ORIGINAL RESEARCH

PILATES: EFFECTIVE FOR DEVELOPING CORE STABILITY, BUT LIMITED SESSIONS HAVE LIMITED GLOBAL BENEFITS.

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ABSTRACT

Introduction: The National Physical Activity Guidelines for Australians recommend a minimum of 30 minutes of physical activity most days of the week to maintain good health. The American College of Sports Medicine suggests Pilates may be an effective mode of physical activity, however there is limited evidence to support the efficacy of Pilates for a range of its commercially claimed benefits.

Methods: In this observational cohort study, healthy adults (4 males and 14 females), who had not participated in Pilates exercise prior to the study, completed 12 weeks of studio and/or mat based Pilates classes once per week and were compared to age matched controls. Before and after the 12 week intervention, participants completed a dual energy X-Ray absorptometry scan to assess body composition and bone mineral density; completed the 5 stage Sahrmann Core Stability assessment; were assessed for joint mobility at the shoulder, cervical and lumbar spine, hip and ankle using a goniometer; had their lower limb strength assessed through heel raises and isokinetic dynamometry; and their energy expenditure and energy intake monitored utilising the SenseWear™ Armband Mini and a five day food record.

Results: There were no significant differences identified between the groups (Pilates and control) at baseline in relation to demographics (age, weight, height) and all aforementioned physiological characteristics, with the exception of cervical neck flexion. After the 12 week intervention, positive changes in core stability as identified through the Sahrmann core stability test among Pilates participants was evident though not statistically significant. Pilates group mean change 0.78 ±1.30AU, control group mean change -0.33 ± 1.11AU (p = 0.070). No other meaningful differences were identified.

Conclusions: Though 12 weeks of Pilates completed once per week may be effective for enhancing core stability, it did not appear to elicit positive outcomes for range of motion, body composition and foot strength.

Keywords: pilates training; body composition; range of motion; exercise; muscle strength
INTRODUCTION

The National Physical Activity Guidelines for Australians recommend a minimum of 30 minutes of physical activity most days of the week to maintain good health. The American College of Sports Medicine suggests that Pilates may be an effective mode of physical activity, however there is limited evidence to support the efficacy of Pilates for a range of its commercially claimed benefits. Pilates has been defined as a mind-body exercise requiring core stability, strength, and flexibility, with attention to muscle control, posture and breathing. Pilates has been shown to stimulate proprioception and a mind-body connection that may enhance body-awareness, motor performance, and improve muscular endurance and uniform muscle development.

Published literature suggests Pilates exercises completed from 1-3 times per week over a period of 7-12 weeks in apparently healthy populations can improve abdominal (core) strength, abdominal endurance, balance, and range of motion (ROM) at the hip, and shoulder. However many of these studies lack true experimental designs, control groups and rigorous assessment techniques for their primary and secondary outcome measures, drawbacks highlighted in multiple review papers. Despite methodological flaws in many studies, the most recent systematic review concluded there is strong evidence for improvements in flexibility (ROM) and dynamic balance, and moderate evidence for increased muscular endurance in healthy people completing Pilates based exercises.

Aside from Pilates enhancing abdominal strength, endurance and joint ROM, favourable changes in body composition are often proclaimed. Scientific evidence for the claimed benefits of fat mass reduction and increased muscle mass are limited, with a direct assessment of body composition and bone mineral density (BMD) through the gold standard technique of dual energy x-ray absorptometry (DEXA) non-existent among Pilates literature to date. A recent systematic review concluded there is poor empirical evidence indicating a positive effect of Pilates on body composition. One of the underlying reasons for the lack of evidence linking Pilates to favourable body composition changes may be due to the number of external parameters such as diet and other forms of physical activity that play a significant role in anthropometrical changes. To date, these factors do not appear to be considered or measured and therefore reported in Pilates research.

Market research in The Unites States of America suggest that Pilates and Yoga participation has increased from 4.3 million people in 2001 to an estimated 22.1 million in 2012 with revenue reaching $6.9 billion in 2012, indicating an increasing number of people are participating in Pilates exercise as a form of physical activity to maintain health. Therefore, it is imperative consumers are aware of the suggested benefits (or lack thereof) that can be gained from participating in this particular form of exercise. It would also be advantageous to qualify how often this type exercise needs to be completed to gain physiological and health benefits.

The aim of this study was to assess changes in abdominal (core) strength, body composition (fat mass, lean mass, fat free mass, bone mineral content), BMD, ROM at the neck, shoulder, spine, hip and ankle, and lower limb strength and endurance after 12 weeks of Pilates exercises completed once per week. We hypothesise that regular participation in Pilates exercise would promote an increase in abdominal (core) strength, joint mobility and foot strength, yet body composition and BMD would remain unchanged in individuals who are new and inexperienced in Pilates exercise.

METHODS

Participants. Eighteen (4 male, 14 female) healthy adults who had not completed Pilates exercises in the past were recruited for the study. Nine of the participants were recruited through a local Pilates studio before they commenced any Pilates sessions, then aged matched controls were sort from the University community. All participants provided
their written informed consent, and the study was approved by the University’s Human Research Ethics Committee (Approval number: 13-175). Inclusion criteria for the Pilates participants were a paying member of the local studio enrolled in the 12 week program, and free from any injuries or chronic medical conditions. Exclusion criteria for all participants was planned changes in physical activity and nutritional habits in the 12 weeks between baseline and post testing.

**Pilates Instruction**

The Pilates intervention involved either a 60 minute matwork or Pilates studio equipment based session, that focused on all parts of the body and was pitched at a basic/foundation level. All participants completed one class per week of their chosen format (mat or studio). The sessions were progressed from the basic/foundation level to a progressive level of work by the end of the 12 weeks. The matwork sessions contained between 21-38 exercises over the 12 weeks, and each exercise ranged from 4-10 repetitions. Each studio equipment session ranged from 43-57 exercises with 4-10 repetitions for each exercise. Template programs for both matwork and studio equipment sessions were followed by all instructors, which were delivered with progressions towards a higher level of Pilates work (requiring more complexity and skill base) for the 12th week.

All Instructors were trained in the Pilates International Training Centre (PilatesITC) method of Pilates and followed the PilatesITC interpretation of the traditional Pilates repertoire. The programming utilised was the PilatesITC PIC System™ (Pilates International Category System) for both matwork and studio work. There was a maximum of 4 participants in the equipment classes, and 10 in the matwork classes, and all classes were taught at an introductory level. Repertoire examples include:

Matwork: Pelvic Curls (Bridge); Chestlift (or Curl Ups) with both feet on the floor and progressed to both feet in the air; The Hundred (including preparations towards); Single Leg Stretch; Leg Circles; Rolling; Seated Spine Twist; Saw; Spine Stretch; Side-lie series; Prone Half Swimming; Single Leg Kick; Kneeling Swimming; Front Support; Back Support Preparations; Roll Up; Roll Back; Roll Downs.

Equipment: Leg and Footwork were completed on the Reformer (Balance Body Pilates Allegro 1, Sacramento, CA, USA) and progressed to the Wunda Chair (Balance Body Exo chair, Sacramento, CA, USA); The Hundred; Reformer Strapwork; Cadi Strapwork (doubles); Pelvic Curl (Bridge) with knee/hip extension; Knee Stretches; Upstretch modified to 1 and 2; Elephant; Basic Lunges on Reformer; Seated armwork on the Reformer; Magic Circle Adduction; Glute series (variety); Side Reach on Wunda Chair; Basic Swan on Wunda Chair; Side Lift on Spine Corrector; Short Box basic abdominal series on Reformer.

**Outcome Measures**

The following outcome measures were assessed at baseline and 12 weeks after the initial assessment.

*Body Composition.* Body weight was measured using an electronic scale (Tannita BC-541, Australia) and height by a stadiometer (Seca 240, Germany). Fat mass, lean mass, fat free mass, and bone mineral content were assessed by DEXA using a Lunar Prodigy Pro scanner (GE Lunar Corp., Madison, WI USA). BMD (g·cm²) values of both the femur and anterior-posterior spine of lumbar 1-4 (spine) were also measured by DEXA. DEXA scanning was completed in accordance with the University’s DEXA scanning protocol that has been validated in previous research.

*Core stability.* A clinical measure of core stability was obtained using the Sahrmann core stability test. A pressure biofeedback unit (Chattanooga Group Inc., Hixson, TN) was placed under the natural lordotic curve of the participant and inflated to 40 mmHg while they lay supine. The test consisted of 5 levels (graded 1 through 5), with each level increasing in difficulty. Consistent with previous research, the lumbar spine position had to be maintained as indicated by a change of no more than 10 mmHg of pressure as measured by the pressure biofeedback unit for the level to be deemed successful. A detailed explanation of each
level can be found elsewhere. 27

Range of Motion. ROM (flexion, extension and abduction) at the shoulder, hip, ankle, thoracic and lumbar spine was assessed using standard goniometric techniques utilising a G300 goniometer (Whitehall Manufacturing Inc. California, USA). 28

Foot strength. Maximum peak torque produced in both plantar flexion and dorsiflexion at 30, 60, 90 and 105 deg·sec⁻¹ was assessed using the isokinetic dynamometer (HUMAC/NORM™ Testing and Rehabilitation system, Computer Sports Medicine Inc. Stoughton, MA) as has been described in previous research. 29 The dorsiflexion/plantar flexion ROM was recorded for each participant, and limb weight measured with the ankle relaxed in order to correct the measured torques for the effects of gravity. Following 3 sub-maximal practice plantar and dorsiflexion repetitions and 1 minute rest, 3 maximal concentric active plantar flexion and dorsiflexion contractions were completed. As a more functional and practical method of assessing foot strength that may be applied in a studio setting, heel raises to fatigue (maximum of 50 repetitions) was utilised to assess muscular endurance in the lower limb.

Energy Expenditure and nutritional intake. Each participant wore a SenseWear™ armband and recorded their nutritional intake for five consecutive days in the first week (week 1) and last week of the study (week 12). The SenseWear™ armband is a validated device that is worn on the back of the upper arm and calculates the energy expended during activities of daily living. 30 A five-day food diary was kept by all participants, which was subsequently analysis by the FoodWorks Nutrient Analysis software package (Foodworks®, version: 7.0.2983; Xyris software). Collection of this information enabled the research group to identify if physical activity patterns and nutritional habits changed over the course of the intervention, due to their influence on body composition.

Statistical Analysis

Data collected at baseline and at 12-weeks were analysed to identify significant changes across the intervention, comparing baseline and post testing measurements for both the control group and the Pilates group, and also comparing the mean change of the control group with that of the Pilates group. Data were analysed using SPSS Statistics 21 (SPSS Inc, Chicago IL). One-way analysis of variance (ANOVA) independent samples and paired t-tests were employed to compare difference within and between groups. Significance was accepted at the 0.05 level.

RESULTS

Table 1 summarises the participant demographics. No significant differences were identified between the groups for baseline demographics. Similarly, no significant differences were identified between groups for any baseline parameters with the exception of cervical flexion, with the Pilates group demonstrating a greater ROM at the neck when compare to the control group (p = 0.003).

Core Stability. The Sahrmann core stability test

Table 1. Participant Demographics at baseline. No significant differences were identified between groups or within groups for any parameter.

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<th>Pilates Participants</th>
<th>Control Participants</th>
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<tr>
<td></td>
<td>Male (n=2)</td>
<td>Female (n=7)</td>
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<tr>
<td>Age (y)</td>
<td>27.5 ± 10.61</td>
<td>32.00 ± 13.03</td>
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<tr>
<td>Height (cm)</td>
<td>180.50 ± 12.16</td>
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<tr>
<td>Weight (kg)</td>
<td>82.03 ± 4.21</td>
<td>66.58 ± 7.03</td>
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<tr>
<td></td>
<td>Combined (n=9)</td>
<td>Combined (n=9)</td>
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<tr>
<td>Age (y)</td>
<td>31.00 ± 12.05</td>
<td>34.43 ± 10.63</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>170.7 ± 8.13</td>
<td>169.06 ± 8.52</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>70.01 ± 9.26</td>
<td>63.13 ± 16.47</td>
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levels 1 through 5) determined that core stability in the Pilates group improved from baseline to post testing with a mean change (SD) of 0.78 ± 1.30 AU, whereas the control group participants regressed, with a mean change of -0.33 ± 1.12 AU. However this change was not significant (p = 0.07). Figure 1 shows the results of the Sahrmann test of core stability for the Pilates and control group before and after 12 weeks of Pilates exercise.

**Body Composition.** No significant differences were identified between or within groups from baseline to post testing for fat mass, lean mass, fat free mass, bone mineral content, or BMD. However the BMD of the neck of femur from baseline to post testing trended towards a significant improvement (p = 0.05), see table 2.

**Energy Expenditure and nutritional intake.** The mean energy expenditure of participants in the Pilates group was 2373.00 ± 291.60 kCal at baseline and 2312.71 ± 399.90 kCal post intervention. Similarly, the control groups energy expenditure was 2750.33 ± 660.82 kCal and 2659.00 ± 716.54 kCal at baseline and post intervention respectively. No significant differences were identified between or within groups for energy expenditure. In regards to nutritional intake, the Pilates participants reported a mean energy intake of 1703.29 ± 757.10 kCal and 1591.50 ± 376.71 kCal at baseline and post intervention respectively, and the control group 2230.00 ± 577.41 kCal at baseline and 2156.78 ± 650.67 post intervention. No significant differences were identified between or within groups for energy intake.

**Range of Motion.** With the exception of cervical flexion, no significant changes in ROM were identified between or within groups after the 12 week Pilates intervention. The control group ROM improvement significantly for cervical flexion from baseline to post testing from a mean 32.78 ± 10.47 degrees to 17.50 ± 7.56 degrees (p = 0.003), whereas the Pilates group ROM did not change (p = 0.82).

**Foot Strength.** Though there was a trend towards the Pilates participants improving muscular endurance in the lower leg as assessed by the heel raises from 36.67 to 40.22 repetitions, this was not significant (p = 0.243). The control group mean

<table>
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<th>Table 2. Participants body composition characteristics. No significant differences were identified between groups or within groups for any parameter.</th>
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<tr>
<td><strong>Pilates Participants</strong></td>
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<tr>
<td>-------------------------------</td>
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<tr>
<td><strong>Pre</strong></td>
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<tr>
<td>Percent body fat (%)</td>
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<td>Fat free mass (kg)</td>
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<td>Fat mass (kg)</td>
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<tr>
<td>Lean mass (kg)</td>
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<tr>
<td>Bone mineral content (kg)</td>
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<tr>
<td>BMD Spine (g·cm²)</td>
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<td>BMD neck femur (g·cm²)</td>
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Figure 1. Sahrmann test of core stability data for the Pilates and control group before and after 12 weeks of Pilates. No significant differences between groups were identified.
repetitions did not change, with a mean 42.33 repetitions completed at baseline and 42.56 repetitions completed post intervention (p = 0.86).

When assessing force production at the ankle joint using the isokinetic dynamometer, no significant differences between or within the groups were identified in maximal peak torque for plantar and dorsiflexion at any speed.

**DISCUSSION**

As hypothesised, 12 weeks of Pilates exercise enabled healthy individuals to better activate the abdominal muscles as identified through the Sahrmann core stability test when compared to the control group, though the degree of improvement was not statistically significant. A small change was expected as the activation of the deep abdominal muscles is a key focus of the Pilates repertoire, yet the frequency of Pilates training in this study did not appear to be sufficient to elicit a significant change. Other contributing factors to the limited changes may relate to the small sample size and large variation in core stability scores between individuals. As previous experience with other forms of exercise that may activate transverses abdominis, for example resistance training were not an exclusion criteria for this study, the large individual variability is most likely due to the varying training backgrounds of participants, a consideration for future research.

This study demonstrated that Pilates may be beneficial for strengthening transverse abdominis and the surrounding musculature after completing one session per week, which may lead to greater lumbo pelvic stability. Enhanced lumbo pelvic stability may assist with the management of non-specific low back pain. Due to the high global prevalence of low back pain and the lack of definitive conclusions investigating Pilates and non-specific low back pain, this is an area of great interest that requires further investigation.

The findings of this study concur with previous research suggesting that completing Pilates once per week may be sufficient to gain abdominal (core) strength benefits. Due to the large variability in Pilates exercises and styles reported in the literature, there is uncertainty surrounding the optimal dose and repertoire required to optimise core stability gains, and therefore elicit the positive benefits that have been suggested with enhanced lumbo pelvic stability. Literature has demonstrated anywhere from 1-3 sessions per week can have positive improvements, however the extent to which completing two or three sessions per week compared to one session per week has yet to be determined. Due to the often large financial cost for enrolling in Pilates sessions, this would be valuable information for the general population.

As expected, changes to the participants body composition for fat mass, lean mass, fat free mass and bone mineral content were not identified after completing one Pilates session per week over the 12 week period. Due to the number of variables that influence an individual’s body composition, specifically energy intake and energy expenditure, these results are not surprising. Though regular participation in physical activity can have a positive influence on body composition, the extent of these changes are dependent on the type and volume (frequency, intensity and duration) of exercise performed. Completing 45-60 minutes of Pilates mat exercise has previously been reported to elicit sufficient energy expenditure to induce positive body composition changes. The lack of body composition alterations in this study may be due to lower energy expenditure within the sessions. Olson et al. (2004) reported that an advanced mat based Pilates session elicits an energy expenditure of 33.49 kJ·min⁻¹ where as a basic mat Pilates workout would only expend 19.26 kJ·min⁻¹. Due to all sessions pitched at a basic/foundation level of Pilates, the lack of body composition changes are not surprising.

In conjunction to body composition, BMD at the neck of femur and spine were assessed using DEXA. As expected BMD did not change, most likely due to the limited load and impact imposed on an individual completing Pilates. Though it is unclear as to which specific training method is most advantageous for enhancing BMD, the majority of scientific evidence suggests high-impact and weight
lifting exercise,\textsuperscript{36} which is not encompassed in a traditional Pilates class.

The ROM results from this research provide limited insight into the efficacy of Pilates for enhancing mobility at the shoulder, hip, ankle, thoracic and lumbar spine. In fact, this study suggests Pilates exercise does not impact on ROM at all. The significant change in cervical flexion in the control participants is unusual considering they did not undertake any exercises to enhance their ROM at the neck. Though the reliability of goniometry for assessing both active and passive ROM has been determined,\textsuperscript{37, 38} technical error when completing goniometric analysis is possible and no solid conclusions can be drawn from this study regarding changes to cervical flexion ROM.

Due to the participant group comprising of healthy adults, with normal ROM at each joint, it is not surprising that limited changes were identified.

In regards to foot strength, though no significant differences were identified between groups for heel raises, a trend towards improved muscular endurance in the lower leg among the Pilates participants was evident. However, no significant differences, or trends towards significance, were identified for maximal peak torque at any speed. The slight improvement in heel raises could be attributed to the footwork completed in the reformer series, and the balance component encompassed in the mat series, which encourages lower limb muscular endurance. Though the changes were small and insignificant, this is an area for further research, as small improvements in foot strength may have clinical applications in the area of balance, falls risk and ankle rehabilitation, as has been suggested in previous research.\textsuperscript{39}

**Study Limitations**

Similarly to many exercise intervention studies, participant numbers were limited, particularly due to the requirement of those participants in the Pilates group being paid members to a local Pilates studio. Enabling free access to supervised Pilates classes may enhance participant numbers and will be considered in further research. Another limitation is the inability to control for an individual's diet and physical activity habits over the 12 week period. As we did not provide individualised meals and require the participants to wear an activity monitor for the duration of the study, it is impossible to identify if a participant's physical activity and nutritional habits changed over the 12 week period.

**CONCLUSION**

In conclusion, completing Pilates exercise once per week for 12 weeks may contribute to enhanced core stability, but does not alter body composition, improve joint mobility or foot strength.

**PRACTICAL APPLICATION**

- Completing Pilates exercises once per week may contribute to a small increase in core stability, however the required number of Pilates sessions per week to achieve optimal core strength is not known.
- Pilates exercises in isolation is not effective for altering an individual's body composition. Including additional exercise and nutrition advice may be required to alter body composition if that is the desired outcome of the exercise intervention.
- When there is not a specific focus on flexibility when completing Pilates exercises, improvements to range of motion at the major joints throughout the body does not inherently occur.

**REFERENCES**

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