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LITERATURE REVIEW

The effectiveness of Pilates training in healthy adults: An appraisal of the research literature

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Summary Pilates has gained momentum and attention in the past 5 years as a modality for improving flexibility, strength and mind–body awareness. What is not revealed, however, is the scientific basis for this practice. The two-fold purpose of this review was to (1) critically appraise published research on Pilates in healthy adults and (2) propose future research options for this method in healthy adults. An extensive literature search was conducted, using *Pilates* as the search word. A total of 277 articles were found. Thirty-nine articles and abstracts were published in refereed, professional journals, of which there were only three clinical trials in healthy adults. The strengths of these three clinical trials were the (1) use of established measurements for stated outcomes and (2) documented need for research in this area. The weaknesses were (1) lack of true experimental designs, (2) small sample sizes, and (3) lack of a defined method of Pilates. There is cautious support for the effectiveness of Pilates in improving flexibility, abdominal and lumbo-pelvic stability and muscular activity, primarily due to a lack of sound research methodology surrounding each study. Utilizing a true experimental design and stating the Pilates method utilized can strengthen and improve future Pilates research in healthy adults.

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Introduction

Pilates is a mind–body fitness program gaining in popularity and acceptance within the fitness community. Named after its founder, Joseph H. Pilates, and detailed in his publications (*Pilates, 1934, 1945*), this fitness program incorporates the use of

special apparatus and equipment into movement routines designed to enhance flexibility, strength, and coordination. Pilates is advocated as a beneficial exercise method in adult populations (*Reyneke, 1993; LaBrusciano and Lonergan, 1996; Latey, 2001, 2002; Stanko, 2002; Muscolino and Cipriani, 2003a, b; Smith and Smith, 2004*).

With this ongoing interest in and support for Pilates as an exercise method in healthy adults, an established scientific framework based on evidence

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from research studies would be expected. To learn more about the scientific basis for Pilates, a literature search and critical appraisal of the published research were undertaken to answer the question: What is the evidence for Pilates as a method of exercise in healthy adults?

Method

An electronic and paper literature search was conducted using the OVID search engine. Data bases searched were Medline, Allied and Complementary Medicine (AMED), Cumulative Index to Nursing and Allied Health Literature (CINAHL), SportsInfo, and the Cochrane Database of Systematic Reviews. Journal articles published from 1990–2005 were searched. The key word searched was *Pilates*. Articles were retrieved for appraisal if they were human subjects research published in refereed, professional journals. A total of 277 articles and abstracts were identified. No meta-analyses or systematic reviews were found. Table 1 outlines the distribution of published Pilates articles.

Only 10 (3.9%) research studies were published in refereed, professional journals. Of these, five research studies were conducted in dancers and gymnasts (Fitt et al., 1993; Parrott, 1993; McLain et al., 1997; Hutchinson et al., 1998; McMillan et al., 1998); two studies were conducted in special populations (Savage, 2005; Mallery et al., 2003); and three studies (1.08%) conducted in healthy adults (Herrington and Davies, 2005; Segal et al., 2004; Petrofsky et al., 2005). These three studies are reviewed and appraised.

Literature review of the three published studies

Herrington and Davies (2005) conducted an observational study to assess and compare the contraction of the transversus abdominis muscle among

healthy females trained in Pilates, traditional abdominal curls and a control group. Thirty-six healthy females (mean age = 32.6 years) served as the study subjects who were divided into three groups. Twelve were categorized as Pilates trained, based on their attendance of one or two 45-min Pilates classes each week for a 6-month period. Another 12 subjects were categorized as abdominal curl trained, having attended 15-min abdominal curl classes, once or twice weekly for 6 months. The last 12 subjects did not practice Pilates or abdominal curls. To indirectly measure contraction of the transversus abdominis muscle and to monitor lumbar–pelvic stability, a stabilizer pressure bio-feedback unit (Chattanooga Group Inc.) was employed. A tester, blinded to group category, conducted the measurements.

Results indicated that 10 (83%) Pilates group, 4 (33.3%) abdominal curl group and three (25%) control group subjects passed the transversus abdominis stability test. Overall, less than half of the 36 subjects ($n = 17$, 47%) passed this test. For the lumbar–pelvic stability test, only 5 (42%) Pilates group subjects passed this test, with all others failing this test, leaving 14% overall who were able to stabilize the lumbar–pelvic area. The authors concluded that females who train in Pilates may be better able to recruit and utilize their deep abdominal muscles and stabilize the pelvic area compared to those not trained in Pilates.

Segal et al. (2004) conducted an observational, prospective, repeated measures study to assess the effects of Pilates training on flexibility, body composition, and health status of healthy adults. A power analysis was calculated for a sample size of 16 subjects. Adult members of a health club (31 women (average age = 41 years) and one man (age 42 years)) were assigned into classes of 8–12 students. All subjects participated in 1-h weekly Pilates mat class for 6 months. Exercises progressed in difficulty. Outcomes measured at baseline, 2, 4 and 6 months were composite flexibility (fingertip-to-floor), body composition (height, body mass index (BMI), body mass, segmental fat, and lean body mass); perception of health and function

Table 1 Distribution of published Pilates literature.

No meta-analyses or systematic reviews were found
Seventy-one (25.6%) no match in the Ulrich's Periodicals Directory
Four (1.4%) published in foreign languages
Eighty-five (30.7%) trade magazines
Seventy-eight (28.1%) printed in consumer publications (magazines, newspapers, and newsletters)
Thirty-nine articles and abstracts (14%) published in refereed, professional journals

$N = 277$.

(American Academy of Orthopedic Surgeons (AAOS) outcomes questionnaire); and event log (self-report of problems with the Pilates class). Composite flexibility improved from baseline to 6 months ($P < 0.01$). There was no statistically significant change in body composition or in the AAOS questionnaire. Self-reported event log had themes of adverse events with pain or discomfort in back and neck muscles ($n = 6$). Positive comments were improved posture, improved flexibility, and cessation of morning stiffness, among others. The authors concluded that Pilates exercises may improve truncal flexibility in healthy adults.

Petrofsky et al., (2005) conducted an observational study to compare Pilates exercises with and without a resistance band, and to compare these exercises against those performed with commercial exercise equipment. Six healthy subjects, four males and two females, (mean age = 25.3 years) were enrolled. Muscle activity was measured during the exercises with electromyogram (EMG), and this technique was validated in other studies. The resistance band used during the Pilate exercises was an oblong ring (Zone Pilates Sculpter, Svier LP, Santa Fe Springs, CA), and weight lifting was done on a Keiser weight lifting system (Wilmington, DE). Each subject participated in all exercises. Subjects first completed Pilates exercises without the resistance band, then completed Pilates exercises with the resistance band. Pilates exercises included squats, leg adduction, and hip extension. Once EMG was assessed with the Pilates exercises, the subjects completed commercial equipment exercises on the quads, inner outer thigh, and hamstring machines. The weight applied on each exercise machine was compared with the results of EMG activity during the Pilates exercises completed with and without the resistance band. The results showed little muscular activity during the Pilates exercises without the resistance band, averaging 20% of the total muscle activity for the leg muscles. Pilates exercises with the resistance band increased the muscle activity by at least 50%. Pilates exercises with and without the resistance band exercised multiple muscle groups simultaneously. Pilates may be beneficial in those seeking a resistance workout that places less stress on the joints and muscles.

Appraisal of the research studies

These three studies reflect the extent of current published research in healthy adult subjects using Pilates. Each study had its strengths, weaknesses,

and limitations. The theory behind each of these studies—the effect of Pilates exercises on muscle activity, flexibility, body composition, and muscular strength—were well defined. Subjects across all studies were in a similar age range, with females over-represented, and all studies used the subjects as their own controls. The instruments used to measure study outcomes were valid and reliable, as demonstrated by data from previous studies. Intra-rater reliability was established. Subject consent was obtained, and study protocols appeared to be followed consistently. Overall, data analyses appeared to be adequate for the level of data collected. The researchers drew their conclusions from their study data and did not go beyond their findings in translating their findings into practice. All researchers agreed that additional research in Pilates is needed. These strengths add to the body of empirical evidence needed in the application of Pilates exercises and outcomes in a healthy adult population.

Numerous weaknesses were found across the studies. Aside from Segal et al. (2004) who recruited from a health club, it is unclear how subjects were recruited into the studies by Herrington and Davies (2005) and Petrofsky et al. (2005). All sample sizes were very small, which does not allow for generalizability of the findings. Only Segal et al. (2004) calculated sample size to determine the effect needed to measure differences in fitness attributes before and after the Pilates interventions.

The Pilates exercises themselves were a source of concern. Segal et al. (2004) utilized the Stott–Pilates method, and the classes were taught by a Stott–Pilates certified instructor. The Stott–Pilates method is taught through an established curriculum, and instructors follow a prescribed sequencing of exercises similar to that taught by Pilates himself. The method of Pilates utilized in the remaining two studies is unclear, leaving doubt as to whether or not Pilates actually was performed. Herrington and Davies (2005) enrolled subjects who self-reported their practice of Pilates, but there was no verification of the Pilates method practiced by the subjects or their ability to perform Pilates exercises. Similarly, Petrofsky et al. (2005) listed Pilates exercises as muscle groups worked (leg adduction, hip extension), and the translation into a Pilates exercise is not given. Readers, then, may arrive at or draw different assumptions about what Pilates method was practiced.

The lack of a defined method of Pilates, the small sample sizes, and the lack of randomization influenced the studies' results. While Segal et al. (2004) utilized a defined Pilates method and

specified a power calculation, randomization and a control group were lacking (although each subject served as his/her own control). Their findings support increased flexibility and no changes in body composition or self-reported health following a period of Pilates training. However, positive comments about the benefits of Pilates in their activities of daily living were provided. These results show promise for future large-scale studies in Pilates training. [Herrington and Davies \(2005\)](#) showed that the Pilates-trained subjects had the highest passing rates for transversus abdominis isolation and lumbar–pelvic stability compared to those subjects trained in abdominal curls or those in the control group. While subject randomization was not possible, the randomizing of the measurements for transversus abdominis isolation and lumbar–pelvic stability would have avoided bias in the test measurements and perhaps the results. Because the Pilates method used by the Pilates subjects was not explicated or tested, it cannot be said for certain that the subjects' results were due to Pilates training. Similarly, [Petrofsky et al. \(2005\)](#) did not randomize their testing order and kept standard the order of Pilates exercises, Pilates exercises with the resistance band and then weight machines. The order of muscle activity also was kept standard. Again, the method of Pilates utilized by subjects when completing the exercises as well as the subjects' prior experience with or proficiency in Pilates was not stated, allowing for uncertainty as to whether or not Pilates exercises were executed or executed properly.

Implications for Practice

Despite the hundreds of published articles on Pilates, the extant scientific evidence for Pilates is limited. An extensive literature search found 277 Pilates articles published in the past 14 years; only 10 (3.6%) were human subjects research and of these, only three were conducted in healthy adults. The research presented in this appraisal was published very recently (2003–2005), at a height in the Pilates movement. Ideally, one would expect to find a significant number of well-controlled research studies in healthy adults conducted at universities, or at fitness centers, Pilates studios, health clubs, rehabilitation or other settings. Remarkably, very few research studies have been published where Pilates has been rigorously and empirically tested and evaluated, in any population. This lack of published research is disappointing, considering the popularity of Pilates, the numerous established curricula for instructor and

student training, and how it is adapted and taught in a variety of settings.

Overall, each study's purpose and questions were well stated. The rationale for studying Pilates was thorough, and documentation of the need for such study was clear. All investigators stated that Pilates warranted further study in healthy adults. The lack of randomization, either in group assignment or in outcome measurement, raises questions of bias. This bias cannot be discounted, despite similarities in gender (mostly females) and age (adult) across the studies. Furthermore, there was no direct measurement of the subjects' prior training in or skill level with executing Pilates exercises.

A limitation of this appraisal is that articles may have been missed that were not available through the OVID search engine. Unpublished master's theses and doctoral dissertations were not obtained through this search, and these studies may hold additional data of interest to researchers and practitioners.

Conclusion

This appraisal of three human subjects research studies utilizing Pilates finds support for the effectiveness of Pilates in healthy adults to improve flexibility, transversus abdominis activation, lumbar–pelvic stability, and muscular activity. This support is given cautiously, due to small sample sizes, lack of true experimental research designs, and bias in subject recruitment and measurement. The lack of specificity and description of the Pilates method used in two of the studies leaves room for doubt as to how Pilates was defined and practiced.

Researchers and practitioners alike agree that there is a lack of, and need for, published research on the effectiveness of Pilates in healthy adults ([Fitt et al., 1993](#); [Brown, 1999](#); [Stone, 2000](#); [Lange et al., 2000](#)). Human subjects research must be conducted with Pilates to establish an evidence base for its practice.

Well-designed experimental studies that randomize subjects, utilize a control group, define the Pilate method utilized, calculate statistical power and sample size, and using valid and reliable methods to measure outcomes, would build a body of scientific evidence of Pilates' efficacy and effectiveness in practice with healthy adults.

References

- Brown, S., 1999. Pilates: man or method. *Journal of Dance Medicine and Science* 3 (4), 137–138.

- Fitt, S., Sturman, J., McClain-Smith, S., 1993. Effects of Pilates-based conditioning on strength, alignment, and range of motion in university ballet and modern dance majors. *Kinesiology and Medicine for Dance* 16 (1), 36–51.
- Herrington, L., Davies, R., 2005. The influence of Pilates training on the ability to contract the transversus abdominis muscle in asymptomatic individuals. *Journal of Bodywork and Movement Therapies* 9, 52–57.
- Hutchinson, M., Tremain, L., Christiansen, J., Beitzel, J., 1998. Improving leaping ability in elite rhythmic gymnasts. *Medicine and Science in Sports and Exercise* 30 (10), 1543–1547.
- LaBrusciano, G., Lonergan, S., 1996. Pilates: a method ahead of its time. *Strength and Conditioning* August, 74–75.
- Lange, C., Unnithan, V., Larkam, E., Latta, 2000. Maximizing the benefits of Pilates-inspired exercise for learning functional motor skills. *Journal of Body Work and Movement Therapies* 4 (2), 99–108.
- Latey, P., 2001. The Pilates method: history and philosophy. *Journal of Bodywork and Movement Therapies* 5 (4), 275–282.
- Latey, P., 2002. Updating the principles of the Pilates method—part 2. *Journal of Bodywork and Movement Therapies* 6 (2), 94–101.
- Mallery, L., MacDonald, E., Hubley-Kozey, C., Earl, M., Rockwood, K., MacKnight, C., 2003. The feasibility of performing resistance exercise with acutely ill hospitalized older adults. *BMC Geriatrics* 3 (3), 3.
- McLain, S., Carter, C., Abel, J., 1997. The effect of a conditioning and alignment program on the measurement of supine jump height and pelvic alignment when using the current concepts reformer. *Journal of Dance Medicine and Science* 1 (4), 149–154.
- McMillan, A., Proteau, L., Lebe, R., 1998. The effect of Pilates-based training on dancers' dynamic posture. *Journal of Dance Medicine and Science* 2 (3), 101–107.
- Muscolino, J., Cipriani, S., 2003a. Pilates and the "powerhouse"—I. *Journal of Bodywork and Movement Therapies* 8, 15–24.
- Muscolino, J., Cipriani, S., 2003b. Pilates and the "powerhouse"—II. *Journal of Bodywork and Movement Therapies* 8, 122–130.
- Parrott, A., 1993. The effects of Pilates technique and aerobic conditioning on dancers' technique and aesthetic. *Kinesiology and Medicine for Dance* 15 (2), 45–64.
- Petrofsky, J., Morris, A., Bonacci, J., Hanson, A., Jorritsma, R., Hill, J., 2005. Muscle use during exercise: a comparison of conventional weight equipment to Pilates with and without a resistive exercise device. *The Journal of Applied Research* 5 (1), 160–173.
- Pilates, J., 1934. *Your Health*. Presentation Dynamics Inc., Incline Village, NV.
- Pilates, J., 1945. *Return to life Through Contrology*. Presentation Dynamics Inc., Incline Village, NV.
- Reyneke, D., 1993. The Pilates method of exercise and rehabilitation. *Physiotherapy in Sport* 18 (3), 19.
- Savage, A., 2005. Is lumbopelvic stability training (using the Pilates model) an effective treatment strategy for women with stress urinary incontinence? A review of the literature and report of a pilot study. *Journal of the Association of Chartered Physiotherapists in Women's Health* 97, 33–48.
- Segal, N., Hein, J., Basford, J., 2004. The effects of Pilates training on flexibility and body composition: an observational study. *Archives of Physical Medicine and Rehabilitation* 85, 1977–1981.
- Smith, K., Smith, E., 2004. Integrating Pilates-based core strengthening into older adult fitness programs. *Topics in Geriatric Rehabilitation* 21 (1), 57–67.
- Stanko, E., 2002. The role of modified Pilates in women's health physiotherapy. *Journal of the Association of Chartered Physiotherapists in Women's Health* 90, 21–32.
- Stone, J., 2000. The Pilates method. *Athletic Therapy Today* 5 (2), 56.

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