Pilates for Improvement of Muscle Endurance, Flexibility, Balance, and Posture

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Abstract

Kloubec, JA. Pilates for improvement of muscle endurance, flexibility, balance, and posture. *J Strength Cond Res* 24(3): 661–667, 2010—Many claims have been made about the effectiveness of Pilates exercise on the basic parameters of fitness. The purpose of this study was to determine the effects of Pilates exercise on abdominal endurance, hamstring flexibility, upper-body muscular endurance, posture, and balance. Fifty subjects were recruited to participate in a 12-week Pilates class, which met for 1 hour 2 times per week. Subjects were randomly assigned to either the experimental ($n = 25$) or control group ($n = 25$). Subjects performed the essential (basic) mat routine consisting of ~25 separate exercises focusing on muscular endurance and flexibility of the abdomen, low back, and hips each class session. At the end of the 12-week period, a 1-way analysis of covariance showed a significant level of improvement ($p \leq 0.05$) in all variables except posture and balance. This study demonstrated that in active middle-aged men and women, exposure to Pilates exercise for 12 weeks, for two 60-minute sessions per week, was enough to promote statistically significant increases in abdominal endurance, hamstring flexibility, and upper-body muscular endurance. Participants did not demonstrate improvements in either posture or balance when compared with the control group. Exercise-training programs that address physical inactivity concerns and that are accessible and enjoyable to the general public are a desirable commodity for exercise and fitness trainers. This study suggests that individuals can improve their muscular endurance and flexibility using relatively low-intensity Pilates exercises that do not require equipment or a high degree of skill and are easy to master and use within a personal fitness routine.

Key Words calisthenics, sit-ups, push-ups, fitness, core strength

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Introduction

According to Physical Activity and Health: A Report of the Surgeon General (1996), "Given the numerous health benefits of physical activity, the hazards of being inactive are clear" (18). Creating exercise-training programs that address the specific concerns of physical inactivity, that are accessible and enjoyable, and that have been shown to provide health benefits for participants are an unquestionable public health mandate. Pilates has been promoted as an exercise that would meet these criteria.

Joseph Pilates began developing his exercise system in the early 1900s. During the latter part of World War I, Pilates served as an orderly in a hospital on the Isle of Man, where he began to work with nonambulatory patients. He attached springs to hospital beds to support the patient's limbs while he worked with them, and he and the doctors noticed that they seemed to recover more rapidly (13). He originally entitled his method, "The Art of Contrology" or muscle control and drew his inspiration from yoga, martial arts, Zen mediation, and Greek and Roman exercises. Unique at the time, Pilates' method allowed and encouraged movement early in the rehabilitation process by providing needed assistance. His experiences led him to the development of his distinctive method of physical and mental conditioning, which he brought to the USA in 1923 (3).

The dance community has embraced the Pilates' method for years, and throughout the past decade, Pilates has become increasingly popular within the general fitness community as well. The Pilates' Method Alliance reported that there were over 11 million practitioners in the USA in 2005, and a simple online research showed more than 30 different Pilates-affiliated organizations producing hundreds of videotapes and DVDs.

Modern Pilates practitioners perform in a series of approximately 25–50 simple, repetitive, low-impact flexibility and muscular endurance exercises with an emphasis on muscular exertion in the abdominals, lower back, hips, thighs, and buttocks. Using a core stabilization program such as Pilates has been hypothesized to increase muscular endurance and flexibility of the abdomen, low back, and hips and improve dynamic postural control, balance, and joint movement around the low back-pelvic-hip complex. Advocates of this system claim that exercises can be adapted to provide either a gentle strength training program suitable for rehabilitation or a challenging workout for skilled athletes. The exercises require no equipment, are simple enough for a beginner to be able to master in a relatively short period, and fit well with the guidelines set forth by the American College of Sports Medicine (ACSM) (2).

Pilates has been marketed to athletes to improve the "core" and "functional fitness" and to individuals with medical conditions, such as low-back pain and rheumatoid arthritis, with such claims that it "balances strength and flexibility," "produces longer leaner muscles," "improves posture," "increases core strength and peripheral mobility," "helps prevent injury," and "enhances functional ease of movement" (12). Although all these sound enticing, the scientific validity of these claims remains untested.

Even though Pilates has over an 80-year history, few empirical research studies have been conducted on its efficiency to improve basic physiological variables it touts improving such as muscular strength, muscular endurance, balance, flexibility, and so on. (9,12). Many of the benefits that were claimed by early Pilates enthusiasts have not been supported by research (3). However, research of similar type activities does support the common movement principles found in the Pilates exercises (1,5,6,17). Given the popularity and the heightened expectations that practitioners have been led to expect from regular practice of Pilates, research that begins to quantify the risks and benefits of Pilates is timely.

Methods

Experimental Approach to the Problem

The purpose of this study was to determine the effect Pilates exercise had on abdominal endurance, hamstring flexibility, upper-body endurance, posture, and balance. The hypothesis of this study was that participants would improve on each of these variables after a 12-week training period.

Subjects who participated in variety of recreational fitness activities, but had no previous Pilates experience, were recruited to participate in the study. The study was conducted at Gustavus Adolphus College in St. Peter, MN, from January through mid-March to minimize recreational confounders affecting the results. Because participants were already active, by performing the Pilates exercises for 12 weeks, it was hypothesized that any changes in fitness could be attributed to the addition of the Pilates exercises. The dependent variables were selected based on previous Pilates outcome claims. To measure these parameters, all subjects and controls performed a series of standard fitness tests to assess abdominal and pelvic stability, hamstring flexibility, upper-body muscular endurance, posture, and balance both pre and post training.

Subjects

Fifty, healthy, active male and female volunteers, aged 25–65 years, were recruited to participate in the study and were randomized into 2 groups comprising 25 individuals each (20 women and 5 men in both the training and the control groups). To avoid possible data contamination, participants were asked to have no prior substantive Pilates experience. A total of 22 participants completed the study; 22 members of the control group also returned to be assessed. Table 1 provides additional descriptive subject data. Subjects were informed of the possible benefits of study participation. No additional incentives for participation were provided, and there was no cost to participate in the study. Written informed consent was obtained from all participants, and Institutional Review Board approval was obtained from the University of Minnesota and Gustavus Adolphus College.

Procedures

Gender, height, and weight data were collected on all subjects. The 1-minute YMCA sit-up test was used to assess abdominal endurance. Additionally, leg lowering was selected as a marker to assess lower abdominal endurance and pelvic stability. Participants were also asked to perform the maximal

Table 1. Age, weight, and height of participants by group.

	Participants ($n = 25$)			Control ($n = 25$)		
	Mean	Range	*SD*	Mean	Range	*SD*
Age (y)						
Pre	42.08	26–58	9.12	45.84	30–59	8.23
Post	41.95		9.45	46.95		7.61
Weight (kg)						
Pre	164.28	108–234	33.73	156.04	125–208	25.65
Post	162.91	108–233	34.82	158.18	123–211	25.65
Height (cm)						
Pre	166.36	152–189	10.00	166.36	154–181	6.87
Post	167.27*	152–189	10.16	166.34	154–181	6.97
Body mass index						
Pre	26.24	19–37	5.15	26.83	20–31	3.53
Post	25.36	19–37	5.17	25.32	20–30	3.39
Gender						
Pre	21 women, 4 men			21 women, 4 men		
Post	19 women, 4 men			19 women, 4 men		

*Significant to $p \leq 0.05$.

number of push-ups they could do according to the ACSM assessment protocol. Women were allowed to do their push-ups from their knees, whereas men used the standard straight body form. To measure hamstring flexibility, the sit and reach test and supine hamstring flexion test were used. Two methods of hamstring flexibility assessment were used because there was uncertainty as to which method would be most sensitive. Postural analysis was determined by having all participants stand behind a clear postural analysis grid. Participants were analyzed from 3 different angles and were evaluated by comparing the degree(s) of deviation at specific anatomical markers. To assess balance, participants were asked to balance on a modified balance board for 1 minute. A counter recorded each time a participant deviated from a midpoint balanced position, and the total number of deviations was recorded.

Subjects took part in a 12-week series of 1-hour Pilates classes meeting 2 times per week. The Pilates mat series of exercises involves approximately 25 essential (beginning) exercises that can all be completed using no equipment other than a floor mat. The Stott Pilates method was selected for this study, and modifications of exercises were consistent with those detailed in the Stott Pilates Comprehensive Matwork Manual (14). Pilates uses a highly sequenced routine and uses only a small number of exercises that are simple enough for a beginner to be able to master in a relatively short period. The nature of Pilates also dictates that the method of instruction be very consistent: cuing, sequence, and number of repetitions are all predetermined. Therefore, the same sequence of exercises and approximately the same number of repetitions of each exercise were preformed each class period. Sessions were led by the same trained instructor (the primary researcher) throughout to maintain consistency. As the study progressed and participants mastered the individual exercises, they were able to properly perform additional exercises within the same period. The hour period was an adequate time frame to perform all the exercises, in sequence, for each of the class meetings. Therefore, by the end of the study, the same sequence of exercises and approximately the same number of repetitions of each exercise were preformed each class period.

Participants in the control group were asked to maintain their current level of activity throughout the duration of the study and to also refrain from beginning any new activities during this time frame (Figures 1 to 8).

Statistical Analyses

SPSS for Macintosh (Rel. 11.0.1. 2001, SPSS Inc., Chicago) was used for all data analysis. Mean, *SD*s, and analysis of covariance (ANCOVA) were calculated for all physiological data. Two-way contingency table analysis was conducted on the postural data. Statistical significance was set at $p \leq 0.05$.

Postintervention statistics included ANCOVA using the data collected from each of the following dependent variable tests from both the training and control group subjects. The

Figure 1. Ab prep.

Figure 2. Breaststroke prep.

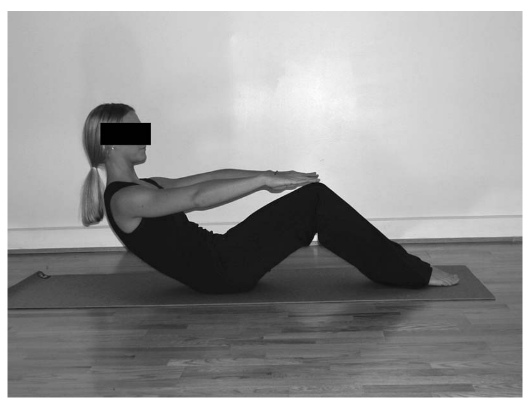

Figure 3. Half Rollback.

Figure 4. Leg pull front (a).

Figure 7. Rolling like a ball (b).

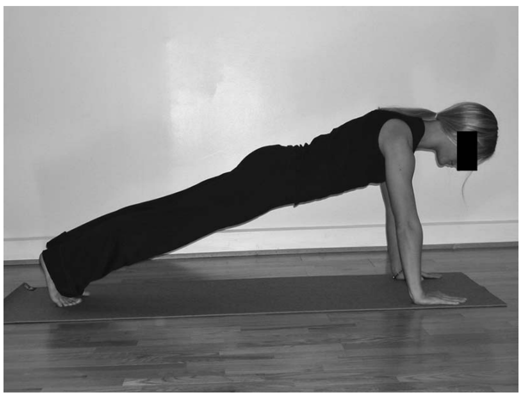

Figure 5. Leg pull front (b).

Figure 8. Spine twist.

Figure 6. Rolling like a ball (a).

dependent variable was the postassessment value for each physiological variable, whereas the covariate was the corresponding preassessment value. With the exception of the balance test and postural evaluation, the literature showed that the assessments used to measure fitness demonstrated correlation coefficients (*r*) in the range of 0.93–0.94. Tests used to assess the dependent variables included the following: leg-lowering test and YMCA sit-up test (measuring abdominal endurance), sit and reach test, spine hamstring flexibility testing (measuring hamstring flexibility), ACSM push-up test (measuring upper-body endurance), and a 1-minute balance board test (measuring balance). Posture was also evaluated.

Power calculations were conducted using an alpha level of $\leq$0.05 and using *SD*s on selected outcomes from previous studies. Using these data, the proposed sample size of 25 was expected to yield sufficient power to reject the hypotheses.

Table 2. Mean and *SD*s of physiological variables pre and post training by group.

	Participants (*n* = 22)		Control (*n* = 22)	
	Mean	*SD*	Mean	*SD*
Sit and reach (cm)				
Pre	30.68	10.14	31.40	9.82
Post	33.41*	8.86	33.13	9.95
Hamstring left (°)				
Pre	88.41	13.20	91.86	17.43
Post	99.09**	8.57	94.68	13.63
Hamstring right (°)				
Pre	93.14	12.48	91.45	15.28
Post	102.41*	10.45	96.45	12.00
Leg lowering (°)				
Pre	53.18	16.71	48.25	10.97
Post	27.32*	21.09	46.10	15.01
Sit-up (number)				
Pre	34.68	11.42	32.77	13.75
Post	48.27**	21.26	32.95	21.56
Push-up (number)				
Pre	24.18	22.34	20.41	17.97
Post	35.59**	25.60	21.10	19.30
Balance (touches)				
Pre	57.55	9.04	53.55	9.68
Post	62.05	15.18	51.32	19.09

*$p \leq 0.05$.
**$p \leq 0.001$.

Table 3. ANCOVA results for physiological variables.†‡§

Variable	*df*	*F*	*p* value	*p* value ignoring outliers	*SD*
Sit and reach	1	4.676	0.037*		Pre 10.14 Post 8.66
Hamstring left	1	4.929	0.032**	0.000**	Pre 13.20 Post 8.56
Hamstring right	1	5.613	0.023*		Pre 12.48 Post 10.45
Leg lowering	1	32.041	0.000*		Pre 16.71 Post 21.09
Sit-up	1	10.564	0.002**	0.006*	Pre 11.42 Post 21.26
Push-up	1	23.957	0.000**	0.000**	Pre 22.34 Post 25.60
Balance	1	0.110	0.753		Pre 9.04 Post 15.18

*$p \leq 0.05$, **$p \leq 0.00$,
†ANCOVA = analysis of covariance.
‡$n = 22$.
§The left hamstring, sit-up, and push-up data sets contained data from 1 or 2 individuals who were inconsistent with other data collected (outlying data to either end of the spectrum). When these data were removed and the data were retabulated, both hamstring and sit-up data resulted in a $p \leq 0.05$.

Results

A 1-way ANCOVA was conducted to adjust for differences in all participants' pretest levels and to adjust for age and gender. A separate ANCOVA was conducted for each of the physiological variables: abdominal endurance (sit-ups and leg lowering), hamstring flexibility (sit and reach and right and left hamstring flexibility), upper-body endurance (push-ups), and balance. The dependent variable was the postassessment value for each physiological variable, whereas the covariate was the corresponding baseline assessment value. The independent variables included age and gender. A preliminary analysis evaluating the homogeneity of slopes assumption indicated that the relationship between the covariates and the dependent variables did not differ significantly as a function of the independent variables for any of the physiological variables.

The data showed that the Pilates training group participants were able to perform significantly more sit-ups and push-ups than the control group subjects. The Pilates training group participants were also able to lower their legs closer to zero degrees without lifting their lumbar spine off of a flat surface, indicating greater abdominal endurance and pelvic control than the control group participants. All flexibility variables (sit and reach and the right and left hamstring flexibility) demonstrated statistically significant improvement from the baseline assessment for Pilates-trained participants. The ability to maintain and regain balance using a balance board and posture was not statistically significantly different for the Pilates-trained subjects when compared with the control subjects. Tables 2 and 3 summarize the results of the ANCOVA. All variables, except for balance, were statistically significant at $p \leq 0.05$. Leg lowering and push-ups were statistically significant at $p \leq 0.001$.

Discussion

This study demonstrated that in active middle-aged men and women, exposure to Pilates exercise for 12 weeks, for two 60-minute sessions per week, was enough to stimulate statistically significant increases in abdominal endurance, hamstring flexibility, and upper-body muscular endurance. However, participants did not demonstrate improvements in either posture or balance when compared with the control group.

Calisthenics, such as sit-ups and push-ups, are a popular form of strength and muscular endurance training, and Pilates could be considered the ultimate "calisthenic exercise series." Previous research on calisthenics as a way to improve strength, body composition, and flexibility has been somewhat limited; however, studies have shown improvements in muscular endurance and strength (6,17). These studies also imply that calisthenic exercises alone may not provide participants with the "most bang for their exercise buck." Pilates exercise, as carried out in this study, has shown that individuals can engage in simple exercises that require minimal time commitment and equipment and achieve improvements in strength and flexibility.

Given the numerous abdominal exercises included within the Pilates series, changes to abdominal strength were more expected than changes to flexibility and upper-body endurance that was shown. Improvements in abdominal endurance were expected, and parallel results are found in a variety of other general fitness protocols.

Results from hamstring flexibility and upper-body endurance (push-ups) were also positive but less expected given how little time is spent during the actual Pilates exercises replicating these activities. Previous research suggests that improvements of hamstring flexibility have been shown to be the most beneficial if the participants statically hold the stretch for 30–60 seconds in duration (4,5). In Pilates, the stretching is most often dynamic in nature, with the stretch held for no longer than 2–3 seconds. This dynamic movement is, however, repeated 4–8 times throughout the exercise set. Although Pilates would not be characterized as a ballistic exercise, the exact mechanism of the improvements seen in hamstring flexibility remains unclear.

Upper-body endurance improved from participants doing approximately 10 push-ups or static upper-body endurance exercises 2 times per week. Other studies have shown improvements in upper-body endurance but used a longer study duration (7), greater exercise frequency (15), or a different population (10). It could be that learning other scapular stabilization techniques (participants are frequently cued throughout the class to engage in slight scapular retraction and depression) paired with the increase in abdominal strength, endurance, and pelvic control also aided in the improvement seen.

Interestingly, Pilates participants also increased their mean height compared with control group participants. As height in adults is a relatively stable measurement, this finding is of interest. Pilates practitioners have subjectively noted postural improvements after engaging in regular practice, but the increase in height in this group appears to be more structural in nature because gross postural changes were not seen in this study. Segal et al. (12) reported no change in height in their participants; however, their participants also echoed the present study population's subjective reports of improved posture (12).

Balance and posture were also hypothesized to show improvement in this study; however, neither was enhanced. Balance has been studied more extensively using participants with specific disabilities (vestibular disturbances, stroke, or other neurological diseases) or using older individuals as participants and may require a more sensitive instrument to measure accurately in a healthy population.

To date, most postural studies have tended to use a more global concept of posture and have applied this to special populations (e.g., individuals with cerebral palsy or spinal abnormalities) and among the elderly. A Medline search revealed a paucity of research studies that addressed the effect of exercise on the posture of individuals within normal populations. When postural deviations are great, it seems that exercise has a positive effect on correcting the misalignment. When posture is within normal limits, exercise may have more of a blunted effect. In this study, neither balance nor posture showed improvement and appeared to be very static. However, participants did demonstrate a statistically significant increase in height, which indicates that there may have been some structural changes in spinal alignment that the postural analysis was not sophisticated enough to detect.

Practical Applications

Core strengthening has become a major trend in sports training and in rehabilitation. The term has been used to connote lumbar stabilization, motor control training, and other regimens. Core strengthening is, in essence, a description of the muscular control required around the lumbar spine to maintain functional stability (1). To develop core strength, individuals need to involve all those forces. Although traditional crunches and back extensions help to develop core strength, core competency exercises often involve balance as well and, therefore, demand the efforts of many muscles to work synergistically. Many Pilates exercises aim to integrate all these qualities and therefore the focus is as a neurological exercise rather than developing absolute strength.

Because much of Pilates requires using proper body form throughout the implementation, it would be interesting to investigate if its effect translated over to other forms of exercise or if participants could simply be taught the cues and then asked to participate in their typical exercise and if these cues could help them to make their normal exercise routines more beneficial. For example, research suggests that the curl up, when compared with the sit-up, optimizes the challenge to the abdominal muscles while minimizing shear and compressive forces on the lumbar spine. Baxter et al. (6) demonstrated that curl up–type abdominal exercises did not significantly improve abdominal strength after a 6-week program, although standard sit-up exercises did improve performance in maximal, timed, 2-minute sit-up tests. Specificity of training can account for these results. Other studies have shown that engaging all the abdominal musculature is important (6,11,16) and that improvements in abdominal strength were best transferred into every day actions if participants complete a variety of movements in training sessions (6,8,11,16). Because Pilates-type exercises initiate movements from a variety of body positions, it can be assumed that the abdominal musculature has been recruited in a variety of ways and specificity of training should be minimally effected. Pilates practitioners may see improvements in a variety of abdominal strength exercises, as demonstrated by the present study.

In summary, this study demonstrated that participating in a 12-week Pilates exercise program was capable of producing statistically significant increases in abdominal endurance, hamstring flexibility, and upper-body muscular endurance in active middle-aged men and women. Multiple benefits from regular practice of Pilates exercises were demonstrated, and this study provides the foundation for follow-up studies to look at the advantages of Pilates exercise in more specific populations. Specific groups that may benefit from more study include those interested in Pilates as a way to improve overall sport or athletic performance, those with low back pain and spinal structural problems, and individuals with urinary incontinence.

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