphasis on improving the physical state of muscle fascia and functional mobility of all joints.

Recent research emphasizes the significance of fascia in functional training (Myers, 2011). Fascia has been reported as a unitary tensional network, which consists of sparse and dense fibrous collagenous soft connective tissues, with no separation, that goes all over the body, from top to toe, from skin to core or from birth to death (Zügel, et al., 2018; Schleip & Muller, 2012; Myers, 2011). It penetrates and encompasses all organs, muscles, bones and nerve fibres, creating an appropriate environment for the function of body system as a single whole (Adstrum et al., 2017). According to Zügel, Maganaris, Wilke et al. (2018) “The fascial system includes adipose tissue, adventitia, neurovascular sheaths, aponeuroses, deep and superficial fasciae, dermis, epineurium, joint capsules, ligaments, membranes, meninges, myofascial expansions, periostea, retinacula, septa, tendons (including endotendon/peritendon/ epitendon/paratendon), visceral fasciae, and all the intramuscular and intermuscular connective tissues, including endomysium/perimysium/epimysium”. Another term that can be used for the peritoneal network is the Extra Cellular Matrix (ECM), that may include everything in our body that isn’t cellular and it consist mainly of fibres, glue and water (Myers, 2011). The researchers Schleip and Muller (2012) report some crucial training principles, which are the following:

- The Ninja principle.
- Proprioceptive refinement principle.
- Hydration and regeneration principle.
- The Sustainability Principle.

The fascial system is far more innervated than the muscular system, so to train two basic elements of functional training, the proprioception and kinesthesia, the training should focus primarily on fascial, not muscular system. According to the above training principles and the findings of Myers (2011), which are important in training of fascial body, an exercise programme for fascia health includes a variety in terms of joint angle, tempo of training and training load. The type of exercises selected and the appropriate duration of loading and release phases are very important for the hydration and the adaptive elasticity of fascial net. In such program the most suitable exercises are circular movement like bouncing, hopping, running, walking, slow or fast micro-movements as well as large macro-movements involving the whole body, which performed smoothly with gradual slowdown and acceleration as well as a continuous flow between exercises. Moreover, because remodelling can be seen in days, weeks or even years, the implementation of programs should be applied consistently in terms of frequency of sessions.

Admittedly, people who participate at Flowbility classes, refer a feeling of physical and mental health immediately after class. This feeling lasts for hours after training, and that’s why they want to do the class again.

The AP is an exercise program that is performed at a steadily slow or medium pace and follows the same principles as FB but is performed at a constant steady pace from the beginning to the end of the session, with subsequent exercises and is more rigorous in body position during the exercises and the range of motion, with regard to the initial positioning of the body, the execution of the exercises and the use of the breath during the exercise (Pilates & Miller, 1998). In order to perform each exercise correctly, these instructions must be strictly followed, which apply the 6 basic training principles described in the method (concentration, control, concentration, flow, accuracy and breathing). According to researchers who have studied the method from the motor biomechanical point of view, by performing the exercises, applying these training principles, simultaneous activation of the local and peripheral muscles of the torso is achieved, thus helping to improve and maintain the balance of the spine (Rossi, et al., 2014).

The difference in these two exercise programs applied in the present study, except for the exercise position, where for the AP it is mainly from a sitting or lying position (supine or prone) while for the FB it is mainly from an upright position, also subject to the rigidity of the range of motion of the joints in order to maintain the alignment of the body parts during the execution of the exercises, where for the AP the training instructions must be strictly followed in order to achieve the correct alignment while in FB the movements are not so strictly controlled. The practitioner can move parts of the body, such as the limbs or pelvis, with greater freedom in terms of range and direction of movement. Moreover, differs the type of muscle activation; in the AP becomes more targeted and static activation of the core muscles, while in FB there are constant changes in body position with dynamic conditions of muscle activation.

The purpose of the study was to evaluate and compare the effect of two different body weight training programmes, «Flowbility» (FB) and «Authentic Pilates» (AP), on physical abilities(Strength, Flexibility - Mobility and Functionality – Stability) and at the size of the TrA and LM in healthy students of Democritus University of Thrace (D.U.T.H.).

Methods

Participants

To conduct the research, 58 healthy students (27 girls, 31 boys) of the Democritus University of Thrace (Greece), Department of Physical Education and Sport Science were recruited, with an average age of 20 years old. Participants who had no experience in the two exercise programmes were randomly divided into 3 groups, the "Flowbility" group (FB, n = 10 girls, the n = 10 boys), the "Authentic Pilates" group (AP, n = 12 girls, n = 16 boys) and the control group (C, n = 5girls, n = 5boys).

Experimental data collection procedure

To record the physical abilities of trainees, were used 4 functional tests. The endurance of strength of abdominal muscles (ES-ABS) was assessed by the «crunch test» (Ransdell, et al., 2003), the strength of the back muscles (F-BM) was evaluated by «Sorensen test» (Demoulin et al., 2006), the flexibility- mobility of lumbar spine and hamstrings (F/M- LS&H) was assessed by «fingertip test» (Segal et al., 2004) and the balance-functionality (index Si) at both legs was evaluated by apparatus Biodex Balance System (Arfin et al., 2014). Muscle thickness measurements were obtained using an ultrasonic apparatus (SSD-3500, ALOKA, Japan) with an electronic linear array probe of 10 MHz wave frequency and a length of 6 cm. The image signal was stored in digital form through an analogue to digital converter (Canopus, Model ADVC 100, Grass Valley Inc., USA) at a rate of 25 Hz. The primary investigator operated the ultrasound unit and did all the scanning for this study. Training of the primary investigator in the use of US included a 2-month of 1-on-1 practice with an experienced researcher (with 12-

years' experience) and a further 1-year practice with the specific measurements prior to commencement of the study. The assessments of thickness of muscle were made at resting and contraction conditions. For assessment of TRA thickness, we used the protocol proposed by Hides et al. (2007). Particularly, ultrasound (US) measurements were performed whilst the participant performed the abdominal drawing-in maneuver. Ultrasound images were obtained at rest and during contraction from the left side, while holding the drawing-in maneuver. For assessment of LM thickness, we used the prone upper extremity lifting task as described by Kiesel et al. (2007) and Brenner et al. (2007). To determine the percentage changing of TrA and LM thickness from resting phase to contraction, was used the equation «Activity-Rest/Rest × 100» (Hwang & Park, 2018; Kiesel et al., 2007). This percentage change in muscle thickness from rest to activation represented muscle activation (Kiesel et al., 2007). The same equation was used accordingly, to calculate the percentage change at the functional tests. All tests were performed in 3 time periods, before and after intervention, and one month after the end of the experimental programme, except for US test, which was performed before and after intervention, only at girls.

The intervention lasted 6 weeks, with a frequency of 3 times per week, with each session lasting 45 minutes. The FB team performed the "Plan 7" of the programme, which includes 8 min. dynamic functional warm-up (includes 10 exercises aimed to dynamic stretching and mobility, that were performed, once for 32 counts of music tempo), 30 min. main pre-choreographed programme and 7 min. cool down (includes 8 exercises aimed to mobility stretching and calm down of neuromuscular system). The main programme included 18 exercises (ex.), which were in the order of which they were executed: 2 ex. aimed to upper trunk and shoulder mobility, 3 next ex. aimed to balance at one leg and at hip mobility and core muscle endurance, 2 ex. aimed to coordination with front/ back movement and mobility of shoulders, spine, hips and ankles and leg's muscle strengthening, 4 support ex. in 3 points (2legs and 1 arm, 2 arms and 1 leg) and 4 points (2 legs & 2 arms) aimed to upper trunk, arms and gluts strengthening and thoracic- shoulder mobility and 5 ex. of core strengthening. The warm up and the main programme performed mainly from standing position, except from the core ex. which performed lying or sitting position. At the main programme the practice became with cycling method: in each cycle they started performing a couple of exercises for 64 counts (music tempo) and at the next cycle performed the old couple of ex. for 32 counts and a new couple of ex. for 64 count, until completing_the programme and then repeating the whole programme again and again.

The AP team applied the original series of Pilates mat exercises (Lessen, 2007), 37 exercises in total. Pilates ex. were performed with the method in stations (10 repetitions once each ex.) mainly at the sitting or lying position and aimed to core strengthening and improvement of joint mobility. The exercises namely are: hundred, roll up, roll over, one leg circle, rolling back, one leg stretch, double leg stretch, one straight leg stretch, double straight leg stretch, spine stretch, open legs rocker, cork-screw, saw, swan-dive, one leg kick, double kick, neck pull, scissors, bicycle, shoulder bridge, spine twist, jack knife, side kick, teaser, hip circles, swimming, leg-pull – front, leg-pull, side kick kneeling, side bend, boomerang, seal, crab, rocking, control balance, and push up.

Finally, the control group did no exercise.

Statistical analysis

After collecting data on the performance in the functional assessment test and the US test, statistical analysis was performed using SPSS 16.0 statistical package. Furthermore, analysis of variance for dependent samples on two factors (group & measurement), one of which was repeated (two-way repeated measures ANOVA, 3 × 3) was applied for functional tests and analysis of variance for dependent samples, two-way repeated measures ANOVA (3 × 2), was applied for US test. The allowing confidence interval in all tests was 95% ($p < 0.05$).

Results

One-way Anova analysis was initially used and it was found that the averages of the variables evaluated at baseline did not differ between the FB, AP and C groups ($p > .05$).

A statistically significant improvement in ES-ABS only for the team AP for girls, with values $F_{(2,28)}$= 7.48, p<.05, $F_{(2,28)}$= 2.64, p>.05 and $F_{(2,28)}$=1.68,p>.05, for AP, FB and C group respectively. Repeated measurement variance analysis revealed a statistically significant interaction between factor «group and measurement», between all levels of factor measurement for the AP group and only between the first and second measurements for the FB group, while no statistically significant was found for C group. In addition to boys, there was a statistically significant improvement in ES-ABS for FB, AP groups and a decrease for C group, with values $F_{(2,32)}$=47.419, p<.05, $F_{(2,32)}$=48.415, p<.05 και $F_{(2,32)}$= 5.991, p<.05 respectively. Repeated-measures analysis of variance showed a statistically significant interaction between factor «group and measurement», between all factor levels only for the experimental groups.

Furthermore, in the US test, at resting phase, was observed a decrease in the size of the TrA, with values $F_{(1,31)}$= 5.33, p<.05, $F_{(1,31)}$=2.40, p>.05, $F_{(1,31)}$=0.35, p>.05, for the FB, AP and C group respectively, which was statistically significant only for the FB group. Repeated-measures analysis of variance showed no statistically significant interaction between factor «group and measurement» ($F_{(2,31)}$= 2.393, p> .05.) for all groups. At the contraction phase, no significant change was seen in either group as for the LM at the rest where it decreased (p> .05). An increase in the size of the LM muscle was found in the US test, in the contraction phase, for the FB and AP, ($F_{(1,31)}$=0.03, p>.05 and $F_{(1,31)}$=0.43, p>.05, respectively) and reduction for C group ($F_{(1,31)}$=9.29, p<.05), where it was statistically significant only for C group. Repeated-measures analysis of variance showed that there was a statistically significant interaction between factor «group and measurement» ($F_{(2,31)}$= 3.99, p<.05).

As for the F/M- LS&H in girls there has been a statistically significant improvement for FB and AP group ($F_{(2,28)}$= 11.46, $F_{(2,28)}$= 36.18, p< .05, respectively), but not in C group which did not improve ($F_{(2.28)}$ = 0.611, p> .05). Repeated-measures analysis of variance showed a statistically significant interaction between factor «group and measurement», in all 3 measurements for both AP & FB groups, except for the 1^{st} in the 3^{rd} measurement for the FB group. A statistically significant improvement was also found in boys for FB and AP group ($F_{(2,32)}$= 86.14, p<.05 και $F_{(2,32)}$= 191.83, p<.05, respectively), but not in C group ($F_{(2,32)}$= 2.07, p>.05). Repeated-measures analysis of variance showed a statistically significant interaction between factor «group and measurement», between all factor levels for the FB and AP groups, while no statistically significant was found for C group.

Table 1. Means ± standard deviations (M ± SD), the F value for the index of functional tests of boys, for the three groups in the initial, final measurement and maintenance measurement.

Boys Gro-ups	Back Muscles			Endurance of ABS strength			Mobility Lumbar spine& Hamstrings		
	PRE M±SD	POST M±SD	DT M±SD	PRE- M±SD	POST M±SD	DT M±SD	PRE M±SD	POST M±SD	DT M±SD
FB	1.09 ± 0.29	2.14 ± 0.52*	1.63 ± 0.49*†	12.20 ± 9.19	27.00 ± 14.76*	17.00 ± 11.75*†	-8.60 ± 6.46	-0.50 ± 7.45 *	-1.60 ± 7.97 *
AP	0.95 ± 0.21	1.86 ± 0.71*	1.59± 0.61*†	13.43 ± 4.92	23.12 ± 9.44*	18.87 ± 6.39*†	-2.43 ± 6.34	7.12 ± 6.52*	5.81 ± 5.67*
C	1.16 ± 0.29	1.15 ± 0.17	0.99 ± 0.22	14.30 ± 8.57	11.90 ± 7.51	11.20 ± 7.29*	-5.40 ± 8.82	-4.90 ± 7.95	-6.80 ± 8.43

Data are presented as mean ± SD. FB= Flowbility group; AP= Authentic Pilates group; C = Control group; PRE= results of tests before the implementation of the experimental programme; POST= results of tests after the implementation of the experimental programme; DT= results of tests after one month of the end of the implementation of the experimental programme. Significance was set at an alpha of 0.05.
*Significant difference with baseline.
†Significant difference with second measurement.

Table 2. Means ± standard deviations (M ± SD), the F value for the index of functional tests of boys, for the three groups in the initial, final measurement and maintenance measurement

Boys Gro-ups	Balance-Functionality (index Si) at both legs right (R), left (L)					
	PRE R M±SD	PRE L M±SD	POST R M±SD	POST L M±SD	DT R M±SD	DT L M±SD
FB	12.07 ± 1.22	11.44 ± 1.42	9.84 ± 2.26*	8.63 ± 1.57*	10.21 ± 1.52*	9.79 ± 1.70*†
AP	11.97 ± 2.15	10.58 ± 2.56	9.95 ± 2.43*	8.90 ± 2.51*	11.09 ± 2.46*†	9.43 ± 2.78*
C	12.39 ± 1.42	11.31 ± 2.32	11.28 ± 1.34*	11.0 8± 2.23	12.75 ± 1.40†	11.43 ± 2.26

Data are presented as mean ± SD. FB= Flowbility group; AP= Authentic Pilates group; C = Control group; PRE= results of tests before the implementation of the experimental programme; POST= results of tests after the implementation of the experimental programme; DT= results of tests after one month of the end of the implementation of the experimental programme. Significance was set at an alpha of 0.05.
*Significant difference with baseline.
†Significant difference with second measurement

Table 3. Means ± standard deviations (M ± SD), the F value for the index of functional tests of girls, for the three groups in the initial, final measurement and maintenance measurement.

Girls Groups	Back Muscles			Endurance of ABS strength			Mobility Lumbar spine& Hamstrings		
	PRE M±SD	POST M±SD	DT M±SD	PRE- M±SD	POST M±SD	DT M±SD	PRE M±SD	POST M±SD	DT M±SD
FB	2.23 ± 0.58	2.42 ± 0.60	2.27 ± 0.95	11.10± 10.40	20.90± 8.51*	13.20 ± 8.80	11.20 ± 8.48	15.20 ± 8.12*	11.10 ± 9.55†
AP	1.83 ± 0.63	2.69 ± 1.25*	2.25 ± 1.26*†	12.41 ± 11.00	27.16 ± 28.51*	16.25 ± 14.12*†	6.04 ± 6.99	14.58 ± 6.85*	11.20 ± 9.05*†
C	2.38 ± 0.60	1.87 ± 0.66*	1.63 ± 0.63*	14.30 ± 8.57	11.90 ± 7.51	11.20 ± 7.29	7.85 ± 9.15	7.40 ± 7.15	8.55 ± 8.01

Data are presented as mean ± SD. FB= Flowbility group; AP= Authentic Pilates group; C = Control group; PRE= results of tests before the implementation of the experimental programme; POST= results of tests after the implementation of the experimental programme; DT= results of tests after one month of the end of the implementation of the experimental programme. Significance was set at an alpha of 0.05.
*Significant difference with baseline.
†Significant difference with second measurement.

Table 4. Means ± standard deviations (M ± SD), the F value for the index of functional tests of girls, for the three groups in the initial, final measurement and maintenance measurement.

Girls Groups	Balance-Functionality (index Si) at both legs right (R), left (L)					
	PRE R M±SD	PRE L M±SD	POST R M±SD	POST L M±SD	DT R M±SD	DT L M±SD
FB	10.15 ± 2.61	8.76 ± 3.28	7.87 ± 2.27*	7.68 ± 2.93*	8.61 ± 3.21*	8.14 ± 3.39
AP	7.80 ± 2.81	6.85 ± 2.44	7.20 ± 1.84	7.04 ± 2.53	7.01 ± 1.92	6.82 ± 2.20
C	9.40 ± 2.90	7.84 ± 2.38	9.60 ± 2.82	8.25 ± 2.39	10.00 ± 2.75	8.72 ± 2.31

Data are presented as mean ± SD. FB= Flowbility group; AP= Authentic Pilates group; C = Control group; PRE= results of tests before the implementation of the experimental programme; POST= results of tests after the implementation of the experimental programme; DT= results of tests after one month of the end of the implementation of the experimental programme. Significance was set at an alpha of 0.05.
*Significant difference with baseline.
†Significant difference with second measurement.

Table 5. Changing TrA thickness from rest (REST) to contraction (CON), before (PRE) and after (POST) the intervention.

	PRE (M±SD)		POST (M±SD)		PRE %	POST %
	REST	CON	REST	CON		
FB	4.13±0.93	6.53±1.29	3.60±0.63*	6.66±0.59	↑58 %	↑85%
AP	4.04±0.74	5.85±1.11	3.71±0.72	5.75±0.81	↑44.8 %	↑55%
C	3.93±1.19	6.08±1.63	4.05±1.02	6.19±1.44	↑54.7%	↑52%

Data are presented as mean± SD and as the percentage %. FB= Flowbility group; AP= Authentic Pilates group; C = Control group; PRE (M±SD) = results of tests before the intervention; POST(M±SD) = results of tests after the
intervention; PRE %/ POST %= Changing TrA thickness from rest (REST) to contraction (CON), before (PRE) and after
(POST) the intervention
Significance was set at an alpha of 0.05.
*Significant difference with baseline.

Table 6. Changing LM thickness from rest (REST) to contraction (CON), before (PRE) and after (POST) the intervention.

	PRE M±SD		POST M±SD		PRE	POST
	REST	CON	REST	CON		
FB	27.40±3.77	34.39±3.28	26.49±4.02	34.58±4.17	↑25.5%	↑30.2%
AP	24.78±1.98	33.94±2.87	24.45±2.61	34.61±3.97	↑37%	↑42%
C	27.06±3.36	32.80±2.27	25.72±3.44	29.66±2.60*	↑21.1%	↑15.2%

Data are presented as mean± SD and as the percentage %. FB= Flowbility group; AP= Authentic Pilates group; C = Control group; ;PRE (M±SD) = results of tests before the intervention; POST(M±SD) = results of tests after the intervention;
PRE %/ POST %= Changing LM thickness from rest (REST) to contraction (CON), before (PRE) and after(POST)
The intervention. Significance was set at an alpha of 0.05.
*Significant difference with baseline

Table 7. Results of functional test in the percentage % in adult girls (G) and Boys (B).

Groups	Back Muscles				Endurance of ABS strength				Mobility Lumbar spine& Hamstrings			
	PRE-POST		PRE-DT		PRE-POST		PRE-DT		PRE-POST		PRE-DT	
	B	G	B	G	B	G	B	G	B	G	B	G
FB	↑95*	↑8	↑94*	↑2	↑120*	↑88*	↑39*	↑19	↑94*	↑36*	↑81*	↓1
AP	↑96*	↑47*	↑67*	↑23*	↑72*	↑119*	↑41*	↑31*	↑393*	↑140*	↑339*	↑85*
C	↓1	↓21*	↓15	↓30*	↓17	↓17	↓22*	↓22	↑9	↓6	↓26	↑9

PRE-POST= Change in performance after 6 weeks. PRE-DT= Change in performance after 1 month compared to initial performance. ↑= improvement in performance, ↓= decrease in performance. Significance was set at an alpha of 0.05.*Significant difference with baseline.

Discussion

This study compares a quick cycle exercise programme (FB) with mobility, balance, swings, bouncing exercises, in a variety of directions and rhythmical changes, working the whole body in positions and angles forgotten in everyday life, which emphasizes at the improvement of fascial health and at functional mobility and strength at the full range of motion of joints with an exercise programme steadily slow or medium rhythmical (AP). The AP consist of the same elements but performed at a constantly rhythm from the beginning to the end of the session and it is more strict at the exercises position and at the range of motion, as well the flow between exercises is not always constant in contrast to the other programme.

According to the results of the present study, there was a significant improvement in the ES-ABS in both programs (table 5), with only 6 weeks training (3 sessions / week). Earlier studies such as Kloubec and June (2010) found improvement in the same factor by applying interventions practicing Pilates, with longer duration (12 weeks) and shorter frequency (1-2 times/ week), while Pazare et al. (2018) discovered that fewer weeks with more exercise frequency with PM (5 days per week for 4 weeks) brings positive results to the abdominal strength & endurance. However, in the current study, it has been observed that strength, in both girls and boys who participated in the AP team, was better maintained, at the detraining measure, than of those participations of FB group. That's may happen, because of the muscle activation at the AP programme is more stable and longer duration than in the FB, as a result of the difference in the rhythm and the way of performing of exercises in the two programs. The benefits of PM in ES-ABS, with a similar functional test «crunch test», discovered in a previous research, where applied 40 min. Pilates exercises for 8 weeks, 3 times per week. The researchers examined the ES-ABS at 30 and 60 min. of the test, and they found significant improvement at 30 min., but a greater improvement at 60 min. (Wang et al., 2012).

Another study which examined students, applied an 8 week program with exercises for the stabilization of thoracic spine (with duration 3 days/week, 45min/day) and found that, improved the core muscle strength (Toprak Çelenay & Özer Kaya, 2017). It is well known that the TrA muscle is one of the most important muscles of the core of the body. In this investigation, was found an increase of the muscle size of TrA, when the muscle contracts from the resting phase, before and after the intervention (table 5), but after was 27% higher than before the experimental programme. These findings are consistent with results of previous surveys of Sim et al. (2016) and Endleman and Critchley (2008), who observed, with ultrasound test, that the thickness of TrA in the contraction phase compared to the resting phase increased during Pilates exercises. Also Giacomini et al. (2016) found that practicing with AP mat, for 8 weeks (2 times/week, 60 min./session) promotes hypertrophy of the TrA (42.3%, $p<0.001$) in young women (32.4+/-10.4 years old). In addition, in the current study it was observed that the improvement of strength of TrA, is accompanied by reducing in resting phase of the muscle size after intervention at the experimental groups, with FB exceeding 4.5% by AP (12.7% & 8.2%, respectively), while in the control group there was an increase in muscle size 3.05% (table 5). Moreover, by 1st to 2nd measurement, by resting at contraction phase, the muscle size of TrA, increased 27% and 10.2% for FB and AP respectively (table 5). This reduction in muscle size at rest after the experimental exercise program means that the muscle was more sculptured after intervention (figure 1). As regards, the size of the LM muscle, not observed by this study large changes, however, an increased activation of the muscle after intervention was found [(4.7% FB, 5% AP), table 6]. Researchers Hwang and Park (Hwang & Park, 2018) also found an increase in the thickness of the LM muscle, by ultrasound, from the rest to the contraction. They applied, at participants, 12 healthy young men and women, a functional exercise «Superman» to 3 levels of difficulty, with and without the «draw-in maneuver» technique (2 groups respectively: GSE & GSE-AD). They recommended that the application of the "draw-in maneuver" technique with the superman exercise of grade 3, strengthens stability and reduces fatigue of spine muscles. Also Queiroz et al. (2010), in their research found increased activation of the LM muscle when performing Pilates exercises from a quadrupedal position. These results are in agreement with recent research of González-Gálvez et al. (2019), who found with functional tests, that Pilates training for 6 weeks (2 days / week, 55min /

session) significantly improved the endurance of trunk flexors muscles, the back muscle strength and the F/M- LS&H in adolescent students. At the present study, was observed statistically significance improvement, at these three factors in both exercise programmes (AP, FB) except for the girls who participated in the FB group, who did not significantly improve the strength of back muscles, while not maintaining significant performance in this test, as well as in terms of the flexibility and mobility of the lumbar spine and hamstrings (table 1, table 3). It could be due to the fascia health, if we take into account, that opposed to muscle strength training (in which big gains appears early on and a small percentage of them are really beneficial) the fascia changes at a slower rate and the results are more lasting (Schleip & Muller, 2012), so for some trainees the time of experiment wasn't enough to make the improvements of fascia fitness obvious on the outside. According to latest references this desired remodelling of fascia net may occur after 3 or 24 months of regular training (Vychodilová et al., 2020). The researchers Sekendiz et al. (2007), was determine that practicing with a modern PM exercise for 5 weeks (3 days / week 60min / session) can significantly improve the F/M- LS&H in adult women who are sedentary, while they found positive impacts on strength and endurance of abdominals and on strength of lower back muscles. These results are similar to the results of our intervention. On the contrary, Mostagi et al. (2015), in their research where they examined the effectiveness of the PM, compared to general exercises, at pain and functionality after 8 weeks (2 sessions / week, 60 min./ session) and follow-up three months, in 22 people with unspecified lower back pain, found that general exercises were better than PM exercises to increase F/M- LS&H. Furthermore, in this study it was observed that the boys and girls, who participated in the experimental groups, improved in their performance, in terms of the evaluation of the SI Balance Index of the right and left foot, after the intervention (table 2, table 4). The results of the balance assessment was statistical significant for the groups of boys FB (18.5%) and AP (16.9%) and girls FB (22.5%), except for group of girls AP (7.7%). In addition, one month after the intervention, the performance of the girls and boys of the FB group remained more improved (15.2%, 15.3% respectively) than that of the AP group (10%, 7.4% respectively), compared to their initial performance, where the improvement was statistically significant for all group except for the girls AP group. Recently, Watson et al. (2017) found significant increases on dancers balance by applying a core training programme for 9 weeks, 3 days a week. Moreover Yalcinkaya et al. (2017), found improvement in the balance of working young healthy women who exercised with PM, 3 times a week for 45 min., for 10 weeks. On the other hand Dinç & Ergin (2019) observed that a core strength training intervention with duration 8 week and frequency 3 times per week, did not effect on athletes balance but they found a positive effect on the explosive force and agility. Three key findings emerged from this study:

- The programme which promotes the fascial health (FB) results in the strongest and most sculpted TrA muscle from the AP programme.
- Both exercise programmes improve strength of back muscles and ES- ABS and F/M- LS&H but these benefits were better maintained in people of AP group than for individual of FB group. The FB program may need to take longer to make the benefits of exercise more apparent.
- The participants who followed the fascia health program (FB) had better adaptations, in both sexes, than Pilates group as the factors of functionality and balance are concerned.

Interestingly, in the present study the performance, after one month of the end of intervention compared to initial performance, remained high for the fascia health program (Flowbility) and Authentic Pilates groups (table 5, table 6, table 7). To conclude, it has been found that one programme which promotes the fascia health like the «Flowbility» as well as the «Authentic Pilates», contribute to improvement of physical abilities and to activation and at the size of transverse abdominal and multifidus muscles in healthy young students. Also, it is clear from the results, that the «Flowbility» needs more application time to digest the practitioner benefits in their bodies compared to «Authentic Pilates». The application of these programmes can expand to trainees to improve physical fitness and enhance functional mobility and at the field of prevention and rehabilitation injuries and chronic diseases, because of the group of core muscles is one of the most important things in this field. The importance of research lies in the fact that interventions that promote physical activity based on objective measures are necessary for the public and innovative.

Figure 1 Left: TrA at rest phase Pre intervention. Right: TrA at rest phase Post intervention

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