Effects of a mat Pilates programme on muscular strength and endurance in elderly women

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Abstract

Ageing decreases physical functioning while dependency increases. Arising from these physical limitations is an increasing urge for the use of complementary and alternative medicine such as Pilates. However, whether Pilates should be used as a substitute for conventional modes of exercises, especially in the elderly is debatable. The present study was thus conducted to determine the effects of mat Pilates on muscular strength and endurance in elderly women (aged > 60 years). Fifty sedentary, apparently healthy females aged 60 and older were randomly assigned into a control (CG, n = 25) or an intervention (IG, n = 25) group. The IG took part in an eight-week progressive mat Pilates exercise programme, three times weekly while the CG did not participate in any structured exercises throughout the eight-week period. All subjects underwent pre- and post-test in which muscular strength and muscular endurance were assessed. Results obtained from the present study indicate that eight-weeks of mat Pilates produced significant ($p \leq 0.05$) improvements in upper-body muscular strength (19.12 ± 5.13 repetitions (reps) - 27.84 ± 5.68 reps; p = 0.000), lower-body muscular strength (13.24 ± 3.23 reps - 7.52 ± 3.81 reps; p = 0.000) and muscular endurance (24.48 ± 11.62 reps to 44.16 ± 18.97 reps; p = 0.000). It is therefore, concluded that an eight-week mat Pilates exercise programme is sufficient enough to produce significant improvements in muscular strength and muscular endurance in elderly women.

Keywords: Aged, alternative medicine, complementary medicine, exercise, muscular performance, power.

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Introduction

Age is a critical factor affecting an individual’s muscular strength and endurance. According to Yassierli, Nussbaum, Iridiastadi and Wojeik (2007), the elderly exhibit a decrease in maximum muscular strength and peak power output also substantially declines with age (Runge, Rittweger, Russo, Schiessl & Felsenberg, 2004). This loss of muscle mass and strength in ageing can be due to impairments in neuromuscular function, degradation of the hormonal system and intrinsic factors such as age-related alterations in calcium homeostasis (Ryall, Schertzer & Lynch, 2008). The elderly, however, do not only lose strength in skeletal muscle, but also the respiratory muscles, which also appears to be related to loss of muscle mass due to an age-related factor as well as neuromuscular changes (Kim & Sapienza, 2005). However, increased expiratory muscle strength may enhance an elderly individual's ability to generate and maintain the expiratory driving force critical to cough, speak and swallow (Kim & Sapienza, 2005).

In contrast, muscular endurance has been found to be either maintained or improved with advancing age, which can be explained due to a shift to predominantly type 1 muscle fibres, which exhibit good endurance characteristics (Bemben, 1998). Bemben (1998) also stated that fibre atrophy occurs with advancing age and it is the result of a decrease in fibre size, which alters muscular endurance. Thus, atrophied muscles are at greater risk of muscle fatigue when performing any task compared to muscles that have not atrophied. Advancing age, therefore results in limited abilities to perform certain physical movements and individuals become more dependent on others for the performance of daily activities.

Due to limitations in movement and loss of strength, there is an increasing usage of complementary and alternative medicine therapies such as Pilates as developed by Joseph Hubertus Pilates (Chang, Wallis & Tiralongo, 2007). This mode of exercise is enjoyable and can be used by the majority of people, extending across different ages and genders and can best be described as an extremely orderly system of smooth, controlled, flowing movements (Latey, 2001; Jago, Jonker, Missaghian & Baranowski, 2006). Pilates has been shown to effectively improve the musculoskeletal system by enhancing muscle strength, tone, posture, flexibility, joint mobility, bone density and dynamic balance, body composition by improving body mass index (BMI) and efficiency of the respiratory, circulatory and lymphatic systems (Robinson, Fisher, Knox & Thomson, 2000; Lamond, 2002; Jago *et al*., 2006; Herrington & Davies, 2007; Johnson, Larsen, Ozawa, Wilson, Kennedy, 2007; La Forge, 2007; Sekendiz, Altun, Korkusuz & Akyn, 2007). As such, Pilates may be able to assist in the prevention of falls and recovering from injuries (Bertolla, Baroni, Leal & Oltramari, 2007), especially in the elderly. These positive physical changes arising from Pilates are however, based mainly on apparently, healthy middle-aged females (Von Sperling de Souza & Brum Vieira, 2006). Further, despite the numerous popular press reports on Pilates, the existing scientific evidence for Pilates is limited (Bernardo, 2007) creating a need for scientific evidence to either support or refute Pilates as an adjunct to conventional modes of exercises, especially in the elderly.

Methodology

Subjects

A sample of 50 elderly female subjects (≥ 60 years of age), selected from caring facilities within Pretoria, Gauteng Province, South Africa were randomly assigned into one of two groups using a random numbers table; with 25 subjects undergoing an eight-week mat Pilates programme (IG), while the other 25 subjects participated as a non-exercising control group (CG). The research protocol was approved by the Institutional Review Boards of the Tshwane University of Technology, Pretoria, South Africa and was endorsed by the International Physical Activity Projects (IPAP). Permission to conduct the study at the caring facilities was obtained from the relevant care facilities and all subjects signed a written informed consent form indicating all the advantages and risks involved in participating in the study. All subjects were required to obtain medical clearance prior to commencement of pre-testing procedures. Both groups took part in identical pre- and post-tests. Subject demographics at baseline are shown in Table 1.

Table 1: Subjects' demographic data

Variables	Non-exercising control group (CG) (n = 25)	Mat Pilates programme group (IG) (n = 25)
Age (years)	65.32 ± 5.01	66.12 ± 4.77
Weight (kg)	75.19 ± 14.78	71.71 ± 14.92
Body mass index ($kg.m^{-2}$)	29.32 ± 5.44	28.32 ± 6.77

Values are means ± standard deviation ± SD; kilogrammes per square meter

Physical evaluation

All subjects were required to undergo muscular strength and muscular endurance testing prior to and at completion of the eight-week treatment period. Upper-body muscular strength was measured by the number of arm curls the subject completed in 30 seconds using a 2.5 kilogramme dumbbell, while in a steady, upright seated position (Rikli & Jones, 2001). The arm curl movement began with the weight held at the subject's side, perpendicular to the floor, in the dominant hand with a handshake or internally rotated grip. From this downward position, the weight was curled up with the palm gradually rotating to a facing-up position, until complete elbow flexion was achieved. The weight was then returned to the fully extended down position in the handshake grip. Lower-body muscular strength was measured by the number of times in 30 seconds the subject could stand up from a seated position using a chair with a height of 43.18 centimetres, with the arms folded across the chest (Rikli & Jones, 2001).

Muscular endurance was measured by the number of squats the subject was able to perform until fatigued. Subjects were required to stand in front of a chair with their feet shoulder width apart, feet facing approximately five degrees in external rotation, hands on their hips, while facing the opposite direction. Subjects were then instructed to squat down and lightly touch a chair with a height of 43.18 centimetres before standing back up to the starting position (Antonetti, 2008).

Programme

Mat Pilates exercises and exercise prescription variables were determined in accordance with the guidelines of (Worth, 2004) in order to compile the supervised mat Pilates exercise programme with all sessions being conducted by a qualified Pilates instructor. The periodised, eight-week Pilates programme consisted of three non-consecutive sessions weekly each lasting 60 minutes in duration. Prior to commencement of the programme, all subjects in the intervention group were trained on how to perform the Pilates exercises by a qualified practitioner. For each of the exercises, subjects were firstly familiarised with the exercise programme and then provided with simple step-by-step written instructions an explanation of the basics of mat Pilates and an explanation of the neutral position of the spine and also the correct breathing techniques to be used during Pilates. All sessions began with breathing, followed by a flowing system from standing, to sitting, to lying down exercises and ended with the rest position (Worth, 2004). Non-exercising control group subjects were instructed to maintain their normal daily activities throughout the eight-week experimental period and were phoned three times weekly to ensure compliance.

Statistical analysis

Statistical analysis consisted of basic statistics to determine pre- and post-test means and standard deviations. A paired samples t-test was used to determine if a significant change took place in the measurements at post-test. Differences in measurements were compared using a one-way analysis of variance (ANOVA) and Dunnett T3 *post-hoc* analysis. Data was analyzed using computer software (Statistical Package for Social Sciences (SPSS) Version 17, Chicago, IL) and statistical significance set at $p \leq 0.05$.

Results

At pre-test, the CG and IG were homogenous for upper-body muscular strength ($p = 0.366$), lower-body muscular strength ($p = 0.112$) and muscular endurance ($p = 0.555$). Following the eight-week mat Pilates programme, the IG demonstrated a significant ($p \leq 0.05$) increase in their upper-body muscular strength (from 19.12 ± 5.13 repetitions to 27.84 ± 5.68 repetitions; $p = 0.000$), lower-body muscular strength (from 13.24 ± 3.23 repetitions to 17.52 ± 3.81

repetitions; p = 0.000) and muscular endurance (from 24.48 ± 11.62 repetitions to 44.16 ± 18.97 repetitions; p = 0.000) (Table 2). Despite the CG demonstrating no significant difference in the muscular endurance at the completion of the eight-week period (p = 0.825), the CG did demonstrate significant improvements in upper- and lower-body muscular strength from pre- to post-test (p = 0.028 and p = 0.031, respectively). Despite the CG improving their upper- and lower-body muscular strength *post hoc* analysis revealed that eight-weeks of mat Pilates was more effective than no structured exercise (p = 0.000 and p = 0.001, respectively).

Table 2: Pre- and post-test muscular strength and endurance changes in the mat Pilates and non-exercising control groups

Variables	Non-exercising control group (CG) n = 25			Mat Pilates programme group (IG) n = 25		
	Pre-test	Post-test	p-value	Pre-test	Post-test	p-value
Upper-body muscular strength (repetitions)	17.88 ±4.47	19.92 ±3.85	0.028*	19.12 ±5.13	27.84 ±5.68	0.000*
Lower-body muscular strength (repetitions)	11.44 ±4.52	12.52 ±3.82	0.031*	13.24 ±3.23	17.52 ±3.81	0.000*
Muscular endurance (repetitions)	22.52±11.73	22.16±11.79	0.825	24.48±11.62	44.16±18.97	0.000*

Values are means ± standard deviation ± SD;
*: Indicates significant difference from pre- to post-test ($p \leq 0.05$).

Discussion

Results obtained from the present study indicate that eight-weeks of mat Pilates produced improvements in upper-body muscular strength, lower-body muscular strength and muscular endurance. As such, mat Pilates may negate or even reverse, as was the case in this study, some of the most serious consequences of ageing as its effects on skeletal muscle as both muscle strength and muscle endurance are related to independent walking in the elderly. One of the physical changes associated with aging is sarcopenia, which is an age-related decline in muscle mass and function including a decrease in force producing capacity, maximum velocity of shortening and a general slowing of contraction and relaxation (Ryall, Schertzer & Lynch, 2008). In turn, functional disability in walking leads to undesirable consequences such as a fear of falling, loss of confidence, loss of independence and lowered quality of life (Ikezoe *et al*., 1997).

The improvements in muscular strength following a period of Pilates training is supported by Sekendiz *et al*. (2007) and Kloubec (2010). In this regard, Kloubec (2010) found a significant increase from 24.18 ± 22.34 repetitions to 35.59 ± 25.60 repetitions in upper-body muscular strength, following 12 weeks of Pilates training in middle-aged individuals while Sekendiz *et al*. (2007) reported significant improvements in 60° flexion/extension and 120 degree extension, following five weeks of Pilates training in sedentary adult woman. Similarly, the improvements in muscular endurance observed in this study are supported by several studies (Sekendiz *et al*., 2007; Kloubec, 2010; Rogers & Gibson, 2009). Kloubec's (2010) study revealed a significant increase in muscular endurance from 34.68 ± 11.42 repetitions to 48.27 ± 21.26 repetitions and from 53.18 ± 16.71 degrees to 27.32 ± 21.09 degrees in abdominal endurance and lower abdominal endurance, respectively, following 12 weeks of Pilates training in middle-aged individuals. Both curl-ups and back extension significantly improved following eight weeks of Pilates training in adults (Rogers & Gibson, 2009). Sekendiz *et al*. (2007) also found a significant increase in curl-ups from 14.0 ± 9.8 repetitions to 29.2 ± 9.8 repetitions, after 5 weeks of Pilates training in sedentary adult women.

The improvements in muscular strength and endurance observed in this study could have been due to a decrease in fat mass (FM) and an increase in lean body mass (LBM). This is plausable since an increased LBM is as a result of muscle hypertrophy, as muscles with larger cross-sectional areas have larger numbers of sarcomeres in parallel thus facilitating more potential cross-bridge heads in contact with actin molecules and thus yielding greater potential for applying force (Hunter, 2000; Wilmore, Costill & Kenney, 2008). This may be the case in the present study in that the 8-week Pilates programme resulted in a significant decrease in FM from 25.03 ± 9.53 kilogrammes to 23.69 ± 8.06 kilogrammes ($p = 0.038$), while concurrently producing a significant increase in LBM from 46.67 ± 6.33 kg to 48.04 ± 7.52 kg ($p = 0.006$). However, strength gains might also have possibly been due to neural adaptations, such as motor unit recruitment or increased rate coding of motor units (Wilmore, Costill & Kenney, 2008).

Further, the CG of the present study also demonstrated improvements in both upper- and lower-body muscular strength possibly as a result of an unintentional motivation to participate or as a result of a learning effect from the pre-test. Despite the improvements in the CG's upper- and lower-body muscular strength, since the CG did not partake in any form of physical activity, they exhibited limited capabilities to perform the muscular strength and endurance testing to the same extent as the IG subjects. Thus, the CG demonstrated lower muscular strength and muscular endurance values compared to the IG.

Conclusion

Inactivity accelerates the irreversible losses caused by the ageing process and in contrast exercise increases life expectancy and decreases the risk of mortality (Mechling & Netz, 2009). Practical forms of exercise are, thus required that will enable the elderly to more effectively perform activities of daily living and therefore, improve their quality of life. Apart from the conventional strength and endurance exercise methods, non-conventional exercise methods, such as Pilates can also be performed by the elderly for health gains as it was found in the present study that an 8-week mat Pilates exercises programme could produce significant improvements in both muscular strength and endurance in the elderly.

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