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Research Article

EFFECT OF 12 WEEKS PILATES BASED TRAINING ON PHYSICAL FITNESS IN YOUNG HEALTHY ADULTS

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ABSTRACT

In today's day and age of growing sedentary lifestyle, Pilates is gaining increasing adulation as a physical fitness programme. There have been many studies determining the effects of Pilates on the individual components of Physical fitness. The purpose of this study was to determine the effect of Pilates on all the components of physical fitness which comprise of core strength, muscle strength, muscle endurance, flexibility and aerobic capacity. 40 subjects participated in the study (mean age of 20.25 ± 1.54) and were divided into 2 groups on the basis of inclusion and exclusion criteria. Group A (20 subjects) received Pilates based training and Group B (20 subjects) was the control group. The Pilates group attended 45 minutes training session, 2 times per week, for a period of 12 weeks. Pre-assessment was done prior to the session followed by post-assessment using a fitness test battery. Analysis was done in SPSS 16 using t-test which showed significant level of improvement ($p \leq 0.05$) in all except aerobic capacity. The study concluded that Pilates based exercises have a positive effect on core strength, muscle strength, muscle endurance and flexibility and thus it can be used as a prescribed exercise program.

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INTRODUCTION

A study conducted by the Indian Council of Medical Research (ICMR) using the Global Physical Activity questionnaire showed that 54.4% people (age >20 yr) were inactive while 31.9% people were active and only 13.7% were highly active whereas less than 10% engaged in recreational physical activity. ^[1] Physical Fitness is defined as the body's ability to function efficiently and effectively in work and leisure activities, not only at a set point of time, but at various ages and stages within a person's life cycle. ^[2] In today's society, that is moving towards a more sedentary lifestyle there is a greater need than ever to increase the daily activity level. In recent years international research on sedentary behavior has increased dramatically and there is growing evidence that a multitude of serious health risks may be connected to "prolonged" and "excessive" sitting. There is evidence for an association between greater sedentary behavior and an increased risk of cardiovascular disease among adults, school-children and youth ^[3,4,5,6,7,8,]. Thus in the current scenario of a desk-bound lifestyle the importance of physical fitness cannot be emphasized enough. Physical activity and exercise can have

immediate and long-term health benefits. Most importantly, regular physical activity can improve the quality of life and reduce the risk of Non-communicable Diseases. Thus it is seen that urgent steps need to be initiated to promote physical activity with incorporating Pilates based exercise.

Pilates based exercises is a physical fitness system developed by Joseph Pilates^[9]. It is based on six essential principles which are: Control, concentration, centering, precision, breath control and flowing movements emphasizing on core strength (Control and precision are direct by-products of the strong mind-body connection developed by proper breathing and concentration). It really allows you to stay within your body during an exercise and to move with better biomechanics.^[9, 10] It improves flexibility, builds strength and develops control and endurance which are the basis of physical fitness, thus gaining increasing popularity in developing physical fitness. Certain tests that have routinely been used to assess components of physical fitness in national surveys and schools are shuttle walk test for cardiovascular endurance, sit and reach for flexibility, curl up, push up and planks for muscular endurance, jump and reach for leg muscle function^[25]. The inadequacy of information along

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with the paucity of research available on Pilates coupled with its necessity as mentioned above makes the study of effect of Pilates on Physical Fitness of Young Healthy adults necessary.

METHODOLOGY

Ethical approval was obtained from the departmental ethics committee of MGM School of Physiotherapy, Navi Mumbai before the commencement of the study. 40 students of MGM school of Physiotherapy, willing to participate between the age group 18-24 were selected on the basis of inclusion and exclusion criteria. An informed consent was obtained from all the participants. Subjects with any recent injury or surgery, cardiac illness, cognitive or neurological conditions were excluded from the study. Subjects were divided into 2 groups , Group A- Experimental group (n=20) and Group B- Control Group (n=20). All 40 subjects were assessed prior to commencement of the intervention using Fitness Battery Test. The following Test were included in the Fitness Battery Test.

Outcome Measure 1: Sit and Reach (SnR): This test involves sitting on the floor with legs stretched out straight ahead with feet placed flat against the box , both knees should be locked and pressed flat to the floor . With the palms facing downwards and hands on top of each other the subject reaches forward along the measuring line as far as possible. The subjects hold the position for 1-2 seconds while the distance is recorded. There should be no jerky movements. The score is recorded to the nearest centimeter or half inch as the distance reached by the hand^[18]



Figure 1

Outcome Measure 2: Jump and Reach test (JnR): The participant stands side on to a wall and reaches up with the hand closest to the wall. Keeping the feet flat on the ground , the point of the fingertips is marked or recorded. The participant then stands away from the wall and leaps vertically as high as possible using both arms and legs to assist in projecting the body upwards scoring is the difference in distance between standing reach height and jump reach height. The best of 3 attempts is recorded.^[19]



Figure 2

Outcome Measure 3: Home Push up Test: This test is modified method of the push up test. The participants kneel on the floor, hands on either side of the chest with keeping the back straight. Then the chest is lowered towards the floor till his/her elbow. The participant does maximum push ups until exhaustion^[20].



Figure 3

Outcome Measure 4: Curl up test: The test begins by the subjects lying on their back with knees bent approximately 140 degrees, feet flat on the floor and legs slightly apart with palms resting on thighs. Keeping the heels in contact with the mat the subjects curls up slowly until the inferior of the scapula clears the ground. The subject performs maximum repetitions as they can^[21].



Figure 4



Figure 5

Outcome Measures 5: Plank Test: The subject lies down in prone position, where elbow and forearm are supported on ground with the hips lifted off the floor. The subject holds the position for maximum duration.^[22]



Figure 6

Outcome Measures 6: Chair stand test: The subjects sits on the chair that is supported against a wall with feet shoulder width apart and touching the floor. From sitting position, the subject stands up completely and back down for 10 repetitions as fast as possible. The examiner records the time.^[23]



Figure 7 and 8

Outcome Measures 7: Saehan Back, Leg and Chest Dynamometer^[24]

Torso Lift (Dynamo B): The subject stands on the base with feet shoulder width apart, knees relaxed, arms straight and palms down. He/she then bends the torso at the hip, pulls the bar straight up and holds without leaning back.



Figure 9

Leg Lift (Dynamo Sq): Subject stands on the base with feet wider than shoulder width apart knees relaxed, arms straight and palms down. Ensuring that the chain is perpendicular to the base, the subject pulls the chain straight up using his legs and holds the chain without leaning back.



Figure 10

Outcome Measure 8: Incremental Shuttle Walk Test (ISWT)
:In the test the subject will be asked to walk between two cones spaced 10 meters apart. The participant will begin by walking at a very slow pace; this pace is set by a beep. The beep will get faster gradually. The subject can discontinue if they are too breathless or tired to continue.



Figure 11

RESULTS

The data obtained was analyzed using SPSS 16.0 .Baseline parameters of Age , Height and BMI are presented in Table no 1.No significant difference was noted between the groups with respect to age ($p=0.9$), BMI ($p= 0.1$) , Height ($p=0.7$) . The pre-intervention and post-intervention analysis of group A and Group B is in Table no 2 and 3 respectively. Table no 4 shows inter group analysis.

Post-intervention score of sit and reach test showed significant change in flexibility by 2.73(4.60) inches ($p=0.000$) in Group A as compared to Group B ($p = 0.795$). Between group comparison showed statistically significant change in flexibility ($p = 0.036$). Post-intervention score of curl-up showed significant change by 17.6(9.04) ($p=0.000$) and plank test by 18.7(14.87) secs ($p=0.000$) in core strength in Group A as compared to Group B ($p = 0.450$) ($p = 0.058$). Between group comparison showed statistically significant change in core strength ($p = 0.002$) ($p= 0.004$). Post-intervention score of Push-up test showed significant improvement in Upper body strength by 19.4(28.04) reps ($p =0.000$) in Group A as compared to Group B. Intergroup comparison showed statistically significant improvement in upper body strength ($p=0.000$). Post intervention score of Jump and reach test showed significant increase in lower limb strength by 3.45(1.80) inches ($p =0.000$), Trunk and lower limb Dynamometer showed significant change in back extensor by 22(13.23) ($p=0.000$) and lower extremity strength by 22.6(15.80) ($p=0.000$) in Group A as compared to Group B ($p= 1.000$) ($p= 0.142$) ($p=0.653$). Intergroup comparison showed statistically significant improvement in lower limb strength ($p = 0.005$) Trunk and lower limb Dynamometer showed significant change in back extensor ($p=0.000$) and lower limb strength ($p= 0.001$). Post Intervention score of Chair stand test showed significant change in lower limb muscle endurance by -5.5(1.29) secs ($p=0.000$). Inter group comparison showed statistically significant change in Lower limb muscle endurance ($p=0.002$).

Intra - Analysis of Group A showed significant increase in core strength, muscle endurance, muscle strength flexibility and aerobic capacity as compared to Group B. Inter-Analysis of Group A and Group B showed significant increase in core strength, muscle strength, muscle endurance and flexibility. No significant change was seen in the Aerobic capacity. The p values marked with * are statistically significant.

Pilates training showed a statistical significant increase in core muscle strength, endurance and strength of lower extremity musculature. Core strength and endurance were measured using Curl-ups and plank test which showed a significant improvement post training $p < 0.005$. According to Sir Joseph Pilates, core stabilization was essential to control human movements.

Table 1 Baseline parameters for Group A and Group B

	Group A	Group B	p value	mean difference	Standard error difference	95% confidence interval of difference	
						Lower	Upper
Age(years)	20.25(1.58)	20.2(1.54)	0.90	0.05	0.05	-0.95	1.05
Height(cms)	160.4(3.35)	159.92(4.94)	0.70	0.48	1.33	-2.22	3.18
Pre-weight(kgs)	60.9(18.54)	66.52(13.16)	0.30	- 5.6	5.09	-15.95	4.71
Pre-BMI(Kg/m ²)	23.6(6.83)	26.55(4.97)	0.10	-2.9	1.89	-6.78	0.88

Key: BMI-Body Mass Index

Table 2 Pre Intervention- Post Intervention Analysis for Group A

	Pre	Post	p value	Mean difference	Standard error difference	95% confidence interval of difference	
						Lower	Upper
weight(kgs)	60.90(18.54)	59.70(17.96)	0.000*	-1.2	0.29	0.60	1.80
BMI(Kg/m ²)	23.60(6.83)	23.15(6.60)	0.001*	-0.5	0.11	0.23	0.68
SnR(inch)	2.70(3.13)	5.43(4.60)	0.000*	2.73	0.48	-3.74	-1.73
JnR(Inch)	6.75(1.80)	11.10(1.80)	0.000*	4.35	0.21	-4.79	-3.91
Push-up(no.of reps)	38.60(22.05)	57.95(28.04)	0.000*	19.4	1.53	-22.55	-16.15
Curl-up(no.of reps)	25.20(7.23)	42.80(9.04)	0.000*	17.6	0.91	-19.51	-15.69
Plank (sec)	28.15(14.68)	46.85(14.87)	0.000*	18.7	0.98	-20.75	-16.65
Chair stand (sec)	18(1.25)	12.52(1.29)	0.000*	-5.5	0.26	4.93	6.02
ISWT (mts)	378.5(45.45)	492(49.58)	0.000*	114	5.14	-124.27	-102.73
Dynamo B(kg)	42.40(13.88)	64.35(13.23)	0.000*	22	1.23	-24.53	-19.37
Dynamo sq(kg)	37.30(16.38)	59.90(15.80)	0.000*	22.6	1.72	-26.20	-19.00

Key:SnR-Sit and Reach Test ,JnR- Jump and Reach test, ISWT-Incremental Shuttle Walk Test, Dynamo B – Dynamometer for Back Extensors, Dynamometer Squats- Dynamometer for Lower Extremity Strength.

*significant p value found using paired t test in spss 16

Table 3 Pre Intervention- Post Intervention Analysis for Group B

	Pre	Post	p value	mean difference	Standard error difference	95% confidence interval of difference	
						Lower	Upper
weight(kgs)	66.52((13.16)	66.58(12.22)	0.050	0.06	0.69	-1.5	1.39
BMI(Kg/m ²)	26.55(4.97)	26.81(5.24)	0.421	0.26	0.313	-0.91	0.40
SnR(inch)	2.64(3.42)	2.56(3.57)	0.795	-0.1	0.282	-0.52	0.67
JnR(Inch)	9.05(2.62)	9.05(2.62)	1.000	0	0.543	-1.14	1.14
Push-up(no.of reps)	27.80(12.40)	27.95(11.04)	0.849	0.15	0.776	-1.77	1.47
Curl-up(no.of reps)	30.85(10.03)	31.9(11.51)	0.450	1.05	1.360	-3.90	1.80
Plank (sec)	29.10(12.7)	32.77(13.85)	0.058	3.67	1.818	-7.48	0.14
Chair stand (sec)	15.85(2.43)	15.20(3.30)	0.255	-0.7	0.553	-0.51	1.81
Dynamo sq(kg)	45.25(11)	44.45(10.69)	0.653	-0.1	1.753	-2.87	4.47
Dynamo B(kg)	46(11.99)	48.10(13.22)	0.142	2.1	1.371	-4.97	0.77
ISWT (mts)	336(60.73)	334(62.94)	0.681	-2	4.790	-8.03	12.03

Key:SnR-Sit and Reach Test ,JnR- Jump and Reach test, ISWT-Incremental Shuttle Walk Test, Dynamo B – Dynamometer for Back Extensors, Dynamometer Squats- Dynamometer for Lower Extremity Strength.

DISCUSSION

The purpose of this study was to find the effect of 12 weeks Pilates based training on Physical fitness in young healthy adults. Given the numerous health benefits of Physical activity, the hazards of being inactive are clear. The specific concerns of Physical inactivity can be addressed through Pilates. This study is related to the physical fitness of young healthy individuals and demonstrates the changes seen in core strength, muscle strength, muscle endurance, flexibility and aerobic capacity.

Hodges *et al.* identify the transversusabdominus muscle as a primary muscle for postural control^[12] In a study by Duncan J. Critchley *et al.* it was found that while performing Pilates exercise “Hundreds”, thickness of Transverse Abdominis was increased and that of Internal Oblique was reduced while performing “Imprint”^[13]. This suggested that Pilates led to an increase in strength of TransversusAbdominis relative to internal Obliques activity during abdominal muscle exercises. This supported our current study where there was an increase in core muscle strength and endurance with 12 weeks of Pilates training.

Table 4 Post Group A- Post Group B Analysis

	GroupA	Group B	p value	mean difference	Standard error difference	95% confidence interval of difference	
						Lower	Upper
weight(kgs)	59.7(17.97)	66.585(12.22)	0.165	-6.89	4.86	-16.72	2.95
BMI(Kg/m2)	23.15(6.61)	26.81(5.24)	0.060	-3.66	1.89	-7.48	0.16
SnR(inch)	5.435(4.69)	2.5655(3.58)	0.036	2.87	1.32	0.20	5.54
JnR(Inch)	11.1(1.80)	9.05(2.52)	0.005*	2.05	0.69	0.65	3.45
Push-up(no.of reps)	57.95(28.04)	27.95(11.04)	0.000*	30.00	6.74	16.36	43.64
Curl-up(no.of reps)	42.8(9.04)	31.9(11.51)	0.002*	10.90	3.27	4.27	17.53
Plank (sec)	46.85(14.88)	32.77(13.85)	0.004*	14.08	4.55	4.88	23.28
Chair stand (sec)	12.525(1.29)	15.2(3.31)	0.002*	-2.68	0.79	-4.28	-1.07
ISWT (mts)	492(49.59)	334(62.95)	0.000*	158.00	17.92	121.73	194.27
Dynamo B(kg)	64.35(13.24)	48.1(13.22)	0.000*	16.25	4.18	7.78	24.72
Dynamo sq(kg)	59.9(15.80)	44.45(10.69)	0.001*	15.45	4.27	6.81	24.09

Key:SnR-Sit and Reach Test ,JnR- Jump and Reach test, ISWT-Incremental Shuttle Walk Test, Dynamo B – Dynamometer for Back Extensors, Dynamometer Squats- Dynamometer for Lower Extremity Strength.
*significant p value found using Unpaired t test in spss 16

Along with increase in core muscle strength and endurance, significant change was noted in Trunk and Lower limb muscle strength ($p < 0.005$). Several studies have found a relationship between trunk muscle activity and lower extremity movement which can be a probable cause for increase in the strength of lower extremity musculature. Activation and synchronized firing of the core muscle depends significantly on the ability of the CNS to monitor the demands being placed on the body through the sensory receptors leading to appropriate force generation in the musculature. Exercises performed in synchronized pattern improve the ability of the CNS to respond efficiently resulting in enhanced muscle activation and higher quality movement secondary to core muscle activation. Hence, through the synchronized movement pattern followed in Pilates there was a significant increase in lower limb strength in our study.

In addition to the core strength, Pilates based exercise help to strengthen upper and lower limb muscles by progressively challenging resistance levels of exercise and movement in exercises like “Swimming, Sidekicks and Side circles”.^[13] This progressive increase in resistance provides muscle strengthening through three phases. In the first phase there is a rapid improvement in the ability to perform the training exercise which is the result of a learning process in which the correct sequence of muscle contractions is laid down as a motor pattern in the central nervous system. This phase is associated with little or no increase in the size or strength of individual muscles. The learning process appears to be very specific to the movement performed and position attained. The second phase is an increase in the strength of individual muscles which occurs without a matching increase in the anatomical cross-section. The mechanism for this is not clear but could be a result of increased neural activation or some change in the fibre arrangement or connective tissue content. The third phase starts at a point where scientific studies usually end, at about 12 weeks when subjects as in the study are beginning to tire of the repeated training and testing. After this point, if training continues, there is probably a slow but steady increase in both size and strength of the exercised muscles. The stimulus for these changes remains enigmatic but almost certainly involves high forces in the muscle, probably to induce some form of damage that promotes division of satellite cells and their incorporation into existing muscle fibers.^[14]

Another study shows that there is 29% more activation of the lumbar extensors while performing double leg kicks^[15] which furthermore strengthens the conjecture that Pilates based exercises lead to Trunk and lower limb muscle strengthening.

This study also provides remarkable insight into the potential benefits of Pilates Based Exercises for flexibility. Flexibility was measured using the sit and reach test which showed significant improvement ($p = 0.001$). Pilates focus on flow of movement throughout the whole body. The increase in flexibility could probably be due to a combination of static and dynamic stretching exercises like “Scissors, Double leg stretch and single leg stretch “which increases the flexibility”^[1]. This effect can be explained by specific concept of Pilates approach, mechanical response of both contractile and non-contractile tissues and Neuro-physiological response to specific volumes of Pilates exercise prescription in current study^[16]. In Pilates, the intensity of movement is the final range of motion at a tightness point without discomfort and frequency of practice is twice a week with 5 repetitions per position. The dosage of 2-10 repetitions of stretching exercise for 10-15 seconds during 4-10 weeks of training period contributes to developing flexibility in accordance to previous studies. Neuro-physiological properties of contractile tissue have a significant response to the stretch applied in Pilates exercise. The slow stretch to soft tissues (i.e. skin, tendon, joint capsule) and muscles leads to the activation of Golgi Tendon organ. This sensory receptor detects the difference in the tension generated by passive stretch which leads to inhibition of Alpha motor neuron resulting in decreased muscle tension thereby permitting sarcomeres to lengthen.

A significant limitation of this study is the small sample size. Further research is required to ascertain the effects of Pilates based training in patients with non communicable diseases (Diabetes, hypertension, obesity) and musculoskeletal disorders (low back pain, osteoarthritis etc).

CONCLUSION

12 weeks of Pilates based exercises were effective in improving physical fitness in young healthy individuals. Further research is required to determine whether these gains are made in patients with diseases like diabetes, hypertension and obesity.

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