Pilates: how does it work and who needs it?

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Summary
Pilates uses a combination of approximately 50 simple, repetitive exercises to create muscular exertion. Advocates of this system of exercise claim that exercises can be adapted to provide either gentle strength training for rehabilitation or a strenuous workout vigorous enough to challenge skilled athletes. The exercises are designed to increase muscle strength and endurance, as well as flexibility and to improve posture and balance. There is cautious support for the effectiveness of Pilates in improving flexibility, abdominal and lumbo-pelvic stability and muscular activity. Stronger support cannot be given at this point in time primarily due to the limited number of studies and the lack of sound methodology in the published research. However, current research does indicate that there may be applications for this type of intervention in certain clinical populations that are worthy of continued investigation.

Key words: pilates, muscles exercises

Introduction

The purpose of this article is to provide a brief history and overview of Pilates and to review the published literature regarding Pilates, its components and its effectiveness in selected aspects of training and rehabilitation.

History and Overview

Plagued by asthma and rickets as a child, Joseph Pilates created an exercise method which sprang from his determination to strengthen his frail and sickly body. He studied yoga, martial arts, Zen meditation and Greek and Roman exercises. 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 therapeutically move the non-ambulatory soldiers. He attached springs to hospital beds to support the patient's limbs while he worked them and he and the doctors noticed that the patients seemed to recover more rapidly (1). Unique at the time, Pilates' method allowed and encouraged movement early in the rehabilitation process by providing needed assistance. His experiences led to the development of his distinctive method of physical and mental conditioning, which he brought to the United States in 1923 (2). Pilates has been used for rehabilitation purposes increasingly over the last twenty years. Although there are some differences, in general, Pilates uses a combination of approximately 50 simple, repetitive exercises to create muscular exertion. Advocates of this system of exercise claim that exercises can be adapted to provide either gentle strength training for rehabilitation or a strenuous workout vigorous enough to challenge skilled athletes (1). The exercises are designed to increase muscle strength and endurance, as well as flexibility and to improve posture and balance; the exercises are relatively easy to initiate and maintain and fit well with the guidelines set forth by the U.S. Surgeon General and the American College of Sports Medicine (3).

All Pilates exercises flow from the "five essentials" – breathing, cervical alignment, rib and scapular stabilization, pelvic mobility and utilizing the transverses abdominis (4). Each exercise is initiated by stabilizing the core musculature, which includes the abdominal, gluteal, and paraspinal muscles in particular, and then proceeds through a controlled range of motion**.** Many traditional methods of muscle conditioning require participants to perform maximal voluntary contractions. In Pilates, the focus is on the most effective recruitment of motor units which places the emphasis on energy efficiency and quality of performance. Each exercise is repeated a few times, usually three to five, rarely more; so the body is constantly being exposed to new muscular and kinesthetic challenges (4).

Pilates exercises can be performed both on a mat or on specialized equipment called a Reformer. In the mat class, participants typically sit or lie supine or prone and use gravity to help stabilize the core. On the Reformer, a sliding horizontal platform within a box-like frame upon which a person sits, stands, kneels or reclines; varying resistance to movement is provided via light springs attached to the moving platform and through a simple pulley system (5).

Body weight is the main resistance that is used throughout the series of Pilates mat exercises. Changes in body position occur (i.e., longer limb levers or increased extension) in individual exercises and changes in the lever lengths of limbs can continue to challenge participants as their fitness levels increase. The additional psychological element of Pilates is evident in the additional focus on breathing and concentration during the execution of these exercises (5).

Does it Work?

Even though it has a long history, few empirical research studies have been done on Pilates. Many of the successes that were claimed by early Pilates enthusiasts, such as improving core strength, and increasing flexibility, circulation and balance have been slowly finding support in the completed research on the movement principles found in the Pilates exercises.

Transversus Abdominis
The transversus abdominis muscle located inferior to the umbilicus in the lower abdomen is specifically cued prior to the initiation of each Pilates movement. The simple action of "pulling in" the lower abdomen has a multitude of consequences. The transversus abdominis muscle is primarily a postural control muscle and is consistently the first muscle activated in relation to any limb movement (6). It is hypothesized that the transversus abdominis is activated independently at a subconscious and submaximal contraction, as part of the motor plan, to provide trunk stiffness during dynamic movement (7).
The transversus abdominis is recruited preferentially to the superficial muscle layers of the abdominal wall during breathing (8). The transversus abdominis normally contributes to respiration when expiration is increased voluntarily by forcing expiration (as is done in the Pilates method breathing) or involuntarily by breathing in against an inspiratory load. In contrast, during normal relaxed breathing the transversus abdominis does not seem to be activated (7).
In clinical settings it has been observed that a normal cognitive contraction of the transversus abdominis is accompanied by a contraction of the lumbar multifidus and, conversely, a normal cognitive contraction of the lumbar multifidus accompanied by a contraction of the transversus abdominis (9). Along with the transversus abdominis and multifidus, the pelvic floor muscles and the diaphragm also contract, which likely maintains the intra-abdominal pressure at a critical level, allowing the greatest spinal support.

Abdominal Exercises
The muscles of the anterior abdominal wall (rectus abdominis, external oblique, internal oblique, and transversus abdominis) play a fundamental role in providing stability to the trunk. Ideally, the objective of any abdominal exercise is to challenge the abdominal muscles while imposing a minimal load to the lumbar spine. Unfortunately, many exercises designed and used to increase muscular strength to improve lower back stabilization provide only minimal development of maximal voluntary contraction of the abdominal musculature. This may be appropriate for clinical populations, but does not elicit enough contraction to train the musculature in a healthy population. Therefore, a variety of exercises to promote abdominal musculature endurance are needed. Numerous studies have demonstrated the importance and efficacy of using a varied program of exercises to develop and maintain abdominal strength and endurance (10-12). One of the strengths of the Pilates method is the variety of abdominal exercises included in the routine. The core musculature is challenged in a variety of ways to theoretically achieve the best result in improving both strength and endurance.
Utilizing electromyography researchers had 20 physical education students perform twelve different abdominal exercises. They discovered that the standard curl-up elicited the lowest muscle action potential (MAP). Elevating the lower limbs with the body supported by the hands with extended and also flexed the knees on an inclined plane elicited the highest MAP for the rectus femoris (13). Studies have also demonstrated that individuals were able to alter the automatic patterns of abdominal muscle activity by specific, cued exercise interventions, resulting in more effective utilization of those abdominal muscles (14,15). For example, one study showed that with minimal instruction subjects were able to volitionally alter the relative activity of the oblique and rectus abdominis muscles when performing trunk curls (12). These both have the potential to be contributing factors during Pilates exercises, as these more challenging body positions are replicated in the series of exercises and muscular actions are well cued throughout the movement series.
Many of the exercises used in Pilates have been considered by some in the fitness professions to be contraindicated, such as double leg lowering and straight-legged sit ups. However, there is evidence that when the suggested Pilates exercises are performed properly, they do have a place within the abdominal exercise regimes for healthy populations. In fact, variations in the pelvic and trunk positions in the knee stretch exercises change the activation pattern of the multifidus, gluteus maximus, rectus abdominis, and oblique muscles. The lower level of activation of the rectus abdominis muscle suggests that pelvic stability is maintained in different body positions (16).
The maximum voluntary contraction (MVC) of the abdominal musculature attained during Pilates exercise is speculated to be similar to other simple therapeutic exercises (17). One study demonstrated between 10-20% of MVC in the multifidi and external obliques while performing Pilates on a Reformer (18). Whether this represents a large enough stimulus to enhance muscular strength or endurance or simply creates opportunity for enhanced neuromuscular action remains to be shown. However, another example is the side bridge exercise, a position similar to the side bridge exercise in Pilates, and activation of the quadrates lumborum. When supported with the feet and elbow the quadrates closest to the floor appears to be activated up to about 50% of maximum voluntary contraction (MVC) and the obliques experience a similar challenge (19). It may be hypothesized that it is the exposure to multiple exercises and body positions that is of the greatest value in creating muscular strength or endurance as a result of performing Pilates.
Research by Porterfield and DeRosa has suggested that proper breathing techniques during exercise also ensure generating sufficient intra-abdominal pressure, to aid in stabilizing the lower back (20). Training subjects to breathe properly, particularly emphasizing the expiratory muscles, can also reduce the sensation of fatigue and the sensation of effort during exercise (21).

Body Position/Posture
Pilates encourages the slight forward flexion of the cervical vertebra, the stabilization of the scapula, the "connection" of the rib cage to the hips and the posterior

pelvic tilt (4). Shirado, et al. showed that a similar position provides the most optimal posture for decreasing lumbar lordosis and for activating trunk flexors and extensors most effectively (22). The best circumstances for trunk muscles to produce maximum EMG activity are when the thoracic cage is fixed and the cervical spine is maximally flexed and the pelvis is maintained in a neutral, stabilized position (22). Efficient organization of head, neck, and shoulder girdle as cued with each exercise, allows the Pilates participant to coordinate the placement of the lower body to achieve maximal muscular contraction.

A recent study sought to determine the effect of a Pilates training program on arm-trunk posture, strength, flexibility and biomechanical patterns. Nineteen subjects (9 controls, 10 experimental) were assessed twice, 12 weeks apart, during which the experimental group performed Pilates training for two 1-h sessions per week. The results indicated that the Pilates training program was effective in improving abdominal strength and upper spine posture, as well as in stabilizing core posture when shoulder flexion movements were performed. Since deficits in these functional aspects have previously been associated with symptoms in the neck-shoulder region, these results support the use of Pilates in the prevention of neck-shoulder disorders (23).

In another recent report, researcher's recruited 34 adults aged 60 and over to participate in a study investigating saggital spinal posture after Pilates-based exercises. Results of their training indicated that immediately after the Pilates-based exercise program, older adults stood with slightly decreased thoracic flexion and sat with slightly increased lumbar extension. The authors concluded that the individually designed Pilates-based exercise program was feasible for healthy older adults, and the high attendance rate supported the suitability of the exercise program over a long period (24).

Low Back Pain (LBP)

By far the most published research has centered on Pilates and treatment of LBP. The Pilates method utilizes principles of various accepted rehabilitation methods that have scientific support for LBP, including core strengthening. This is important since core weakness has been increasingly recognized as a biomechanical deficit in patients with LBP (5).

The principle of stabilization and axial elongation is thoroughly integrated into all Pilates exercises. Axial elongation is thought to organize the spine in its optimal orientation for efficient movement, thus avoiding resting or working at the end of range, which can place undue stresses on the inert and contractile structures of the trunk and extremities. Studies demonstrate that the transversus abdominis, multifidus, diaphragm, and abdominal oblique muscles are key organizational muscles of movement in healthy individuals with low back pain (21, 25, 26). Porterfield's motor control studies and theories of trunk organization and stabilization show that subthreshold contraction of global stabilization muscles (such as those cued and used in Pilates exercises) can provide safe movement throughout daily activities (27). The Pilates method has been increasingly applied for its therapeutic benefits, however little scientific evidence supports or rebukes its use as a treatment regimen for musculoskeletal diagnoses including LBP. While most evidence to date is testimonial or in the form of uncontrolled case series, a few randomized controlled studies do exist regarding the effects of Pilates on patients with nonspecific CLBP (chronic low back pain) (5).

Rydeard and colleagues sought to determine the efficacy of utilizing Pilates as a therapeutic exercise approach in a population with chronic low back pain (CLBP) (28). Subjects in the study participated in a 4-week program on Pilates equipment and noted a significantly lower level of functional disability and average pain intensity at the end of the intervention. Perhaps of greater interest to clinicians is that the individuals in the specific-exercise-training group reported a significant decrease in CLBP and disability, which was maintained over a 12-month follow-up period. Rydeard, et al. concluded that treatment with a modified Pilates-based approach was more efficacious than usual care (defined in this study as consultation with a physician, other specialists and healthcare professionals, as necessary) in individuals with chronic, unresolved LBP (28).

In 2006, forty-three patients completed a study by Donzelli, DiDominica, Cova, Galletti and Giunta (29). Subjects had suffered from nonspecific low back pain for more than three months and performed either usual treatment (Back School) or Pilates exercises. The Pilates group showed better compliance and subjective response to treatment and also demonstrated results which were similar to usual treatment, suggesting that Pilates could be utilized as an alternative approach to treatment for those with chronic low back pain.

In 2008, La Touchea, Escalantea, and Linares published a review article on Pilates and treatment of low back pain (30). Only three studies met the criteria for inclusion of the review, however the authors noted that the results of the studies demonstrated positive effects, such as improved general function and reduction in pain when applying the Pilates Method in treating non-specific CLBP in adults (30). Further research is required to determine which specific parameters are to be applied when prescribing exercises based on the Pilates, however, the limited number of studies which have been completed suggest that Pilates has beneficial effects in terms of decreasing pain and disability in patients with nonspecific CLBP (5).

A more recent research study by da Fonseca, Magini and Freitas, evaluated the influence of pain on vertical ground-reaction force (VGRF) in patients with low back problems and the effect of the Pilates method on the gait of these patients (31). The results of this study suggest that patients with low back pain can develop strategies to attenuate the amount of force imposed on their body and showed that after 15 sessions of Pilates the subjects improved their weight discharge in gait and reduced their pain compared to non-intervention subjects.

Medical practitioners often make the decision regarding whether or not a patient with LBP should pursue an active or passive rehabilitation. Physical therapy directed programs including core stabilization components have been shown to be effective in the treatment of low back pain. Although more research is necessary, the best available evidence suggests that a ***core*** strengthening program may be beneficial in reducing pain scores, functional disability and recurrences of acute ***low back*** pain episodes (32). A Cochrane review concluded that exercise therapy appeared to be effective at decreasing

pain and improving function in adults with chronic ***low-back pain***. In acute ***low-back pain***, exercise therapy was concluded to be as effective as either no treatment or other conservative treatments (33, 34). There is, however, no evidence that one particular type of exercise therapy is clearly more effective than others (34). A recent meta-analysis showed that Pilates was superior to minimal intervention in the treatment of LBP (35). Yoga, which incorporates many similar elements to Pilates, has also been shown to be an effective treatment for LBP (36).

Additional Uses

There is also strong patient and clinician interest in the use of Pilates for postoperative rehabilitation. This has led to the development of safe and modified exercises for patients undergoing orthopedic procedures, such as total hip or knee arthroplasty (37). While Pilates exercises would conform to these standards and appear safe and effective anecdotally, further controlled trials are necessary to prove its validity.

Fall prevention in the elderly is a primary concern for many health care providers. After completing 10 Pilates-based exercise sessions a significant change in dynamic balance was found in the functional reach test mean scores in the exercise group of health adults (38). Twenty-four subjects aged 65 to 81 completed the ten week training program in which they were randomly assigned to a traditional strength plus flexibility group, a Pilates-based-training group and a no exercise control group. Results of the study indicated that Pilates was effective for improving static or postural balance in elderly adults (39). A small pilot study assessed subjects 66–71 years old who participated in Pilates twice a week for eight weeks. The results showed that a training program of Pilates-inspired exercises over a short duration could be safely performed in well-functioning older adults and may lead to improvements in postural stability (40). Additional research specifically on individuals prone to balance disturbances or falling needs to be conducted before any generalizations can be drawn of the effectiveness in fall prevention.

Other research on Pilates has focused on pelvic floor strengthening (41); the functional capacity and quality of life of breast cancers patients (42); pain and quality of life in fibromyalgia patients (43); and personal autonomy, static balance and quality of life in healthy elderly females (44). Several studies (45-47) have demonstrated increases in flexibility after engaging in Pilates; however, none of these studies was able to show changes or improvements in posture or body composition. In contrast, dancers have shown improvements in dynamic posture (48) and leaping ability after Pilates method training (49). Another recent study showed that Pilates could also be effective in increasing functional capacity in very low fit patients (heart failure NYHA class I-II) when compared with standard cardiac rehabilitation medical therapy (50). Taken together, these studies have found that Pilates exercises have had good compliance and have been effective and generally regarded as safe for these populations studied.

A final application of the Pilates method might be in weight management. A study of young girls (10-12 years old) found that participation in Pilates for 4-weeks found a significant reduction in their BMI percentile (51). Another study which investigated responses of adult, novice practitioners (n = 9) to an 8-week traditional mat Pilates program resulted in improvements in sit and reach, shoulder reach, curl up, low back extension, as well as reduced relative body fat and circumferences at the waist, chest and arm (52). More research needs to be conducted to determine if Pilates might prove to be a useful means of increasing activity and thereby curbing the obesity epidemic.

Conclusion

There is considerable interest by trainers and clinicians to be able to adopt Pilates into physical training and rehabilitation schemes. Although Pilates exercises have been utilized for almost ninety years there is little empirical research to definitively support the claims made by early practitioners. There is cautious support for the effectiveness of Pilates in improving flexibility, abdominal and lumbo-pelvic stability and muscular activity. Stronger support cannot be given at this point in time primarily due to the limited number of studies and the lack of sound methodology in the published research. However, current research does indicate that there may be applications for this type of intervention in certain clinical populations that are worthy of continued investigation. The theoretical mechanisms of how and why Pilates are effective appear to well established, therefore, it is suggested that work in the future should center on documenting the application and success of Pilates a wider variety of training and rehabilitation milieus.

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