Evaluation of Pilates training on agility, functional mobility and cardiorespiratory fitness in elderly women

G.M. GILDENHUYS, M. FOURIE, I. SHAW, B.S. SHAW, A.L. TORIOLA AND J. W1TTHUHN

[1]*Department of Sport, Rehabilitation and Dental Sciences, Tshwane University of Technology, Private Bag X680, Pretoria, Gouteng, 0001, Republic of South Africa*
[1]*Entheos Christian School, PO Box 3221, The Reeds, Centurion, 0158, Republic of South Africa*
[3]*0jfice of the Deputy Pro Vice-Chancellor: Research, Monash South Africa, P.O. Box X60, Rwinsig, 1725, Republic of South Africa, inashaw@monash edu*
[4]*Department of Sport and Movement Studies, University of Johannesburg, PO Box 524, Auckland Park, Johannesburg, 2006, Republic of South Africa*
[5]*School of Health Sciences, Monash South Africa, P.O. Box X60, Rufmsig, 1725, Republic of South Africa*

Abstract

Although, Pilates training has gained popularity and is performed with great ease by the elderly, little is known about this mode of training on the development of agility, functional mobility and $V0_2$rnax· The study was conducted to ascertain the effects of Pilates training on agility, functional mobility and $V0_{2max}$ in elderly woman. Fifty inactive, apparently healthy females aged 60 and older were randomly assigned to either a control (CON) (n = 25) or a Pilates training (PIL) (n = 25) group. The subjects in the PIL group participated in an eight week progressive mat Pilates training programme, three times weekly. The subjects in the CON group were requested not to participate in any structured exercise throughout the eight-week period. Results obtained from the present study indicate that eight-weeks of Pilates training significantly improved agility as measure by the eight-foot up-and-go test (from 6.18 ± 1.22 sec to 4.70 ± 0.90 sec; p = 0.000) and functional mobility as measured by the sit-to-stand one-repetition test (from 1.35 ± 0.33 sec to 0.91 ± 0.23 sec; p = 0.000), sit-to stand five repetition test (from 9.81 ± 2.08 sec to 6.97 ± 1.34 sec; p = 0.000) and pick-up weight test (from 2.15 ± 0.77 sec to 1.29 ± 0.18 sec; p = 0.000). However, the eight weeks of Pilates training did not significantly (p :5 0.05) improve $V0_2$rnax (from 17.56 ± 2.76 ml.kg ·ımin -ı to 18.14 ± 2.12 ml.kg ·ımin "1; p = 0.247). Pilates appears to be a cost-effective, pleasant and mild activity that can be easily performed by the elderly, especially when compared to the more demanding forms of exercise. The elderly or those with impaired mobility wishing to increase their agility and functional mobility may benefit by participating in Pilates and as such, prolong their independency. However, additional modes of exercise should be utilised as an adjunct to Pilates to improve cardiorespiratory fitness.

Keywords: Aged, aerobic capacity, calisthenics; exercise, functional ability.

Introduction

The foremost consequence of aging is the loss of functional capacity and the resultant loss of functional independence that occurs due to an inability to perform activities of daily living (Fiatarone, 1996; Frontera & Bigard, 2002). This is so since agility is required to perform both essential activities of daily living such as bathing, eating and dressing and instrumental activities such as cooking and cleaning, also appear to become more difficult with increasing age (Lees *eta!.*, 2005). By improving agility, the elderly's mobility, manoeuvrability and as such number of injury incidents can be reduced (Kalapotharakos *et al.*, 2004; Toraman, Erman & Agyar, 2004; Paatsuke *et a/.*, 2004; Cromwell & Newton, 2004; Ramsbottom *et al.*, 2004).

Cross-sectional data have shown that cardiorespiratory fitness ($V0_2max$) declines at an average of 0.44 millilitres per kilogramme per minute (rnl. kg_,_ min-^{1}) per year up to age 75 years. For women between the ages of 25 and 60 years, the decline is close to one percent per year (Wilmore, Costil & Kenney, 2008). Jones and Rikli (2001) further point out that V02max tends to decline at the rate of five to 15% per decade, after the age of 30, resulting in as much as a 50% loss by the age of70 years. Cardiorespiratory fitness has been used extensively as a measure of functional capacity and can be used as an indicator of global and integrated responses of all systems involved during exercise, including the pulmonary and cardiovascular system, peripheral circulation, systemic circulations, neuromuscular units, muscle metabolism and blood circulation (Crocetta & Loperfido, 2004; Timson *et al.*, 2008). Maintaining an adequate level of cardiorespiratory fitness has both a direct effect on an individual's functional mobility and an indirect effect through its role in reducing the risk for medical conditions such as cardiovascular disease, diabetes, obesity, hypertension and some forms of cancer (Jones & Rikli, 2001). An adequate level of V02max as determined by the ability to take in, transport and utilise oxygen is necessary to perform many daily activities such as walking, bathing, shopping and to participate in leisure and recreational or sporting activities. In this regard, a $V0_2max$ of 15 to 18 millilitres per kilogramme per minute (mi. kg_,_ min-^{1}) is necessary to maintain independent living status. However, declines associated with inactive lifestyles often progress below this point prior to age 80 years (Jones & Rikli, 2001).

Although Pilates has gained popularity over the past few years and is more frequently used for fitness and holistic health (Sorosky, Stilp & Akuthota, 2008) and is performed with ease by the elderly, little is kno'Wll about this mode of training on the development of agility, functional mobility and V02max· The paucity of data that exists on the effect of Pilates training on agility, functional mobility and $V0_2max$ has not conclusively demonstrated that Pilates training can improve these health parameters, especially in the elderly. Furthermore, it is essential to ascertain the effects- of Pilates training on the elderly since a loss of agility and V02max could limit their ability to perform functional tasks, improve energy conservation through more efficient breathing and movement patterns, adaptive equipment use, food procurement and preparation, leisure, sexual functioning andJor work environment demands (Crystal *et al.*, 1997; Fitch Blitvich & Morton, 1986), which could diminish their ability to live independently (Milton *et a/.*, 2008). As such, the purpose of the study was to evaluate the effect of Pilates training on agility, functional mobility and $V0_2$max in elderly women.

Methodology

Subjects

Fifty inactive female subjects (2: 60 years of age), were randomly assigned to an eight-week mat Pilates training (PIL) group (n = 25) or participated as a non-exercising control (CON) group (n = 25). The study was approved by the Institutional Review Board of the Tshwane University of Technology, Pretoria, South Africa. The study was also endorsed by the International Physical Activity Projects (IPAP). Permission to conduct the study at the caring facilities in Pretoria, South Africa was obtained from the relevant care facilities and all subjects signed a written informed consent form. Subject demographics at baseline are shown in Table 1.

Table **1:** Baseline subject demographic data

Variables	Non-exercising control group (CON)	Pilates training group (PIL)
Age (years)	65.32 ± 5.01	66.12 ± 4.77
BodyMass(kg)	75.19±14.78	71.71±14.92
BM1 (kg.m-^{2})	29.32 ± 5.44	28.32 ± 6.77

Values are means± standard deviation (SD); kg: kilogramme(s); Bfvfi: body mass index; kg.m·^{1}: kilogrammes per square meter

Physical Evaluation

For descriptive purposes, body mass was measured in kilograrmnes on a calibrated medical scale (Mettler DT Digital, Mettler-Toledo AG, Ch-8606 GreiFensee, Switzerland) and stature was measured to the nearest 0.1 centimetres (em) using a standard wall-mounted stadiometer with the subjects wearing minimal clothing and no shoes. Body mass index (BMI) was calculated by dividing body mass by stature squared (wcighUstature ^{2}) and expressed as kilogrammes per square meter (kg.m-^{2}).

In order to assess functional mobility, a sit-to-stand and sit-to-stand test with five height (43 em) chair without annrests, five times, as fast as possible with their arms folded, with the time recorded. Subjects undertook the test barefoot and results were recorded in seconds, as the time from the initial seated position to the final seated position after completing five stands. The single sit-to-stand test (STS-1) time from sitting to standing was also recorded (Tiedemann *et al.,* 2008). During the pick-up-weight test, subjects were asked to pick up a bag containing a five kilogramme weight with handles that extended 50 em above the floor in front of them and place it on a table using only one hand. Performance was rated as either able or unable to pick up the weighted bag and place it on a table, and time to do so was also recorded (Tiedemann *et al.,* 2008).

Agility was assessed by measuring the time subjects took to stand up from a chair and to walk around a cone placed eight feet away and back to the chair. The time in seconds was recorded from when the subjects were instructed to stand up until the subject sat down on the chair again. The fastest time of two trials was recorded (Jones & Rikli, 2001).

A six-minute walk test was utilised to estimate maximal cardiorespiratory fitness (V02max) (Crocetta & Loperfido, 2004; Jones & Rikli, 2001). Subjects were required to walk for six minutes around a 46 meter course and had to cover as much distance as possible during the six minutes (Jones & Rikli, 2001). The following equation was then used to convert the distance walked during the six-minute walk test into maximal V02max: V02max = 0.03 x distance+ 3.8 (Crocetta & Loperfido, 2004).

Pilates Training Programme

The Pilates training programme was determined in accordance with the guidelines of Worth (2004). All sessions were conducted by a qualified Pilates instructor. The periodised, eight-week mat Pi1ates training programme consisted of three non-consecutive training sessions a week each lasting 60 minutes in duration. All subjects in the PIL group were initially familiarised with the exercise programme and then provided with simple step-by-step written instructions, an explanation of the basics of mat Pilates and the neutral position of the spine and the correct breathing techniques to be used during Pilates by a qualified practitioner. All sessions began with breathing, followed by a flowing system from standing, to sitting, to lying down exercises and ended with the rest position (\Vorth, 2004). The subjects in the NON group were instructed to maintain their normal daily activities throughout the eight-week period and not to perform any structured physical activities.

Statistical analysis

All data analyses were conducted using the Statistical Package for Social Sciences (SPSS) Version 17, Chicago, IL. Levene's test was used to determine whether the groups were homogeneous or heterogeneous at the preRtest. A paired samples t-test was used to determine if significant changes existed in the measurements at posHest. A $p < 0.05$ was selected as being indicative of statistical significance.

Results

At pre-test, the groups were homogeneous in terms of their agility (p = 0.970), sitRto-stand five repetition test (STS-5) (p = 0.788), sit-to-stand one repetition test (STS-1) (p 0.874), pick-up weight test (p 0.158) and VOzm (p 0.238). Following the eight-week Pilates training programme, the PIL group demonstrated a significant improvement in agility (p 0.000), STS-1 (p 0.000) and STS-5 (p 0.000) and pick-up weight test (p 0.000) from the pre- to post-test (Table 2). However, the PIL showed no significant change in V02max (p = 0.247) following the eightRweek Pilates training period. In the CON, a significant improvement was fmmd in the CON for agility (p = 0.000) and pick-up weight test (p = 0.000) from the pre-test and post-test (Table 2). However, no significant difference was found in the CON for the STS-1 (p 0.113), STS-5 (p 0.100) and vo,m (p 0.619).

Table 2: Agility, functional mobility and cardiorespiratory fitness following and eight-week Pilates ro amme

Variables	Non-exercising control group (CON)		Pilates training group (PIL)	
	Pre-test	Post-test	Pre-test	Post-test
Agility (sec)	6.20 ± 2.10	5.25 ± 1.62*	6.18± 1.22	4.70± 0.90*
Sit-to-Stand One-Rep Test (sec)	1.33 ± 0.45	1.20 ± 0.42	1.35 ± 0.33	0.91 ±0.23*
Sit-to-Stand Five Rep Test (sec)	10.01 ± 3.06	9.19±3.06	9.81 ± 2.08	6.97 ± 1.34*
Pick up Weight Test (sec)	2.45 ± 0.69	1.54:!:. 0.26*	2.15 ± 0.77	1.29±0.18*
Cardiorespiratory fitness vo2rn:tX ml.k .Jmin.J	16.54±3.25	16.74±3.01	17.56±2.76	18.14±2.12

Values are means± standard deviation; *: Indicates significant difference from pre- to post-test (p-:;: 0.05); sec: seconds; rep: repetitions; ml.kg ·1min ·1: millimetres per kilogram per minute.

Discussion

The results of the study showed that eight weeks of Pilates training can effectively improve agility and functional mobility in elderly women, but not cardiorespiratory fitness. The agility of the subjects was improved as a result of the Pilates training subject is learning to correctly use the "core", stability of the spine and quality of movement and flow which required that the exercises be performed smoothly without jerk-y movements (Owsley, 2005; Lange *et al.*, 2000).

Sierpowsk Ciechanowicz and CywiTiska-Wasilewska (2006) study involving 11 elderly women to ascertain the effects of yoga compared to water exercise found no significant change in their functional mobility, contrary to the findings of the present study. The non-significant change in t11e ftmctional mobility of the elderly women reported in Sierpowska, Ciecbanowicz and Cywiilska-Wasilewska (2006) when compared to the present study could be attributed to the improvements in insufficient volume and reduced intensity of yoga when compared to Pilates. In tum, the improvements in the CON could be attributed to a learning effect from the pre- to post-test or the psychological effect induced by participation.

The lack of change in VOzllliiX following the eight-week Pilates programme found in this study could have been due to the type of exercises not eliciting a sufficient volume of exercises and intensity to stimulate the aerobic energy system. The lack of change in VOzmax the present study could also be due to no significant difference in the body mass of the PIL group at post-test. In this regard, the VOzmax was measured relatively, using body mass in kilograrrunes in the calculation and as such, an improvement may be observed should absolute values of VOzmax be utilised in the data analysis. The Pilates programme was not truly constructed to increase the $V0_2$max. but the study aimed to ascertain whether conducting this combination of mat Pilates exercises could indeed solicit changes in VOzmax and to detennine if elderly participating in mat Pilates would have to supplement their training to induce improvements in volmax. The finding that an adjunct mode of training is needed in addition to Pilates to improve cardiorespiratory fitness is substantiated by Segal, Hein & Basford (2004) which stated that Pilates is not a form of aerobic exercise because Pilates involves essentially isometric exercises and as such would not improve $V0_2$ma.x· Jago *et al.* (2006) also pointed out that Pilates is not an aerobic activity and that other intense interventions such as dance should be implemented for aerobic endurance activities to increase VOzmax· Contrary to the present study, a study conducted by Eyigor *et al.* (2010) found a significant increase in VOzmax· Tbis is likely due to additional 20 to 30 minutes of walking three times per week in conjunction to the Pilates programme, which could have lead to the adaptations in the cardiovascular and respiratory systems and hence increase in VOzmax (Jones & Carter, 2000).

Conclusion

Although the use of Pilates exercises has steadily increased due to its social benefits, cost-effectiveness and ease of implementation, the current evidence of its effectiveness is still unsupported reinforcing the need for new high quality studies. In this regard, the present study demonstrated that Pilates training can effectively be used to improve agility and functional mobility in elderly women, but not cardiorespiratory fitness in elderly women. These findings indicate that an adjunct mode of training is needed in addition to Pilates to improve cardiorespiratory fitness especially since Pilates does not provide aerobic exercise as it essentially isometric exercises and as such would not improve $V0_{2max}$ (Segal *et al.*, 2004). Nevertheless, Pilates provides a cost-effective exercise programme that can be utilised by the elderly in either supervised or non-supervised home-based or facility-based settings that may increase the low participation rates of the elderly.

References

Crocetta, C. & Loperfido, N. (2004). *The Relationship of the Six-Minute Walk Test to Maximal Oxygen Consumption Under the Assumption ofSk(mi-Normality.* Foggia: Department of Science Economy, Mathematics and Statistics, University ofFoggia.

Cromwell, R.L. & Newton, R.A. (2004) Relationship between balance and gait stability in healthy older adults. *Journal of Aging and Physical Activity,* 12,90-111.

Crystal, G,.R., West, J.B., Weibel, E.R. & Barnes, P.J. (1997). *The Lung: Scientific Fowuiarions* (2 nded). Philadelphia, New York. Lippincott-Raven.

Eyigor, S., Karapolat, H., Yesil, H., Uslu, R. & Durmaz, B. (2010). Effects ofPilates exercises on functional capacity, flexibility, fatigue, depression and quality of life in female breast cancer patients: A randomised controlled study. *European Journal of Physical and Rehabilitation Medicine,* 46(4), 481-487.

Fiatarone, M.A. (1996). Physical activity and functional independence in aging. *Research Quarterly for Exercise and Sport,* 67, S70.

Fitch, K.D., Blitvich, J.D. & Morton, A.R. (1986). The effect of running training on exercise-induced asthma. *Ann Allergy,* 57, 89-94.

Frontera, W.R. & Bigard, X. (2002). The benefits of strength training in the elderly. *Science and Sport,* 17, 109-116.

Jago, R., Jonker, M. L., Missaghian, M. & Baranowski, T. (2006). Effects of 4 weeks ofpilates on the body composition of yoWlg girls. *Journal of Prevemive Medicine,* 42, 177-180.

Jones, A.M. & Carter, H. (2000). The effect of endurance training on parameters of aerobic fitness. *Sports Medicine,* 29(6), 373-386.

Jones, C.J. & Rikli, R.E. (2001). *Senior Fitness Test Manual.* Champaign, IL: Human Kinetics.

Kalapotharakos, V.I., Micha\opoulou, M., Godo\ias, G., Tokmakidis, S.P., Malliou, P.V. & Gourgoulis, V. (2004). The effect of high- and moderate- resistance training on muscle function in the elderly. *Journal of Aging and Physical Activity,* 12, 1-15.

Lees, F.D., Clark, P.G., Nigg, C.R. & Newman, P. (2005). Barriers to exercise behaviour among older adults: A focus-group study. *Journal of Aging and Physical Activity,* 13, 23-34.

Lange, C., Unnithan, V., Larkam, E. & Latta, P.M. (2000). Maximizing the benefits ofPilates-inspired exercise for learning functional motor skill. *Journal of Bodywork and Movement Therapies,* 4(2), 99-108.

Milton, D., Porcari, J.P., Foster, C., Gibson, M., Undennann, B, Greany, J. & Murray; S.R. (2008). The effect of functional exercise training on functional fitness levels of older adults. *Gundersen Lutheran Medical Journal,* 5(1), 1-5.

Owsley, A. (2005). *An Introduction to Clinical Pi/ales.* Human IUnetics, 10(4), 6-10.

Paatsuke, M., Ereline, J., Gapeyeva, J., Helena, J., Mottus, K. & Taba, P.K. (2004). Leg-extension strength and chair-rise performance in elderly women with parkinson's disease. *Journal of Aging and Physical Activity,* 12, 511-525.

Ramsbottom, R., Ambler, A., Potter, J., Jordan, B., Nevill, A. & Williams, C. (2004). The effect of 6 months training on leg power, balance and functional mobility of independently living adults over 70 years old. *Journal of Aging and Physical Activity,* 12, 497-511.

Segal, N..A, Hein, J. & Basford, J.R. (2004). The effects ofPilates lTaining on flexibility and body composition: an observational study. *Arch Physical Medical Rehabilitation Journal,* 85, 1977-1981.

Sierpowska, A., Ciechanowicz, I.& Cywinska-Wasilewska, G. (2006). Functional fitness assessment among elderly women (60+) participating in yoga or swimming exercises. *Journal of Studies in Physical Culture and Tourism,* 13, 81-83.

Sorosky, S., Stilp, S. & Akuthota, V. (2008). Yoga and Pilates in the management of low back pain. *Journal ofCurrent Reviews in Musculoskeletal Medicine,* 1(1), 39-47.

Tiedemann, A., Shimada, H., Sherrington, C_, Murray, S. & Lord, S. (2008). The comparative ability of eight functional mobility tests for predicting falls in community-dwelling older people. *Journal of Age and Ageing,* 37(4), 430-435.

Timson, B.F., Falls, H.B., Wilson, T.E. & Zimmerman, S.D. (2008). Effect of muscle strength on $V0_2$ plateau occurrence rate. *Journal of Isokinetics and Exercise Science,* 16, 231-237.

Toraman, N.F., Erman, A. & Agyar, E. (2004). Effects ofmulticomponent training on functional fitness in older adults. *Journal of Aging and Physical Activity,* 12, 538-554.

Wilmore; J.H., Costil, D.L. & Kenney, W.L. {2008). *Physiology of Sport and Exercise* (4th ed.). Champaign, IL: Human Kinetics.

Worth, Y. (2004). *Needs to Know Pilates? All the Tips and Techniques You Need to Get a Toned, Flexible Body.* London: Collins.