



EXERCISE PHYSIOLOGY

A novel balance exercise program for postural stability in older adults: A pilot study

D.S. Kaesler, BAppSc, MAppSc^{a,*}, R.B. Mellifont, BSc(Hons), PhD^b,
P. Swete Kelly, BAppSc(Physio)^c, D.R. Taaffe, BSc, MSc, PhD^d

^a*School of Medicine, The University of Queensland, Brisbane, Queensland, 4027, Australia*

^b*Faculty of Science, Health and Education, University of the Sunshine Coast, Maroochydore Queensland, Australia*

^c*LifeCare Physiotherapy, Taringa, Queensland, Australia*

^d*School of Human Movement Studies, The University of Queensland, Brisbane, Queensland, Australia*

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Summary Pilates-inspired exercise is increasing in popularity as a general and clinical exercise training technique. It is purported to improve postural awareness with a large focus on facilitating movement re-education, however, there is limited research to support this. This study examined the effectiveness of a novel Pilates-inspired exercise program specifically designed to improve balance in an upright position, referred to as postural stability, in older adults. Participants for this pilot study were eight community-dwelling men and women aged 66–71 years. The exercise regimen was undertaken twice weekly for 8 weeks and pre- and post-subject assessment included postural sway (static and dynamic), the timed get up and go test (TGUGT), sit-to-stand (timed one repetition and repetitions over 30 s) and a four stage balance test. Seven subjects completed the intervention. There was a significant improvement ($P < 0.05$) in some components of static and dynamic postural sway (8–27%) as well as the TGUGT (7%) following training. These results suggest that a balance training program of Pilates-inspired exercises over a short duration can be safely performed in well-functioning elders and may lead to improvements in postural stability. Future research may consider the variation of specific balance training techniques, primarily movement re-education compared to speed and/or reaction time, to improve postural stability and reduce falls risk.

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*Corresponding author. Tel.: +61 7 3636 5243; fax: +61 7 3636 1981.

E-mail address: d.kaesler@uq.edu.au (D.S. Kaesler).

Introduction

An older adult's postural stability is considered important to perform common activities of daily living (ADL) such as walking, turning, and rising to a standing position. The maintenance of postural stability is multifactorial but normal age-related declines of the sensory and motor systems negatively impact postural stability making the performance of ADL tasks more challenging (Sherrington et al., 2004). Strong associations have been established between outcome measures of postural stability and improved strength, power and range of movement in respect to falls prevention exercise programs (Barnett et al., 2003; Nitz and Choy, 2004). Previous studies have shown that physical activity and exercise can reduce the incidence and risk of falls (Sherrington et al., 2004; Nitz and Choy, 2004; Barnett et al., 2003). However, research on exercise interventions for postural stability and falls management requires further investigation, specifically on the types of exercises that are more effective in maintaining postural stability (Sherrington et al., 2004).

Randomized-controlled trials that utilize structured exercise programs, particularly those with a balance focus, have had a positive effect on improving postural stability and/or reducing falls incidence and injuries (Lord et al., 1996; Barnett et al., 2003; Nitz and Choy, 2004). These balance training programs provide a specific exercise environment for task orientated and functional movement, challenging the body position in space by either changing the size or shape of the base of support. Such principles are similar in the teaching of Pilates-inspired techniques (Anderson and Spector, 2000; Lange et al., 2000).

The purpose of this pilot study was to examine an exercise intervention designed to improve balance in an upright position based on the principles of Pilates-inspired techniques that challenge and re-educate balance and functional movement by using resistance and changing the body's orientation to gravity (Anderson and Spector, 2000). Pilates-inspired techniques are commonly used in clinical practice, to improve postural awareness and facilitate movement re-education focus, but have limited research support.

Methods and procedures

Subjects

The participants were eight men and women aged 66–71 years with a body mass index (BMI) of

19–33 kg/m². A falls risk questionnaire identified the participants as they presented at a LifeCare Physiotherapy Clinic in Brisbane, Queensland and through the Australasian Centre for Ageing 50+ registry at The University of Queensland. The inclusion criteria required subjects to be 65 years or over, with no cardiovascular, neuromuscular or neurological contraindications to exercise. Subjects already involved in equivalent exercise classes were excluded from the study. All participants took at least one medication and four participants were on ACE inhibitors or calcium channel blockers, where dizziness is a possible side effect. Participant information letters and an adapted medical/health questionnaire (Evans, 1999), including the American College of Sports Medicine (ACSM) Par-Q recommendations (Franklin, 2000), were mailed to potential subjects. The study was approved by The University of Queensland Medical Ethics Committee and all subjects provided written informed consent. Where indicated, medical clearance was obtained by their physician.

Exercise intervention program

The program was conducted twice weekly, 1 h per session, for eight consecutive weeks. The session included a 10-min warm-up, 40-min conditioning phase and a 10-min cool-down period, consistent with previous study designs (Lord et al., 1996; Barnett et al., 2003). The design and supervision of all the small group training sessions was performed by the principal investigator, an Exercise Physiologist and a qualified Pilates Instructor through Isodynamic Fitness and Polestar Pilates® Education. The selected exercises and techniques were based on Pilates-inspired principles of disassociation, stabilization, mobilization and dynamic stabilization (Anderson and Spector, 2000). Twelve exercises were chosen to incorporate dimensions of balance, strength and coordination, performed in a closed kinetic chain environment (Table 1). The exercises were designed to work the full range of motion available to each subject in leg and arm flexion, extension, abduction, adduction and rotation, and trunk flexion and rotation for various positions of supine, seated and standing. All movements performed by the participants were slow, controlled and deliberate to increase coordination, sensory awareness and to facilitate transfer and retention to maximize the re-education process (Lange et al., 2000). All exercises were modified and/or progressed through changing the size and shape of the base of support (e.g. lying to sitting to

Table 1 Pilates-inspired balance training program (8 weeks, 2 times per week).

Warm up: 10–15 min; RPE 9–11 (Borg, 1982)

Stepping: big group circles, on the spot and side-to-side. Opposite foot/hand touches behind the body arm circles
Visual

Circuit exercises (1–9) performed on equipment individually

1. Reformer leg press

Supine on reformer, heels on foot bar. Exhale to extend legs. Inhale to return. Maintain neutral pelvis.



2. Theraband seated hip abduction/adduction

Sit tall. Slide knees and feet apart, keeping knees in line with foot. Avoid internal rotation at the hip. Keep feet in light contact with floor. Slowly return knees together.



3. Trapeze table lateral flexion

Pull bar down. Lead elbow toward table with shoulder depression. Elbow extension to push trapeze bar away. Flex trunk to side. Keep weight balanced evenly in pelvis.



4. Trapeze table side leg springs

Pelvis neutral, bottom leg bent to increase support. Inhale to lift leg up, exhale to adduct leg down against spring resistance. Maintain leg length. Move only at hip joint.



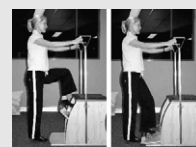
5. Theraband seated rowing

Theraband around the feet. Arms extended down on the thighs to start, holding the taught band. Bend elbows to take hands to hips and elbows back. Squeeze shoulder blades back, down and together. Slowly return to start.



6. Wunda chair standing single leg press

Press through heel to push pedal down. Slowly control pedal return through hip and knee flexion. Control pelvis rotation and knee tracking, hinge at hip. Remain tall through spine.



7. Step up and over

Start standing next to the step. Step up to top of step (photo 1). Step both feet to the top. Step off to other side (photo 2). Stand both feet down on the other side. Cross back over the step to complete. Over and Back is 1 rep.



8. Seated fit ball spine twist

Sit tall, arms in Russian Cossack. Inhale to rotate ribs, shoulders and head over pelvis. Eye gaze remains centered. Exhale to return to center and repeat on other side.



NB: Magic circle or equivalent can be used to assist with maintaining spinal posture

Table 1 (continued)

Warm up: 10–15 min; RPE 9–11 (Borg, 1982)

Stepping: big group circles, on the spot and side-to-side. Opposite foot/hand touches behind the body arm circles
Visual

Circuit exercises (1–9) performed on equipment individually

9. Eve's lunge

Push back carriage, keeping legs straight. Perform available ROM. Pelvis remains forward. Return by bend standing leg at knee to lunge forward toward the foot bar. Concentrate on knee tracking.



Group Exercise (10–12) Performed with the instructor as a group

Visual

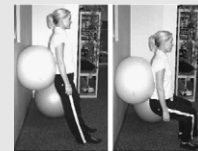
10. Theraband side lunge+triceps extension

Start standing tall, feet together. Side step out. Concentrate on knee tracking. Abduct arm to shoulder height or below and extend the elbow.



11. Fit ball wall squats

Feet parallel, hip width apart. Weight in heels at all times. Squat down, concentrate on knee tracking. Push through heels to return, maintain neutral pelvis.



12. Balance series

Start standing tall on one leg, the other leg hip & knee flexion (photo 1), also the balance position. Extend leg forward, return to balance, extend leg to the side, return to balance, extend leg back, return to balance. Concentrate on keeping the pelvis in neutral. Repeat two more times. Perform the same on the opposite leg.



Cool down: 10 min; RPE around 9

Stretching the major muscles of the body feeling a mild tension. Hold each for 30s or more, relax the body. Focus on shoulder girdle, neck, hamstrings, quads and calves.

RPE: Rate of perceived exertion.

standing) and increasing the resistance of the equipment.

All exercises were repeated twice for 90s where subjects aimed to complete 15 repetitions each time. An active rest of 30s between stations allowed for equipment change. Exercises 1–9 were repeated as a circuit, allowing greater personal instruction with each equipment piece. Exercises 10–12 were performed in a group as minimal equipment was required, provided more group interaction and subjects could easily follow visual cueing from the instructor. All subjects received a workbook containing photographs and written instructions for each exercise to facilitate teaching and familiarization with the program. Program attendance was recorded for each subject on an exercise log.

Primary outcome measures of postural stability

Changes in postural stability were measured by a sway meter. A 53 cm rod attached by a belt to the subject's waist measures the horizontal displacement of the individual to a given task. The sway meter has previously been used in studies where reliability has been established (Lord et al., 1996; Barnett et al., 2003). Static stability was measured in anteroposterior (AP) and mediolateral (ML) directions on two surfaces (floor surface and a 29/200 density foam mat; 60 × 60 × 15 cm) under two conditions of eyes open and eyes closed each for 30s. Dynamic stability was measured with the maximal balance range test that involved the subject's maximal ability for performing voluntary

movements from the ankle joint in the anteroposterior direction (Lord et al., 1996).

Secondary outcome measures of functional performance

Functional performance was assessed by evaluating mobility, lower extremity muscular strength and balance via a battery of four tests:

Timed get up and go test (TGUGT): The TGUGT measures mobility (Rikli and Jones, 2001) and requires each subject to rise from a standard armchair, walk eight feet (2.4m) around a cone and return back to the chair into a seated position. An average score was obtained from three recorded trials.

Sit-to-stand: Two versions of the sit-to-stand were used to measure lower extremity muscular strength. (1) The time to perform one full repetition from a seated position to a fully standing position back to a seated position with arms across the chest and (2) the number of repetitions performed over 30s for the same maneuver (Rikli and Jones, 2001). The single repetition sit-to-stand was preceded by a trial run to ensure the subject could perform the task followed by a single trial of both one repetition and 30s sit-to-stand.

Four scale balance test (4sbt): A 4sbt measured four static balance positions of progressively increasing difficulty of feet parallel, semi-tandem,

full tandem and single leg balance. Each progression had a 30-s ceiling target and was performed without shoes and without assistive devices. The protocol has been described previously (Gardner et al., 2001), with the exception that the subject progressed through all four levels irrespective of whether the ceiling time was achieved or not.

Baseline and post-intervention outcome measures were taken the week prior to and immediately following the 8-week exercise program respectively.

Statistical analysis

Analyses were conducted using Statistical Packages for Social Sciences (SPSS) version 11 (SPSS Inc. Chicago, Ill, USA) and included standard descriptive statistics and paired student *t*-tests. Significance was set at $P < 0.05$ and results are given as the mean \pm SD.

Results

According to the ACSM guidelines (2000), the group was classified as low risk and high functioning, presenting with minimum medications. Four participants were taking medications that may have side effects of dizziness/faintness, possibly to have an

Table 2 Static sway, maximum balance and functional performance tests before and after intervention (mean \pm SD).

Variable	Pre \pm SD	Post \pm SD	% Change	<i>P</i> -value
<i>Static stability and dynamic balance</i>				
Floor eyes open AP(mm)–	19.0 \pm 3.8	18.1 \pm 5.9	–2.2	0.703
Floor eyes open ML(mm)–	8.6 \pm 1.3	10.1 \pm 5.2	12.1	0.523
Floor eyes closed AP(mm)–	20.0 \pm 2.9	20.9 \pm 9.6	7.2	0.822
Floor eyes closed ML(mm)–	11.8 \pm 2.9	12.0 \pm 5.4	–0.85	0.865
Foam eyes open AP(mm)–	35.1 \pm 10.8	35.6 \pm 9.4	2.8	0.932
Foam eyes open ML(mm)–	19.7 \pm 6.8	18.4 \pm 4.3	6.64	0.700
Foam eyes closed AP(mm)–	49.6 \pm 19.8	43.4 \pm 12.9	–9.06	0.200
Foam eyes closed ML(mm)–	44.6 \pm 14.4	30.4 \pm 8.9	–27.34	0.046*
Max balance combined (cm)+	17.0 \pm 2.0	18.3 \pm 1.6	7.82	0.024*
Max balance anterior(cm)+	9.7 \pm 1.6	10.8 \pm 1.5	11.74	0.043*
Max balance posterior(cm)+	7.3 \pm 1.0	7.5 \pm 1.3	3.35	0.649
<i>Functional performance</i>				
Timed get up and GoTest (s)–	6.7 \pm 0.9	6.2 \pm 0.9	–7.2	0.033*
Sit-to-Stand-1Rep (sec)–	2.8 \pm 0.4	2.6 \pm 0.5	–6.6	0.182
Sit-to-Stand-30s (no. of reps)+	10.8 \pm 2.1	10.9 \pm 1.9	1.3	0.829
4 stage balance test (s)+	107.4 \pm 0.8	107.1 \pm 1.2	–0.05	0.949

Significance at * $P < 0.05$.

Negative % change in these measures signifies improved postural stability.

Positive % change in these measures signifies improved postural stability.

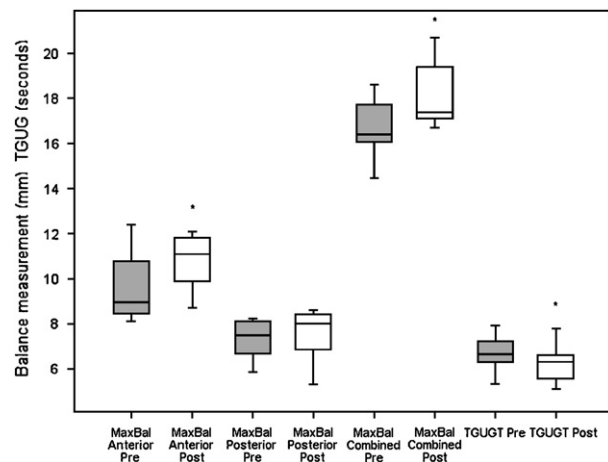


Figure 1 Individual change in dynamic stability, recorded by maximal balance and TGUGT values after 8 weeks of balance training intervention. Horizontal bars indicate the group mean values, the whiskers indicate ± 1 SD, * $P < 0.05$.

effect on their performance and or outcomes. However none of the subjects reported any dizziness/faintness throughout the program. One subject did not complete the study due to work commitments. The mean number of classes attended was 89.3%, indicating good compliance throughout the study, and no injuries were reported. Results of the clinical tests of static stability and dynamic balance (maximal balance), and the four functional performance tests at baseline and post-intervention are shown in Table 2. Improvements in static stability were observed in the more difficult condition of standing on foam with eyes closed in the AP and ML directions, with the change for the ML direction being significant ($P < 0.05$). For dynamic stability, there was a significant improvement ($P < 0.05$) in maximal balance combined and maximum balance anterior as shown in Fig. 1. Performance in the TGUGT improved by 7% ($P = 0.033$), (Fig. 1) with no significant change for the sit-to-stand or the four stage balance test.

Discussion

The major finding of this study was that postural stability improved with increasing difficulty of testing conditions with a short-duration Pilates-inspired exercise program. A positive training effect was demonstrated on the foam surface with eyes closed in ML direction, maximal balance

combined, maximal balance anterior and the timed get up and go test. These results suggest that twice weekly participation in a Pilates-inspired balance training program over an 8-week period may improve postural stability in older well-functioning adults.

Improvement in the more difficult balance tasks was observed following the intervention. Maximal balance combined improved by 1.3 cm (7.8%) which is similar to the 1.6 cm (8.6%) reported by Lord and colleagues (1996) following 22 weeks of group exercise in older women. This suggests that either a ceiling effect may have occurred in this well-functioning group or that the benefits derived from this form of training are achieved following a relatively brief exposure to exercise. The increase in maximum balance combined may be the result of increased anterior sway, however, further research is required to clarify this.

The change obtained in the TGUGT was half of that reported in a 10-week balance training intervention by Nitz and Choy (2004). In their study, whilst they prescribed exercises on different surfaces, a greater focus was placed on increasing the speed of movement, a direct component of the TGUGT. Increasing performance speed was not the focus of the current intervention and may have limited the improvements in the functional performance tests. Pilates-inspired exercise initially increases the subject's awareness of their body movement and ability in space (Anderson and Spector 2000; Lange et al., 2000), Awareness and ability of movement, in addition to speed of movement, can be important aspects resulting in the improved outcomes in postural stability as have been shown in both balance training interventions and the Pilates-inspired exercise.

Several limitations of this study are worthy of comment. Although this was a pilot study to determine the feasibility of implementing this form of training in older adults to improve postural stability, the small sample size limited our ability to detect significant differences. In addition, our design would have been stronger had we included a control group. In the absence of a control group the results may be attributable to reactive or natural changes over time, which can not be ruled out. Lastly, our subjects were a well-functioning group of older adults within a narrow age range and, as such, our results may not apply to all older adults. However, the effect of our program with a frail elderly group may be far greater due to their poorer functional capacity. Nevertheless, improvements were observed in our well-functioning group, increasing functional reserve which may assist in the reduction of falls risk.

Conclusion

While balance training programs differ with the specific types of exercises, the principles of movement generally have common characteristics of tasks performed by either changing the size or shape of the base of support (Lord et al., 1996; Barnett et al., 2003; Nitz and Choy, 2004). It is possible the Pilates-inspired exercise allowed for changes in selected components of postural stability, primarily awareness of body movement in space over a short-time period. In summary, our results suggest that a short-term novel balance training program of Pilates-inspired exercises may improve postural stability in well-functioning older adults. Future research, apart from confirming our findings with a randomized-controlled trial and a larger sample size, may consider the variation of specific balance training techniques, primarily movement re-education compared to speed and/or reaction time.

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