Influence of Pilates on physical factors related to exercise performance

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Purpose: The purposes of this study were to investigate the effectiveness of Pilates exercise on Fitness Factors related to motor performance including flexibility, agility, power, balance, and muscle endurance.

Methods: Forty subjects were randomly allocated to one of two groups. The Pilates group did Pilates exercises 3 times a week for 8weeks, 60 minutes each time, and submitted to evaluation of protocols to assess sitting and reaching tests, a standing broad jump test, a side step test, a balance test using a Biodex Stability System, and muscle endurance using CSMI.

Results: The Pilates group (n=20) participated in Pilates exercises three times in a week for eight weeks. The results show significant post-test differences in the Pilates group in the following areas: flexibility, agility, power, balance and muscle endurance. There was no significant increase in the control group. Post-exercise, there was no significant difference between the Pilates and control group.

Conclusion: The Pilates method can offer significant improvement in personal flexibility, agility, power, balance, and muscle endurance. This study suggests that individuals can improve their Fitness Factors related to motor performance using Pilates exercises that do not require equipment or a high degree of skill. Further study is required to quantify the benefits of Pilates exercise.

Keywords: Motor Performance, Fitness Factors, Early exercise training, Pilates exercise

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I. Introduction

With developments in industry and information, new types of diseases have appeared.[1] Exercise has excellent effects in the prevention of musculoskeletal or cardiovascular diseases[2] and for this reason, great efforts are being expended too determine the effects of therapeutic exercise, not only for traditional variables like strength, flexibility and balance, but also for mechanism of effects of physical therapy.[3]

According to a report of the Public Health Service of the USA, physical activity offers various benefits to health, and inactivity harms the body.[4] Exercise and training programs to replace physical inaction should be easy to understand and pleasant to do, and should have a role in public health programs.[5] Pilates has been encouraged as a way of exercise that satisfies the above standards.[6]

Pilates was developed by a German-born individual named Joseph Pilates in the early 1900s. Around the end of World war 1, Pilates was applied to patients who had difficulties with movement in one hospital on the Isle of Man located between the United Kingdom and Ireland. Pilates were done during exercising as supporting the lower extremity of body by installing a shock absorbing device, and that method became known as a way of helping patient's recovery.[7] That was called the Art of Contrology or muscle control in the early days and was made with inspiration from yoga, dancing, meditation and Greek and Roman exercises. At that time, Pilates was a way of promoting motion during the early processes of rehabilitation by giving help or assistance as needed. Pilates developed more as a special method that combined physical and psychological

aspects through many experiences.[8]

Pilates has been used for years mainly by people whose work relates to dance.[6] Although Pilates has been used as an exercise related to dance, demand has been rising to use Pilates as a method of physical treatment.[9] It has come into wide use as a general exercise for health, and now it is applied not only for keeping in shape, but also for preventing and treating illnesses.[10] About 110 thousands persons in the USA incorporate Pilates into their own exercise programs, and the number of organizations have produced videos or DVDs of Pilates is increasing sharply, as statistics for 2005 show. There is also a consistent increase in goods, devices and newspaper or magazine articles associated with Pilates.[11]

Recent Pilates programs have focused on activities of the abdomen, waist, hip joint, thigh and haunches. People do 25~50 flexibility exercises with low intensity, and muscle endurance exercises repeatedly and briefly.[12] The main features of this method are exercises to enhance flexibility and body balance by correcting wrong posture and by becoming aware of body.[13] A program of core stabilization like Pilates increases flexibility and muscle endurance of the abdomen, waist and hip joint, and develops dynamic posture control and multiple motions of the waist-pelvis-hip joint.[14] So this method can be applied as an initial training program in the process rehabilitation for skilled athletes.[15] And it does not need any devices and is so simple that it is easy to learn in a short time for a beginner.[12]

Pilates has been used for athletes or persons who have medical problems like pain of the waist or rheumatoid arthritis, with emphasis on concepts of 'harmony and muscular strength with flexibility', 'improvement of posture', 'reinforcement of the core and enhancement of mobility of the extremities', 'prevention of damage', 'faciliate of functional movement'.[16]

Though Pilates has its own history of more than 80 years, there are few studies about the physiological effects of physical factors in exercise performances like flexibility, agility, dexterity, balance and muscular endurance. Also, many benefits of initial Pilates are not reported by researchers. But there are a few studies related to this study.[17-20] So, our research evaluated the effect of Pilates on physical factors related with athletic performance such as flexibility, agility, dexterity, balance and muscle endurance. We did this by having normal persons do Pilates for 8 weeks.

II. Methods

1. Subjects

This research was conducted at S hospital in Seoul from September 1st to October 30th. There were 40 subjects (27 males, 13 females). None had exercised during the previous year. They did not have musculoskeletal or neurologic disease, and were healthy and in their twenties or thirties. The subjects were randomized into two group: experimental and control (n = 20 per group).

2. Procedures

Two groups heard explanations about the process of basic measurement and had preliminary measurement of body fat percentage, aerobic capacity and muscular strength. After the experimental group did Pilates for 8 weeks, both groups had post program assessments during the last week. The control group had no intervention for 8 weeks.

1) Pilates exercises

Pilates exercises were done 3 times a week for 8 weeks, 60 minutes each session. Pilates exercise involved four actions such as strengthening and balance training . Each action consisted of three or four motionsand was repeated 10~20 times. Every motion lasted 10 seconds and subjects restedfor the same amount of time before the next motion. Resistance was increased by using dumbbells as a way of gradual loading according to the ability of the subject. and detailed methods of exercise is conducted on table 1.

3. Measures

1) Flexibility

Flexibility was measured by sit and reach tests. Using the inspection plate attached check-out board which is 25 cm upward and 40 cm downward was stuck vertically, subjects were asked to attach both ankles to, spread their legs an additional 5 cm and to affix both feet to. They were asked to place the tip of their hands as far as possible, and then the distance was checked. Subjects were asked to not bend their knees and were asked pushing a checking-device with both hands. After being measured 2 times, the maximum measurement was used.

2) Agility measurement

Table 1. Pilates exercise program

Action	Pilates motion	Material	Repetition
Core stability and abdominal strengthening	Breathing	Mat	10
	Hundred	Mat	20
	Arm series	Ball	10
	Push up	Mat	30
Quadriceps and hip muscle strengthening	Bridge	Foam roller	10
	One leg lift	Mat	30
	Prone knee bend	Mat	10
	Spine stretch	Gymball	20
Thoracic flexibility and shoulder stability	Swan dive	Mat	10
	Goal post wall	Bar	10
	Prone press up	Mat	10
Balance and body integration	Standing leg press	Bend	20
	Heel raise	Bar	20
	Full squat	Bar	20

Agility was measured by conducting a Sargent jump test. After lying in the middle of the floor, subjects stood behind standard linewith their feet shoulder length apart and jumped in place maximally, and then the distance of was checked with a tape measure. The trial was done three times and the average level was calculated.

3) Dexterity measurement

Dexterity was measured by a side step test. A line was drawn in the middle of the floor, and extra right and left parallel lines displaced 1.2 m each from the middle line were drawn. Subjects were asked to do side steps with their feet shoulder length apart. The test was conducted for 30 seconds. Subjects were given 1 point each time they crossed the line, and points were summed. If subjects did not cross the line, or did not step on the floor, the point did not count.

4) Balance measurement

Balance was measured with a Biodex Stability System (Biodex Medical System, USA), a measuring device for dynamic balance ability. This device consisted of the motion of footplate by 8 levels. The levels were initiated from level 8 which was the most stable one, to level 1 which was the most unstable one. Footplate moves all directions about 20° maximally. And once movement is checked, the data was converted into point and printed. If the fewer movements that were made, the lower point is conducted. Subjectswere asked to sustain their posture standing at footplate with one leg, holding both hands on the waist for 30 seconds. This measurement was done for each leg.

5) Muscle endurance

Muscle endurance was conducted by measuring maximum rotation of flexion and extension with a HUMAC Norm (CSMI Medical solution, USA), a measuring device for constant velocity muscle endurance. Subjects bent the knee joint while in a sitting posture on the device's chair. Subjects folded both arm on the chest to avoid associated reaction, and fixed their trunk and pelvis with a belt for stability. The pace of the test for muscle endurance was 180 degree/sec. We checked average torque through 20 repetitions that went from the maximum extension point to the maximum flexion point and back to the maximum extension again. After practicing 3 times with sub-maximum movements, and resting for 5 minutes, subjects exercised using maximum movements 3 times. Then, after rehearsal, subjects were given a rest of 10 minutes and experiments on flexion and extension were conducted. For accuracy of measurement, bias was minimized using verbal orders in a consistent way, delivered by a fully trained researcher.

4. Statistical analysis

We used descriptive statistics for analysis of average and standard deviation of each variable. We used Mann-Whitney U tests to

compare flexibility, agility, dexterity, balance, and muscle endurance the experimental and control groups. The Wilcoxon signed rank test was used to compare situations before and after Pilates. Statistic significance for each variable was defined as $p<0.05$. The SPSS program, version 12.0, was used.

III. Result

1. Subject characteristics

The general features of the experimental and control groups were assessed at baseline. Regarding the sit-and-reachtest, the standing long jump, side stepping, balance, constant velocity and muscle endurance scores were similar for both groups (table 2). There were 14 males (35.0%), and 6 females (15.0%) in the experimental group and 13 males (32.5%) and 7 females (17.5%) in the control group. The average age was 29.6 in the experimental group and 29.1 in the control group. Height and weight were 173.3 cm and 69.8 kg in the experimental group and 173.1 cm and 66.6 kg in the control group. Average body fat percentage was 23.6 % in the experimental group and 22.9 % in the control group.

2. Differences between before and after in experimental group on sit-and-reach, standing long jump, side step, balance and muscle endurance.

For the experimental group, differences between before and after on the tests are shown in table 3. Pre-Post differences for sit-and-reach, standing long jump, and side step tests increased significantly ($p<0.001$) balance for each leg decreased significantly ($p<0.001$) average muscle enduranceon extension of right and left knee joints and average muscle endurance on flexion of right and left knee joints increased significantly ($p<0.01$). The corresponding data for the control group are shown in table 3. Pre-Post differences for sit-and-reach, standing long jump, and side step tests were not significant, nor was the balance test. There were no significant differences for average muscle endurance on extension of right and left knee joint, or for average muscle endurance on flexion of the right knee.

3. Differences between experimental and control groups after exerciseprograms were done for 8 weeks.

Between group differences for sit-and-reach, standing long jump, side step, balance and muscle endurance are shown in table 4. Differences for sit-and-reach was statistically significant but not for standing long jump or side step. Balance of right leg was significantly different ($p<0.05$). But the left leg was not

Table 2. General characteristics (Mean±SD)

	EG (n=20)	CG (n=20)	z	p
Sex (Male/Female)	14/6	13/7		ns*
Age (yr)	29.60±2.13	29.15±3.67	-0.21	ns
Height (cm)	17.30±7.40	173.10±8.25	-0.95	ns
Weight (kg)	69.80±12.18	66.65±10.76	-0.94	ns
Body fat rate (%)	23.69±5.38	22.96±7.23	-0.98	ns
Sit and reach (cm)	7.21±8.13	4.99±9.89	-0.90	ns
Sargent jump (cm)	187.10±35.39	180.00±28.87	-1.13	ns
Side step (repetition)	48.20±8.72	48.70±6.01	-0.17	ns
Rt. Leg balance (index)	1.93±0.46	1.63±0.48	-2.28	ns
Lt. Leg balance (index)	1.76±0.47	1.50±0.48	-1.92	ns
Rt. knee extension average endurance (ft-lb)	74.55±21.20	72.00±21.18	-0.55	ns
Lt. knee extension average endurance (ft-lb)	70.60±21.28	71.10±21.21	-0.10	ns
Rt. knee flexion average endurance (ft-lb)	46.60±14.96	41.55±13.64	-0.81	ns
Lt. knee flexion average endurance (ft-lb)	46.05±16.01	40.95±14.09	-1.15	ns

*ns = not significant

Table 3. The difference between before and after in experimental and control group, experimental and control group post exercise on sit-and-reach, standing long jump, side step, balance and muscle endurance

	EG		CG		Difference	
	Before	After	Before	After	EG	CG
SR	7.21±8.13	10.12±7.73‡	4.99±9.89	5.80±9.76	10.12±7.73	5.80±9.76‡
SJ	187.10±5.39	198.15±2.99‡	180.00±8.87	182.25±0.18	198.15±32.99	182.25±30.18
SS	48.20±8.72	52.70±8.68‡	48.70±6.01	52.70±8.68	52.70±8.68	52.70±8.68
Rt. LB	1.93±0.46	1.29±0.16‡	1.63±0.48	1.64±1.64	1.29±0.16	1.64±1.64‡
Lt. LB	1.76±0.47	1.24±0.23‡	1.50±0.48	1.46±0.46	1.24±0.23	1.46±0.46
Rt. KE	74.55±21.20	79.70±22.84†	72.00±21.18	69.80±21.08	79.70±22.84	69.80±21.08
Lt. KE	70.60±21.28	77.35±21.45‡	71.10±21.21	68.45±21.16	77.35±21.45	68.45±21.16
Rt. KF	46.60±14.96	52.80±15.85‡	41.55±13.64	41.50±14.39	52.80±15.85	41.50±14.39‡
Lt. KF	46.05±16.01	49.25±16.54‡	40.95±14.09	39.25±14.45	49.25±16.54	39.25±14.45

†p<0.01
‡p<0.001

statistically different. There was no significance for differences in average muscle endurance on extension of right and left knee joints, but there was a significant difference on average muscle endurance on flexion of right ($p<0.05$) there was no significant difference for average muscle endurance on flexion of the left knee.

IV. Discussion

There were significant differences comparing pre-post exercise scores for the experimental group on flexibility, agility, dexterity, muscle strength and muscle endurance, and balance of right leg. There were no significant pre-post differences for the control group for flexibility, agility, dexterity, muscle strength and muscle endurance balance of right leg. Moon and Chung[21] reported significant increase in flexibility and balance results from performing of the Pilates on modern dancers, and a significant difference was found after applying a complex exercise program of Hapkido and Pilates to women of middle age.[22] Flexibility of hamstrings was reported to be significantly increased due to implementing Pilates for 12 weeks compared to 50 normal persons[6]. Roger and Gibson[23] observed increases in the measured value of the sit-and-reach test by 7.5 cm after giving a traditional Pilates program for 8 weeks to normal adults –there was a significant improvement in flexibility. The above studies show similar results to our research. The result of sit-and-reach was increased by 3 cm in our research, and this has already been shown by some studies.

Lee et al.[24] reported that there were significant increases in flexor, extensors and so on compared with control groups after applying Pilates to elementary schoolchildren. Moon and Chung[21] reported significant differences in maximum muscle strength and endurance of the trunk after targeting majors of modern dance. Park and Chang[22] found that a complex exercise program that included Pilates increased muscle strength and endurance of the trunk muscles. After performing Pilates for 12 weeks, it was occured improvement of endurance of the abdomen and the upper body,[6] and after doing Pilates for 8 weeks to normal adults, there was significant improvement on muscle endurance.,[23] In our study there was a significant increase in muscle strength of the lower body when measuring muscle strength and endurance by a constant velocity device. Muscle strength of the lower body was measured dissimilarly with previous studies. Strengthening of muscles of the trunk influenced muscle strength of the lower body. Increasing muscle strength of the trunk affected muscle strength of the lower body directly and indirectly.[25] Culligan et al.[26] reported that there was no significant difference between Pilates and pelvic floor muscle exercise to strengthen pelvic floor muscles. Pilates has a significant influence on strengthening pelvic floor muscle and seems to increase muscle strength of the lower body.

Dexterity is the ability to control the body well and make the person react smoothly with speedy motions, or an ability to transfer movement of the whole body or a part, and this can be developed by rapid cooperation between sensory nervesand

motor nerves. Dexterity is an ability that can demonstrate tremendous power in a short time.[27] In our study, the experimental group showed a statistically significant increase in dexterity and flexibility comparing performance before and after Pilates ($p<0.001$). This elements as a physical factor for ability of movement are influenced by muscle strength. So the significant improvements in this study seem to be influenced by increasing muscle strength of the lower body through Pilates exercises.

There was a significant improvement in the experimental group compared with the control group on balance of the right leg as a result of this study ($p<0.05$). This is similar to the findings of Siqueira et al.[28] who reported significant increases in balance after giving Pilates to 52 elderly women. It can be explained as a vitalization of proprioceptive senses by increased flexibility and muscle strength of the lower body. The reason for the significant difference only for the right leg is thought to be caused by Koreans using their right leg dominantly, which increased their degree of skill.

Based on the results and discussion above, Pilates done regularly for 8 weeks appears to exert a significant influence on the ability to perform exercises such as flexibility, agility, dexterity and endurance. Proper Pilates seems to increase the ability to perform exercise and increase quality of life. More studies are needed to quantify these effects and attendant risks.

V. Conclusion

This study was designed to examine the effect of 8 weeks of Pilates on the physical ability to perform exercises such as flexibility, agility, dexterity and endurance. Pilates users scored significantly better after the program than before. There were no significant Pre-Post differences for the control group. Between group differences after 8 weels pf Pilates were statistically significant for sit-and-reach, balance of right leg, and average muscle endurance on flexion of the right knee joint ($p<0.05$). Proper Pilates enhances ones ability to perform exercise and increases quality of life. More studies are needed to quantify the effects and risks of Pilates.

Author Contributions

Research design: Yu JH
Acquisition of data: Yu JH
Analysis and interpretation of data: Yu JH
Drafting of the manuscript: Lee GC
Research supervision: Lee GC

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