The Effects of Pilates Training on Flexibility and Body Composition: An Observational Study

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Objective: To assess claims regarding the effects of Pilates training on flexibility, body composition, and health status.

Design: An observational prospective study.

Setting: A community athletic club.

Participants: A sample of 47 adults (45 women, 2 men) who presented for Pilates training.

Interventions: Not applicable.

Main Outcome Measures: Fingertip-to-floor distance, truncal lean body mass by bioelectric impedance, health status by questionnaire and visual analog scale were assessed at baseline, 2, 4, and 6 months (±1wk).

Results: Thirty-two of 47 enrolled subjects met the protocol requirements of missing no more than 1 weekly 1-hour session Pilates mat class during each 2-month period. Investigators were blinded to measurements from previous time points. Median (interquartile range [IQR]) fingertip-to-floor distance improved from baseline by 3.4cm (1.3–5.7cm), 3.3cm (0.3–7.8cm), and 4.3cm (1.5–7.6cm) at 2, 4, and 6 months, respectively (paired nonparametric analysis, all $P<.01$). There were no statistically significant changes in truncal lean body mass, height, weight, or other body composition parameters. Self-assessment of health also did not change in a statistically significant manner from its baseline median (IQR) value of 77mm (69–85mm).

Conclusions: Pilates training may result in improved flexibility. However, its effects on body composition, health status, and posture are more limited and may be difficult to establish. Further study might involve larger sample sizes, comparison with an appropriate control group, and assessment of motor unit recruitment as well as strength of truncal stabilizers.

Key Words: Body composition; Exercise; Flexibility; Health status; Rehabilitation.

PATIENTS FREQUENTLY SEEK information about complimentary therapies for wellness. This is likely based on popular interest as well as recognition of the incomplete efficacy of current therapies for treatment of chronic pain and other illnesses. The World Health Organization defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."[1] To achieve such a state of health, many patients seek complimentary programs for wellness rather than depend on treatments only when ill. Some of the complementary approaches gaining popularity may contribute to improved flexibility, body composition, and health status. For physicians to be able to offer evidence-based guidance for patients seeking advice about complementary programs, it is important to assess the potential benefits and side effects.

One exercise approach, frequently referred to as Pilates, because of a foundation in the teachings of Joseph Pilates (1880–1967), was initially practiced almost exclusively by athletes and dancers. However, in recent years, Pilates has become a popular trend in rehabilitation and fitness. In the United States, there are over 5 million practitioners,[2] and an Internet search reveals that over 200 videotapes are available.

Pilates training is intended to improve general body flexibility and health by emphasizing "core" (truncal) strength, posture, and coordination of breathing with movement. Joseph Pilates noted that mobilizing early in rehabilitation resulted in a reduced convalescence period after musculoskeletal injuries. Advocates report that the exercises can be adapted to provide either gentle strength training for rehabilitation or challenge skilled athletes with a vigorous workout.[3] Stott Pilates[a] altered Pilates's original program by incorporating more preparatory exercises and modifications in hopes of improving safety and maintaining neutral spine position. Pilates exercises are designed to put participants in a position that minimizes unnecessary muscle recruitment, which could potentially lead to early fatigue, decreased stability, and impaired recovery.

Pilates training, focusing on back extensors and the abdominal musculature, in particular the transversus abdominus, is referred to as core strengthening. Ostensibly, the goal of core strengthening without straining peripheral joints is realized through concentrating on (1) coordinating breathing with movement; (2) scapular, pelvic, and rib cage stabilization during abdominal movements; and (3) head and cervical spine placement to avoid neck strain. Pilates instructors provide physical assistance and verbal feedback to maximize accuracy as well as safety during exercise. The Pilates mat exercise progression initially uses a wide truncal base of support in prone, side-lying, or supine positions, while moving the limbs to vary torque on truncal muscles. As the participant develops improved strength and form, the base of support is gradually reduced to retrain proprioceptive mechanisms while fostering more efficient movement patterns. This is similar in principle to the dynamic stabilization exercises widely used in the treatment and prevention of musculoskeletal low back pain (LBP), which advocates promoting efficiency of deep stabilizers and decreasing contraction of muscles counterproductive to the activity.[4]

Proprioception forms the link between the musculoskeletal and nervous systems, which is essential for spinal stability. It is postulated that inhibition of deep proprioception, because of pain or habit, may lead people to develop compensatory movement patterns, which prolong the healing process because of

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ineffective biomechanics after injury.[4] Through retraining truncal stabilizers, Pilates exercises may contribute to improved movement patterns. Additionally, Pilates involves closed kinetic-chain exercises, which may provide the necessary compressive and decompressive forces to foster nutrition to joints and cartilage to reduce degenerative risk.[5] Thus, if claims are valid and training is safe, Pilates may have a role in attenuating the predisposition to chronic axial musculoskeletal pain caused by spinal instability.

Pilates is marketed to athletes, the general population, and people with medical conditions such as rheumatoid arthritis[2] with the 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."[6] Marketers also claim that Pilates training heightens body awareness, is easy on the joints, improves performance in sports (eg, golf, skiing, skating, dance), and improves balance, coordination, and circulation.[6] However, the scientific validity of these assertions does not appear to have been tested.

Review of the medical literature is remarkable for the lack of research pertinent to Pilates training. We are aware of no published clinical trials specific to Pilates listed in MEDLINE (June 5, 2002 "pilates.tw"), and many physicians and therapists are relatively unaware of the approach. Given the popularity of Pilates and the enrollment of participants with expectations of ameliorating symptoms, research that begins to quantify its risks and benefits seems essential. The frequently publicized claims regarding Pilates exercise noted earlier are difficult to interpret. To form the basis for further clinical research, an initial assessment is necessary. Therefore, this study was designed to assess whether Pilates training is associated with increased flexibility, increased truncal lean body mass (LBM), improved posture, improved health self-assessment, and also to provide preliminary evidence of what side effects might be related to participation.

METHODS

Participants

All adults (over age 18) who presented for a Pilates class at a local athletic club during the 6-month period (beginning in June 2002) and who provided written informed consent to complete the questionnaire and measurements were enrolled. Exclusion criteria were limited to pregnancy and people with implanted metallic devices. There were no inclusion or exclusion criteria based on health club membership or physical fitness level. Our institutional review board approved this protocol.

Pilates Instruction

The head Pilates instructor (JH) involved in the study is a Stott-certified Pilates instructor. She trained under Stott instructors[a] for over 100 hours of mat and 125 hours of Reformer study. She successfully completed the Stott Mat and Reformer examination. Instructors remained the same for each class of subjects and were supervised by the head instructor to confirm compliance with the standard Stott Pilates program.

Subjects were grouped into class sizes of 8 to 12 and participated in a 1-hour Pilates class each week. During the initial 2 months, the class involved a standard Stott Pilates mat progression program (appendix 1).[7] Instructors showed each exercise and then provided verbal cues and physical assistance to assure accuracy of subject movements. Modifications consistent with those detailed in the Comprehensive Mat Stott Pilates Training Manual[7] were prescribed as needed to adjust to each person's level of function and flexibility. Exercises progressed in difficulty during the second and third 2-month periods of training. Because of the challenging nature of the class, participants who felt the need for increased strength and flexibility before progression continued with the second-level exercises throughout the third 2-month period. No specific exercises were assigned for completion between weekly sessions.

Measurements

The following main outcome measures were assessed at baseline, 2, 4, and 6 months (±1wk). Subjects and investigators were blinded to all previous measurements at each time point.

Composite flexibility. Composite flexibility was measured by fingertip-to-floor distance[8] just after subjects entered the health club at the same time of day at all measurement time points. Each subject stood barefoot on the edge of a 20-cm platform and was instructed to "try to touch the floor with your fingertips with your knees straight." No other encouragement or instructions were given. The vertical distance between the middle finger tip and the horizontal platform edge was measured. Reaching beyond the horizontal standing surface was recorded as a negative value.

Body composition. Height was measured to the nearest 0.1cm with a stadiometer. This measure was used to calculate body mass index (BMI) and as a surrogate measure of posture. Body mass, segmental fat, and LBM were determined with multifrequency bioelectric impedance analysis (MF-BIA) by using InBody 3.0.[b] Estimations of LBM[9] and segmental LBM of the trunk and upper and lower limbs[10] were based on validated algorithms[11] and segmental water distribution, assuming a constant LBM tissue hydration of .73L/kg.[12] Participants stood barefoot on the 4 footplate electrodes and held the bipolar handgrips of the MF-BIA unit until segmental body composition measurements were obtained. Typical measurements required approximately 2 minutes. The manufacturer initially calibrated the MF-BIA unit on-site, and investigators ensured continued calibration before each use with a calibration software program intrinsic to the unit. Investigators also confirmed moist hand and foot contact for each measurement. Data were acquired by direct computer link into the Lookin Body software.[b]

Perception of health and function. Subjects completed sections of the well-validated American Academy of Orthopedic Surgeons outcomes questionnaire[13,14] that address demographics, presence of joint or back pain, functional limitations, and self-health assessment on a 100-mm line, which is labeled "poor" at the left and "excellent" at the right ends.[13] Subjects also completed questionnaires on recent dietary changes, planned dietary changes, and medication changes.

Event log. At each assessment, subjects were asked: "Have you had any problems with the Pilates class?" and responses were recorded in an event log.

Statistical Analysis

A prospective power calculation demonstrated that a sample size of 16 would have 90% power to detect a difference in mean fingertip-to-floor-distances of 3.0cm, assuming an intrapatient standard deviation (SD) of 3.39cm, using a 2-sided paired t test with a .050 significance level.[15]

Analysis of all subjects who completed the 6-month training was performed. Completion was defined as missing no more than 1 class during each 2-month period. Continuous variables were summarized as medians (interquartile ranges [IQRs])

Table 1: Baseline Demographics

Demographics	Women	Men	Total	Completers
n	45	2	47	32 (31F, 1M)
Average age (y)	41 (35–48)	42 (35–49)	41 (35–48)	43 (37–48)
Average weight (kg)	68.2 (61.9–70.0)	83.9 (81.6–86.2)	68.3 (61.9–70.9)	68.3 (62.5–70.7)
Average LBM (kg)	45.9 (41.7–49.0)	65.3 (62.2–68.4)	46.3 (41.7–50.2)	46.5 (41.8–49.0)
Average fat mass (kg)	20.3 (16.5–22.5)	18.6 (13.1–24.0)	20.3 (16.3–22.6)	20.5 (17.7–23.5)
Average truncal LBM (kg)	20.0 (18.5–21.4)	28.4 (26.2–30.0)	20.1 (18.5–21.2)	20.5 (18.5–21.5)
Average BMI (kg/m^2)	25.1 (23.1–26.3)	26.7 (24.6–28.8)	25.1 (23.3–26.6)	25.4 (23.7–26.7)

NOTE. Values in parentheses are IQR.
Abbreviations: F, female; M, male.

where more conservative nonparametric analysis was appropriate for nonnormal distribution of results. Categorical variables were summarized with frequencies. For each continuous outcome variable, the paired differences between baseline and each assessment time point (2, 4, 6mo) were calculated. Wilcoxon signed-rank tests were used to test for significant changes from baseline to each time point for each outcome measure. *P* values of .05 or less were considered statistically significant.

RESULTS

Forty-seven subjects were interviewed, and all consented to participate. Thirty-six, 37, and 32 (68%–79%) subjects returned at 2, 4, and 6 months, respectively. At the initial follow-up, 1 subject's body composition could not be measured because of technical problems with the BIA instrument. Forty-five of the 47 subjects at baseline and 31 of 32 subjects at the final follow-up were women (table 1). Three participants continued with the second-level exercises throughout the third 2-month period.

Most subjects who discontinued participation did so between the baseline and 2-month measurements and therefore could not be included in the analysis of changes with respect to baseline. After the 2-month measurements, 5 additional subjects were lost to follow-up. Two of the 5 reported dropping out because of conflicts with their work and vacation schedules, and 1 subject became pregnant, thereby meeting exclusion criteria. The remaining subjects who discontinued participation could not be contacted.

Composite Flexibility

At baseline, the median (IQR) fingertip-to-floor distance was 0.2cm (7.0−7.7cm). The median improvement from baseline and 2, 4, and 6 months, respectively, were 3.4cm (1.3–5.7cm), 3.3cm (0.3–7.8cm), and 4.3cm (1.5–7.6cm), with negative values indicating increased flexibility (paired nonparametric analysis, all $P<.01$; fig 1).

Body Composition

Height (postural assessment), weight, total lean and fat mass, segmental appendicular LBM, and truncal LBM did not change in a statistically significant manner (table 2).

Self-Assessment of Health

Subjects' self-assessment of health on a visual analog scale (VAS) did not change significantly from its baseline median (IQR) value of 77mm (69−85mm) over the course of the study (table 2).

Comments

Comments were too scattered to permit statistical analysis. However, comments regarding adverse events were limited to mid-back pain during supine exercises (n=1), paraspinal muscle pain after class in 2 subjects with thoracolumbar scoliosis during the initial 2 months (n=2), and posterior neck pain during exercises, which was eliminated with use of a towel for neck support (n=1). There were no complaints of joint pain. The most common positive comments regarded improved posture (n=7), improved flexibility (n=4), cessation of morning stiffness (n=2), and decreased aches and pains (n=3). After 5 weeks of training, 1 subject reported cessation of 8 years of abdominal pain, which had been attributed to chronic "adhesions." Another subject reported inability to participate in other group exercise because of lack of rhythm, but felt able to participate in the Pilates class.

DISCUSSION

This study provides some interesting, initial insights into the potential benefits and side effects of Pilates-based exercise. First, despite only 1 hour of Pilates per week, flexibility by fingertip-to-floor distance improved at every follow-up measurement by 3.3 to 4.3cm compared with baseline measurements, a change similar in magnitude to that reported after 10 sessions of intensive physical therapy.[16] Friedrich et al[16] reported that, at 4-month follow-up after initiation of a structured exercise and motivational program, back pain subjects showed an improvement of 3.6cm on fingertip-to-floor testing. It is notable that this Pilates cohort attained similar improvements in flexibility despite the less intense exercise program.

Musculoskeletal flexibility, the ability of muscles to move a body segment through its range of motion, is an important

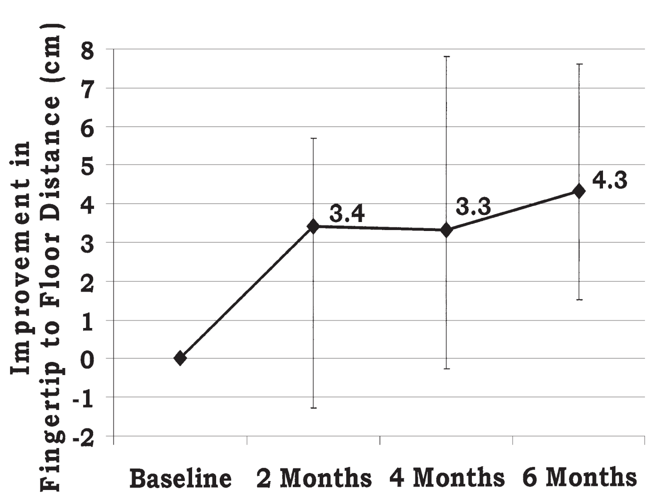

Fig 1. Median improvement in flexibility at each follow-up. NOTE. Bars indicate IQRs. All *P* < .01 by paired nonparametric analysis.

Table 2: Body Composition and Health Assessment Data

Anthropometric Measures and Health Assessment	Baseline	2-Month Difference	4-Month Difference	6-Month Difference
Height (cm)	163.0 (160.2–168.5)	0.0 (−0.7 to 0.2)	0.2 (−0.2 to 0.6)	0.2 (−0.3 to 0.8)
Weight (kg)	68.3 (61.9–70.9)	−0.1 (−1.3 to 0.7)	−0.3 (−1.2 to 1.5)	0.6 (−0.7 to 1.5)
Fat mass	20.3 (16.3–22.6)	0.1 (−1.5 to 1.3)	0.1 (−1.2 to 1.3)	0.5 (−0.6 to 2.1)
LBM (kg)	46.3 (41.7–50.2)	−0.3 (−1.2 to 0.6)	0.0 (−0.9 to 0.8)	0.0 (−0.6 to 0.7)
Truncal LBM	20.1 (18.5–21.2)	−0.1 (−0.4 to −0.1)	0.0 (−0.2 to 0.2)	0.0 (−0.3 to 0.2)
Health assessment VAS (mm)	77 (69–85)	3 (−3 to 10)	3 (−6 to 10)	1 (−11 to 4)

NOTE. Values are median (IQR).

component of health. Patients with arthritis or LBP in physical programs aimed at improving strength, flexibility, and mobility have reported better function and fewer symptoms.[17] Flexibility may contribute to improved physical performance, reduced energy requirements for movement of joints (because of reduced tissue tension), and reduced likelihood of soreness or injury with physical exercise. Thus, improved composite flexibility observed in this group of subjects participating in a Pilates exercise program suggests an important health benefit, which deserves further study.

LBM, truncal LBM, and fat mass did not change over the course of the study. Thus, there was no evidence for the claim that Pilates leads to "leaner muscles." This may not be surprising in that proponents do not claim that Pilates provides aerobic exercise. Because Pilates involves essentially isometric exercises, loss of fat and increase in muscle bulk may not be expected. Rather than increases in truncal LBM, the purported improvement in truncal stability may be related to improved truncal muscle recruitment patterns. If this is the case, then the assessment of transversus abdominus or multifidus motor unit recruitment by electromyography may provide a better tool to measure the effects of the isometric core strengthening targeted by Pilates.

The absence of changes in body composition and health assessment observed also may have been related to subjects participating in the Pilates program only 1 hour each week. Body composition and global self-perceived health are measurements that may depend more on the remaining hours in the week than on the limited time that subjects spent involved in Pilates training. It should be noted that the study was prospectively designed to replicate the most common Pilates training schedule (ie, 1h/wk). The limitation of training hours to the usual schedule may allow the results to be generalizable. Although 2 subjects entered with a high level of physical training, most subjects were middle-aged women who did not participate in regular exercise. Therefore, results are likely representative of this population, considering those who were initiating exercise would be expected to be more sensitive to changes in truncal lean and fat mass than subjects with a high level of prior training.

BIA for body composition measurement is a valid method to assess regional LBM in adults.[10,18] However, the hydration status of subjects, proximity to menses, bladder fullness, as well as adequacy of electric contact with the unit can reportedly affect BIA measurements. These theoretical considerations did not appear to be a significant limitation of the study because follow-up measurements of truncal body composition in each subject were nearly identical to those at baseline.

Although at the 2-month follow-up, there was a small increase in self-assessment of health, data at subsequent time points did not reveal any significant differences. The baseline VAS health assessment was skewed with a peak at nearly 77mm. The high initial assessment of health status may show that the Pilates class attracts a relatively healthy population, and this may be informative for physicians when counseling patients. However, such a high baseline may have resulted in the 100-mm line being relatively insensitive to improvements in health assessment. Reduction of the potential ceiling effects through use of more specific questions regarding symptoms and functional activities may permit more sensitive assessments in future studies.

Height was selected as a surrogate for postural assessment. Measurement technique was considered accurate, with investigators blinded to previous measurements and an SD for height measurements within 0.7cm. However, there was no significant change in height, despite the fact that subjects reported a sense of improved posture. This may indicate that measurement of height was insensitive to postural changes. Instructing subjects to stand up straight for height measurements may have biased the results, invalidating their use for assessment of posture. Subjective reports of improved posture may have been related to retraction of the shoulders or straighter sitting, giving a sense of improvement. To assess whether Pilates affects posture, it may be necessary either to measure height without instructing subjects to stand up straight or to assess posture formally.[19]

This study had several other potential limitations. One limitation was the absence of a suitable cohort of control subjects. Selection of an appropriate control group was complicated by the lack of prior studies. Subjects in an aerobics class at the same health club were considered, but, because of the dramatic difference in the nature of the exercise, this group was believed to be an inappropriate control group. Future studies would be strengthened by including a control group composed of subjects with similar levels of physical conditioning, health status, and motivation to those in a Pilates intervention.

Despite these limitations, retention of 68% of subjects over a 6-month period of Pilates training was considerably better than the usual 15% retention rate over the same period (Jane Hein, PT, Athletic Center Group Exercise Director, personal communication, Nov 2001). Additionally, subjects reported no serious side effects of the Pilates exercise and a very low rate of adverse events. The study was overpowered for the flexibility endpoint. Thus, although more frequent participation in the intervention and greater subject retention may have improved the sensitivity, the improvement in flexibility measurements appears to be valid.

CONCLUSIONS

A community-based Pilates program may improve truncal flexibility in healthy subjects. Claims relating to "leaner muscles" or "improved posture" with Pilates training are more difficult to verify and could not be established in this study. Participation with modifications for comfort appears to be safe on initial assessment. Further study should involve larger sam-

APPENDIX 1: PILATES ESSENTIAL MAT WORKOUT*

Months 1–2	Months 3–4	Months 5–6
Abdominal prep (×8–10 reps)	All previous exercises	All previous exercises
Hundred (sets of 10, 20, 30, . . . , 100)	Roll over (8 reps total)	Shoulder bridge (3 each leg)
Roll up (5–10 reps)	Slow double leg stretch (10 reps)	Open leg rocker (10 reps)
One leg circle (10 reps with each leg)	Scissors (10 reps)	Jackknife (5 reps)
Rolling like a ball (10 reps)	One leg kick (alternate ×8 reps)	Scissors in air (10 reps)
Single leg stretch (5 sets)	Double leg kick (5 to each side)	Bicycle in air (10 reps)
Single leg stretch with obliques (5 sets)	Shoulder bridge prep (3 each leg)	Teaser variation 2
Double leg stretch (10 reps)	Teaser variation 1 (5 reps)	Swimming (40 counts)
Spine stretch forward (5–7 reps)	Swimming prep (×5 reps)	Leg pull front (5 reps)
Saw (5 to each side)	Leg pull front prep (5 reps)	Side bends (5 each side)
Breast stroke preps (5 reps)	Side bend prep (5 each side)	Boomerang (5 reps)
Swan dive (5 reps for each prep)	Push up (3 sets of 3–4 reps)	
Heel squeeze (6–8 reps)		
Neck pull prep (5 reps)		
Obliques roll back (5 to each side)		
Spine twist (5 to each side)		
Side kicks (8–10 reps)		
Side leg lift series (8–10 reps for each)		
Teaser preps (5 reps)		
Seal (10 reps)		

*See reference 7 for diagrams and detailed description.
Abbreviation: reps, repetitions.

ple sizes, controlled design, and consider assessing alterations in truncal motor unit recruitment and strength.

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