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IMPROVING FLEXIBILITY AND ENDURANCE OF ELDERLY WOMEN THROUGH A SIX-MONTH TRAINING PROGRAMME

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ABSTRACT
Purpose. Advancing age is associated with predictable sensory, motor and cognitive changes, which may have a potential impact on an older person's ability to function effectively in society. The purpose of this study was to assess whether two slightly different half-year-long regular training programmes had a positive effect on flexibility, range of motion and endurance in a sample population of elderly persons. Also analysed was which programme was found to be more effective. **Methods.** A group of women (*N* = 42, M = 67.1 ± 4.5 years) was chosen from retired persons clubs from Eger, Hungary. They were randomly divided into three groups. The first group (*N* = 15, M = 66.2 ± 3.8 years) took part in a one-hour-long Pilates training session three times a week, the second group (*N* = 15, *M* = 67.1 ± 5.9 years) took part in an aqua-fitness class twice a week with one Pilates class once a week and the third group (*N* = 12, M = 68.2 ± 3.2 years) was the control group. Pre-and postmeasurements were conducted on: flexion of the right shoulder and hip, lumbar spine flexion, thoracolumbar spine flexion, trunk lateral flexion on the right side, a 6-minute walk test, and a 30-second sit-to-stand test. Significant inter-group differences could be found in all of the measurements. Data were analysed using statistical software with the Paired-Samples T-test and Multivariate Analysis of Variance ($p < 0.05$). **Results.** After the six-month regular training programmes no differences were found in the control group. For the two groups subjected to the training programmes all the other variables showed significant differences. The most remarkable results for the Pilates group were with the 6-minute walk and sit-to-stand test, while for the aqua-fitness and Pilates group shoulder and hip flexion. **Conclusions.** A half-year-long training program can considerably improve the physical performance elderly adults need in everyday life.

Key words: flexibility, range of motion, endurance, Pilates, aqua-fitness

Introduction

The structure of our society is changing, causing remarkable social and sociological age related problems all over the world. It is no surprise that the 21th century has been labelled as "the century of an aging people", as older adults represent the fastest growing population segment in the world [1].

Advancing age is associated with predictable sensory, motor and cognitive changes, many of which can potentially impact an older person's ability to effectively function in society [2]. These age-related physiological changes – reductions in muscle mass, muscle strength, flexibility, vital capacity, bone mineral density, etc. – affect a broad range of body tissues, organ systems and functions, which cumulatively can affect activities of daily living (ADLs) and upholding the physical independence of older adults [3].

Not only the aging process but a sedentary lifestyle can lead to negative changes in posture, which itself can lead to contractures in connective tissues and muscles. The bones are restructured by ageing; this process can be easily seen on the structural and functional changes in vertebras and discusses [4]. Kyphosis has been shown to increase by 6% to 11% per decade for those over 55 years, and even in women without previous vertebral fractures, there is a significant risk factor for future fractures. A similar situation can be found in the case of lumbar lordosis. In addition, an important factor affecting the potential to alter the shape of the spine through exercise was found to be the flexibility of the vertebral column [5].

Decline in maximal aerobic capacity (VO_{2max}) and skeletal muscle performance with advancing age are two examples of physical ageing. Regular physical activity produces a series of physiologic responses leading to the long-term adaptation of the cardiovascular and neuroendocrine systems. The primary aim of these changes is to provide the working muscles with oxygen and nutrients [6, 7].

Experience has proven that regular physical activity is important in the prevention and management of pathological conditions [8–11]. According to the Centers for Disease Control and Prevention (CDC) and the American College of Sports and Medicine (ACSM) in 1995, it was suggested that every American needs to do at least 30 minutes of moderate exercise just three times per week [12]. This suggestion was amended with what

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types of exercises were recommended by the ACSM and American Heart Association (AHA) in 2007. A combined training programme was suggested, which contained endurance, strength, flexibility and balance training for the elderly population [13].

Therefore the purpose of the study was to assess if a half-year long regular training programme would have a positive effect on the flexibility, range of motion (ROM) and endurance in a population sample of elderly women. Furthermore, this study also analysed which of the suggested programmes were found to be more efficient – either a Pilates programme or an aqua-fitness programme combined with Pilates.

Material and methods

42 female volunteers were chosen from retired persons associations in the Hungarian town of Eger. The women were randomly assigned into three groups. The participants in the first and second groups took part in three one-hour long training sessions every week for a total of six months. The first group (N = 15, M = 66.2 ± 3.8 years) performed Pilates three times a week while the second (N = 15, M = 67.1 ± 5.9 years) took part in an aqua-fitness class twice a week with one Pilates session. The third group was a control group (N = 12, M = 68.2 ± 3.2 years). A questionnaire was filled out by the participants before the study on their physical condition (evaluated as low, moderate or vigorous), if they had any existing diseases or medical problems. The participants who did not do any sport or recreational activity were classified as those in the low physical activity (PA) group. A moderate PA was defined as participating in regularly sports activity of a moderate intensity less than three times a week, whereas a vigorous PA meant regularly taking part in a training programme at least three times a week for a minimum of 60 minutes.

Two measurements were performed on the subjects: Measurement (1) – prior to the six-month training programme, Measurement (2) – on completion of the programme. The following variables were measured: flexion of right shoulder and hip, lumbar spine flexion, thoracolumbar spine flexion, trunk lateral flexion on the right side, a six minute walk test, and 30-second sit-to-stand test. Data were analysed using IBM SPSS 17.0 statistical analysis software for Windows with a Paired-Samples T-test as well as Multivariate Analysis of Variance (MANOVA). The differences between Measurements (1) and (2) were figured by boxplots, which represented the mean, minimum and maximum values.

Flexibility was assessed by five types of active joint ROM measurements. The 6-minute walk and sit-to-stand test were chosen from the Fullerton Functional Fitness Test (FFFT) to assess endurance. The FFFT was specially developed for older adults as based on the research conducted at the Lifespan Wellness Clinic at the California State University in Fullerton, California [14]. The tested variables, in more detail, were:

1. *Flexion of right shoulder* (ROM) was measured by a goniometer (°). The humerus was moved in an anterior direction to the limit of motion in elevation (180°). This movement represented a scapular and glenohumeral motion. The goniometer's axis was placed over the centre of the humeral head.

2. *Flexion of right hip* (ROM) was measured by a goniometer (°). The subject laid down flat. The measured hip was flexed to the limit of motion (120°) while flexing the knee. The goniometer's axis was placed over the greater trochanter of the femur.

3. *Lumbar spine flexion* (ROM) was measured with a tape measure (cm). The start position was when the participant stood with feet shoulder-width apart and flexed their trunk until they reached their limit of motion. The tape measure was then used to measure that distance and then mark a point 10 cm above the spinosus process of the S2. A measurement was taken at the start position and the limit of motion, which found the lumbar spinal ROM (18 cm).

4. *Thoracolumbar spine flexion* (ROM) was measured with a tape measure (cm). The participant stood with their feet shoulder-width apart and flexed their trunk toward the limit of motion. The tape measure was then used to measure the distance between the spinosus processes of the C7 and S2. Measurement was taken at the start position and at the limit of motion. The difference between the two measures was found to be the thoracolumbar spinal ROM (10 cm).

5. *Trunk lateral flexion on the right side* (ROM) was measured with a tape measure (cm). The patient stood with their feet shoulder-width apart and laterally flexed their trunk to the limit of motion. The tape measure was then used to measure the distance between the tip of the third digit and the floor.

6. *6-minute walk test* (aerobic endurance). The subject was asked to walk around in a marked path. The subjects were allowed to stop or sit a chair if they needed rest or lost their balance and were allowed continue walking when they physically able to do so. The distance was then measured with a tape measure(m).

7. *Sit-to-stand test for 30 seconds* (endurance and lower body strength).The participant sat in a chair and was asked to stand and sit down, repeating this process for 30 seconds. The numbers of repetitions (pc) were counted.

As previously mentioned, two types of training programmes were chosen in the study by a group of physical education teachers, physiotherapists and Pilates instructors. Pilates is a form of physical training that focuses on posture, flexibility, segmental alignment and core control though posture and movement exercises [5, 15–17]. A number of strength, stretching, range of motion and balance exercises were chosen for all of the participants. The second type of training programme was one of aqua fitness, especially considered for the elderly because moving in water is often easier and less painful than on land. The buoyancy of water provides support to the joints and muscles and allows people with musculoskeletal problems to exercise with less effort and a greater range of motion. Sensory input from water pressure and temperature may decrease feelings of pain and also promotes relaxation which decreases muscle spasm and tightness. Finally, exercise intensity can be controlled by adjusting the velocity of movement in water [18].

Results

A self-made questionnaire was filled out by the participants before the programme regarding their PA (whether low, moderate, vigorous) and medical status. The two most common types of diseases noted were cardiovascular (high blood pressure, artherio- and athero- sclerosis, heart attack, etc.) and musculoskeletal (osteoporosis, arthrosis, rheumatoid arthritis, etc.). These variables were examined by physical education teachers and a physiotherapist. Based on these specialists' opinion, contraindications were established and the participants were then divided into sub-groups according to their level of physical activity and medical status (Tab. 1).

Descriptive statistics (minimum, maximum, mean and standard deviation) of the sample is presented in Table 2. When comparing the results of Measurement (1) and Measurement (2) with MANOVA among the groups, significant differences can be found in shoulder flexion ($F = 3.4$; $p = 0.044$), lumbar flexion ($F = 9.104$; $p = 0.001$) and thoracolumbar flexion ($F = 8.708$; $p = 0.001$) before the six-month training period. All these results were better in the control group (Tab. 3). This could be the result of that group's active lifestyle and their overall better physiological and medical status as based on the administered questionnaire. Regarding Measurement (2), here lumbar flexion ($F = 9.104$; $p = 0.016$), the 6-minute walk test ($F = 6.103$; $p = 0.005$) and the sit-to-stand test ($F = 4.232$; $p = 0.022$) show significant differences. Lumbar flexion was still better in the control group, but the 6-minute walk and sit-to-stand test performance was the most exceptional among the Pilates group.

On the basis of the results of the T-test, significant improvement can be found in all variables of the training programme groups, but none in the control group (Fig. 1–5). Shoulder flexion in the Pilates and aqua fit-

Table 1. Physical activity and medical status of the participants in each group

Group		Physical activity status			Medical problems		
		Low (%)	Moderate (%)	Vigorous (%)	Cardio-vascular (%)	Musculo-skeletal (%)	None (%)
Training Programme	Pilates	53	27	20	30	40	30
	Pilates & aqua-fitness	33	53	14	47	36	17
Control		33	33	34	23	27	50
Total		40	38	22	36	33	31

Table 2. Descriptive statistics and Measurements (1) and (2)

Parameter	*N*	Minimum	Maximum	Mean	SD
Age (years)	42	60	78	67.07	4.53
Shoulder flexion 1 (°)	42	105	180	137.14	22.82
Shoulder flexion 2 (°)	42	100	180	152.00	16.99
Hip flexion 1 (°)	42	60	120	95.48	14.13
Hip flexion 2 (°)	42	75	125	107.24	9.99
Lumbar flexion 1 (cm)	42	2	15	4.83	3.22
Lumbar flexion 2 (cm)	42	2	15	5.85	2.99
Thoracolumbar flexion 1 (cm)	42	0	11	4.33	2.44
Thoracolumbar flexion 2 (cm)	42	1	11	5.60	2.02
Lateral flexion 1 (cm)	42	5	21	12.43	3.76
Lateral flexion 2 (cm)	42	7	22	14.64	3.94
6' walk 1 (m)	42	255	540	398.81	80.97
6' walk 2 (m)	42	260	680	482.67	111.72
Sit-to-stand 1 (pc)	42	10	26	16.71	4.14
Sit-to-stand 2 (pc)	42	10	28	21.43	4.53

Table 3. The significant inter-group differences between Measurements (1) and (2)

Group	Parameter	*N*	Minimum	Maximum	Mean	SD
Pilates	Shoulder flexion 1 (°)	15	110	180	138.00	24.039
	Lumbar flexion 1 (cm)	15	3	5	3.67	.900
	Thoracolumbar flexion 1 (cm)	15	0	8	4.07	2.187
	Lumbar flexion 2 (cm)	15	4	5	4.73	.458
	6' walk 2 (m)	15	390	640	528.80	67.709
	Sit-to-stand 2 (pc)	15	20	28	23.87	2.532
Aqua + Pilates	Shoulder flexion 1 (°)	15	105	160	127.00	16.125
	Lumbar flexion 1 (cm)	15	2	6	3.73	1.223
	Thoracolumbar flexion 1 (cm)	15	1	5	3.00	1.069
	Lumbar flexion 2 (cm)	15	4	7	5.37	1.043
	6' walk 2 (m)	15	320	680	503.33	115.429
	Sit-to-stand 2 (pc)	15	15	24	20.67	3.519
Control	Shoulder flexion 1 (°)	12	105	180	148.75	24.227
	Lumbar flexion 1 (cm)	12	2	15	7.67	4.830
	Thoracolumbar flexion 1 (cm)	12	2	11	6.33	2.807
	Lumbar flexion 2 (cm)	12	2	15	7.83	5.024
	6' walk 2 (m)	12	260	620	399.17	112.449
	Sit-to-stand 2 (pc)	12	10	28	19.33	6.257

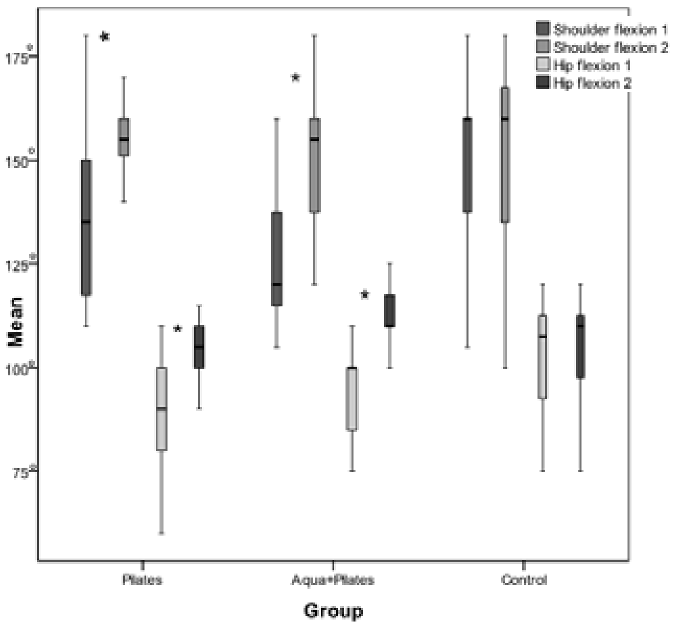

Figure 1. The boxes represent the results of the Paired Samples T-test for shoulder and hip flexibility (°). * denotes $p < 0.05$

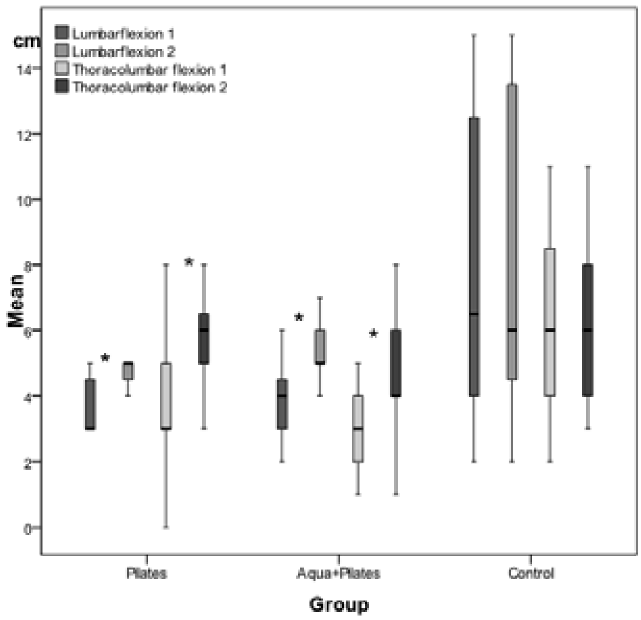

Figure 2. The boxes represent the results of the Paired Samples T-test for lumbar and thoracolumbar flexibility (cm). * denotes $p < 0.05$

ness group showed the largest improvement as well as in hip flexion. The spinal ROMs were found to have approximately the same results. The most remarkable improvement was the Pilates group's 6-minute walk test and in their sit-to-stand test.

Discussion

Numerous studies can be found about improving flexibility and endurance or other motor abilities that are needed in ADLs [5, 8, 15–18]. As was proved through our training programme, people over 60 years of age can improve their physical condition by using a combined training programme, which should include aerobic, muscle strengthening and flexibility exercises [19]. Both of our training programmes were categorized into strength, stretching, range of motion, and balance training. They included exercises for thoracic extension, general back and abdominal strengthening, lumbar (core) stabilization exercises for the deep abdominal

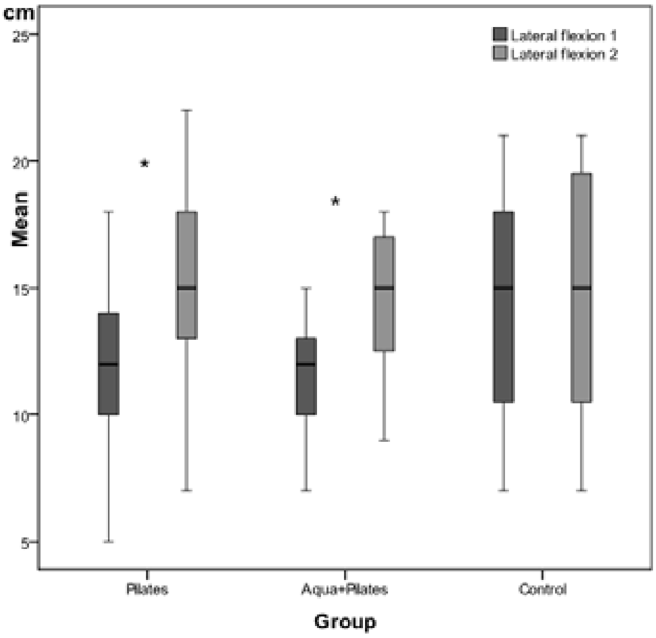

Figure 3. The boxes represent the results of the Paired Samples T-test for lumbar flexion of the right side (cm). * denotes $p < 0.05$

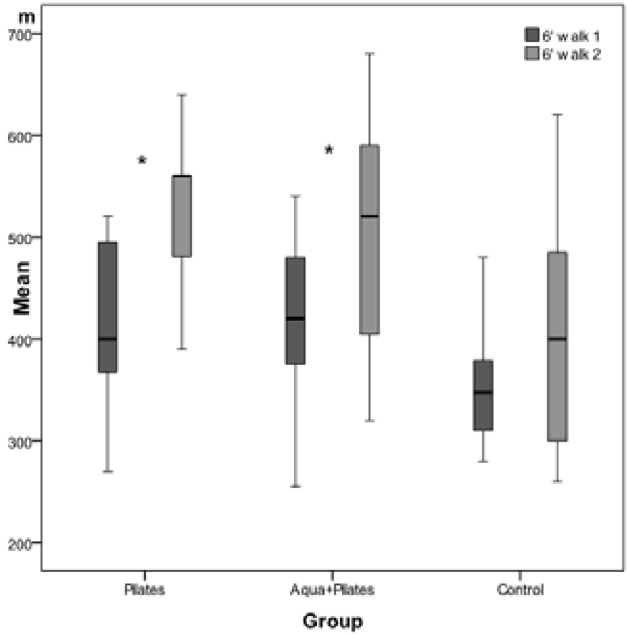

Figure 4. The boxes represent the results of the Paired Samples T-test for the 6-minute walk test (m). * denotes $p < 0.05$

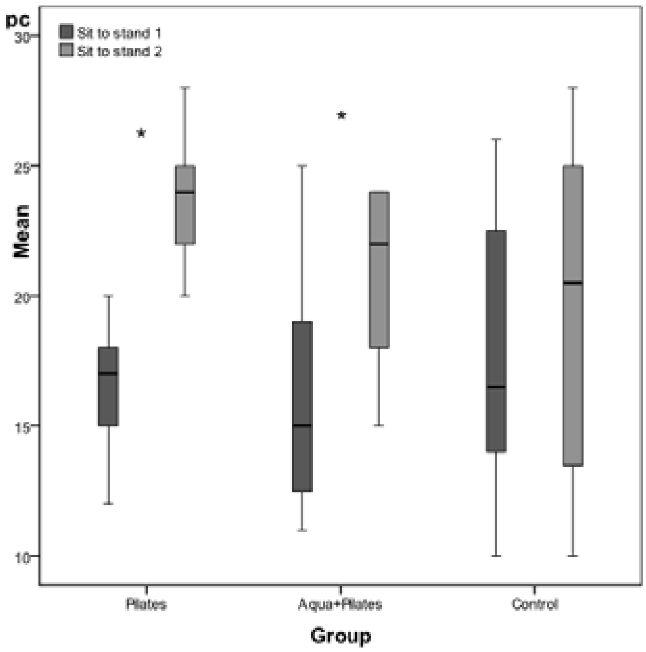

Figure 5. The boxes represent the results of the Paired Samples T-test for the sit-to-stand test (pc). * denotes $p < 0.05$

muscles, and Pilates to promote lumbo-pelvic control in various positions. As the study results show, it can be stated that modified Pilates training and Pilates combined with aqua fitness had a significant effect on all of our variables.

The Pilates approach focused on developing control of the pelvic and shoulder girdles using specific muscle recruitment strategies. As control improves, emphasis is moved to segmental alignment during movement, improving spine stability and mobility during sit to stand [15]. This control can make movement, for example during sit to stand or walking, safer and faster. The 6-minute walk and sit-to-stand test improved significantly in the Pilates group in our study, which is not only the result of endurance exercises but also of improved muscle control. As Emery et al. pointed out in 2010 [15], a Pilates training program is effective in improving abdominal strength and upper spine posture as well as in stabilizing core posture as shoulder flexion movements were performed.

On the other hand, Pilates combined with aqua fitness showed better results in the variables where flexibility was concerned. This might be the result of providing support to the joints and muscles by the natural buoyancy of water, which allows people with musculoskeletal problems to exercise with less effort and a greater range of movement. Wang et al., in 2007, [18] also found significant improvements in hip and knee flexion after a 12-week aquatic training programme.

Conclusions

The regular physical exercise programme was found to be feasible for older adults, and the high attendance rate supports the suitability of such an exercise programme for a long period of time. According to participant feedback, both training exercises – Pilates and aqua fitness – were found to be very useful for their activities of daily living, and the pleasant interaction with the instructors kept them interested and motivated throughout and after the 6 month period of the study.

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