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Effects of physical training on the physical capacity of frail, demented patients with a history of falling: a randomised controlled trial

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Abstract

Background: to develop a physical training programme to improve balance in dependent, demented, people with a history of falling, and so decrease falls and increase autonomy.
Methods: the study was undertaken on 20 demented elderly people with a history of falling with an average age of 81.4 ± 4.7 years and an average mini mental state score of 16.3 ± 6.5. They had all passed 'get up and go', 'chair sit and reach', walking speed and static balance tests. They were assigned to a control group or a training group; the latter were trained with two sessions a week for 16 weeks.
Results: walking, mobility, flexibility and static balance were significantly improved in the training group ($P < 0.05$), but not in the controls. The trained subjects did not suffer a relapse, while the controls did during the training period.
Conclusion: the balance of frail, demented, elderly patients with a history of falling can be improved by training.

Keywords: *balance, training, falls, dementia, older people*

Introduction

Many studies have demonstrated changes in walking with age [1, 2]. Step length, walking speed and reaction times all decrease while posture in head flexion and balance become poor [2]. These postural disorders can result in many falls [3]. Falls are generally multifactorial, and the principal causes are neurodegenerative disorders [4], postural hypotension [5], adverse drug reactions [2], and vestibular [6], visual [6] or musculoskeletal problems [7, 9]. However, some frail older subjects have gait disorders that cannot be easily ascribed to underlying disease, although these underlying diseases are probably partially responsible for the senile gait disorders [10].

An inability to walk regularly reduces physical fitness [11] and imposes a sedentary life style. Thus, an excessively sedentary lifestyle leads to serious pathophysiological consequences, including muscle atrophy, impaired balance, orthostatic hypotension and impaired cardiorespiratory function; as well as psychological consequences such as apathy, depression and cognitive decline [12]. The lack of physical stimulation in institutional care increases the likelihood of gait disorders in frail elderly subjects [12, 13] and hence the number of people in wheelchairs. Many residents also become dependent on wheelchairs because they fear falling, or have extremely weak muscles [14, 15]. Residents are frequently not allowed to dress themselves, make their beds, or walk to the dining room because their capabilities are underestimated, because there are time constraints, or because the institution is concerned about its legal liability [16]. However, rehabilitation therapists recognise the importance of keeping long-term care residents mobile and active [13, 15, 17].

Lazowski *et al.* [18] demonstrated that general physical training has a positive influence on balance in institutionalised frail elderly subjects, while Rubenstein *et al.* [19] showed that physical training based on strength, endurance and mobility improved balance in fall-prone elderly subjects. Lastly, Pomeroy *et al.* [20, 21] demonstrated that physiotherapy based on music and movement groups, plus body awareness and functional mobility training, significantly improve the mobility skills of elderly people with a dementing illness.

We are not aware of any study on the effect of physical training on the balance of frail, demented fallers. We postulated that physical training to stimulate the balance and muscle functions of these subjects would reduce the number of falls and improve walking speed, so increasing their autonomy.

We therefore examined the effects of a general physical training programme on the mobility, balance, walking speed and flexibility of frail elderly people who were demented and had a history of falls, with the aim of reducing the number of falls.

Methods

Subjects

A group of 20 elderly demented patients with a history of falling aged 81.4 ± 4.7 years were studied; their mini mental state (MMS) score was 16.3 ± 6.5 [22]. All had fallen twice or more, either at home or in an institution, but neither the family nor the medical environment could indicate the exact total number of falls. Nevertheless, all the subjects had fallen during the 3 months immediately preceding the study. A fall was defined as any event that led to an unplanned, unexpected contact with a supporting surface. We excluded falls resulting from unavoidable environmental hazards such as a chair collapsing.

All the subjects who took part in this study could walk at least 10 m with or without the assistance of a cane, frame or another person, had fallen at least twice, and had an MMS score below 21. Persons whose medical condition was unstable were excluded.

We explained to each potential subject the training program individually in his/her bedroom, using simple sentences and exercises, because we did not oblige the subjects to participate in the training if they did not agree. People were then asked for their oral consent. Their severe cognitive impairment precluded the signing of a written agreement.

Two subjects were suffering from Alzheimer's disease, another had Parkinson's disease, two had a history of stroke and ten subjects had had several fractures (thighbone, arm, etc) following falls. Only 5 of the 20 subjects were classified as having a specific disease. The others had already entered institutionalised care with mental impairment and the physicians had not performed any tests (e.g. MRI) to determine its aetiology. Seventeen subjects were on anti-inflammatory drugs, 12 were taking psychoactive medication, 10 were on diuretics, 12 were on antihypertensive drugs and 15 were taking analgesics. These medications contributed to the impairment of gait and balance.

Protocol

A randomised cross-over design was used. Subjects were randomly allocated to either the control (CG) or training (TG) groups, with 10 subjects in each group. The control subjects continued their daily routine for the 16 weeks.

Evaluation and physical training were conducted in the morning at the institution. The initial evaluation was done two days before training began and the final evaluation was done two days after it ended. The tests were conducted by a physician who was experienced in assessment. He took no part in the physical program and so did not know who was in the control and trained groups.

Each new fall suffered by the subjects in the institution in the course of the 16 weeks was noted.

All subjects performed the following tests before and after training: 'get up and go' [23], 'chair sit and reach' [24], walking speed over 10 m [25], and posturography platform QFP (French Association of Posturography, 1995). The study design is summarised in Figure 1. The training program was offered to the control subjects at the end of the study but was outside the investigation.

Get up and go

This test of balance is commonly used to examine functional mobility in community-dwelling, frail elderly subjects. The test requires the subject to stand up, walk 3 m (10 ft), turn, walk back, and sit down. The time taken to complete the test is strongly correlated with the subject's functional mobility. Older subjects who can complete the test in less than 20 s are independent in transfer tasks that are normal activities of daily living.

Chair sit and reach

Flexibility was measured by asking the subject to sit on a chair and stretch one leg keeping the heel on the floor. He/she was then asked to touch his/her toes with the fingers. The distance between the fingers and toes was measured.

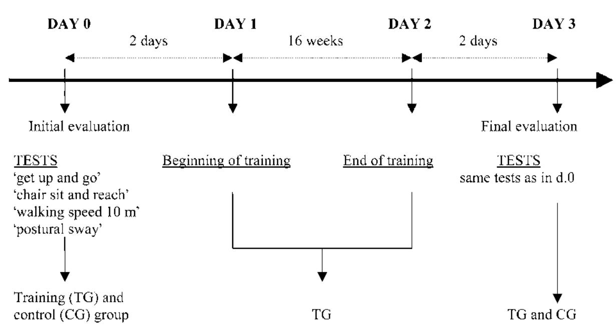

Figure 1. Study design.

Walking speed over 10 m

Subjects walked 10 m and the time taken was measured with a chronometer.

Posturography platform QFP

Balance was measured as the area of postural sway over one minute. This test measures the static balance of older adults. The subject stood on a platform and static balance was measured over 51.2 s. This test was performed 'eyes open' (S0). The platform calculated the elliptical area covered by the moving centre of gravity (mm^2).

Physical training

The subjects in the TG attended two supervised 1-h exercise sessions per week for 16 weeks. The total time of the physical training was only 45 min because the hour included fetching the subjects from their bedrooms and returning them there, to ensure that they did not become lost. The training group was divided into two groups of five subjects, each with two physicians because of the subjects' physical and mental dependence. It was impossible to stimulate 10 subjects continuously with only two physicians. The two groups performed exactly the same exercises in the same order. At each session, subjects undertook exercises to develop muscular strength, proprioception, static and dynamic balance and flexibility.

Examples of exercises

Muscle strength: The subject placed their feet in the notch of an elastic band and stretched the elastic band several times; the tension developed depended on the position of the feet in the notch. The subject sat in a chair with arms or in a wheelchair, then raised his/her bottom with or without the help of arms and sat on the edge of the seat. This exercise was repeated several times. Another exercise involved the subject sitting on a chair and flexing and extending his/her legs several times.
Proprioception: The subjects walked on a variety of surfaces or on hard and soft surfaces alternately (e.g. one foot on a hard floor and one foot on a soft carpet).
Static and dynamic balance: The subject stood on one foot and touched the supporting leg with the other foot at different heights (e.g. tibia, ankle). The same exercise was repeated but without touching the support. The subject stood between parallel bars and the physician swung a ball suspended from the ceiling; the subject was asked to avoid the ball. The subject stepped over obstacles of different heights (0–10 cm); this exercise was performed between parallel bars or free standing.
Flexibility: The subject sat on a chair with a skate-board under his foot; then he bent and stretched his leg as far as possible while keeping his foot on the skate-board without the heel slipping backward. The subject placed an outstretched leg on a big ball and tried to touch his feet with his fingers.

In general, for a better comprehension, the physician carried out the exercises at the same time as the patients or helped them.

Statistics

Values are expressed as means ± the standard deviation (SD). The anthropometric characteristics of the two groups (age, weight, MMS) were compared before training using Student's unpaired *t*-test. We compared the mobility, balance, walking and flexibility of the two groups before and after training by two-way analysis of repeated measures (ANOVA). When the ANOVA interaction was significant, means were compared by the Newman-Keuls method. Statistical significance was set at $P < 0.05$.

Results

Before training

The anthropometric characteristics (age, weight, MMS) (Table 1) and the initial values for the various tests of the two groups were not significantly different (Table 2).

After physical training

Balance was significantly improved in the TG, whereas there was no change in the CG ($P < 0.01$). The elliptical areas in the eyes-open posturography test were

Table 1. Anthropometric characteristics of the subjects

	Training group $n = 10$	Control group $n = 10$
Age (years)	81.0 ± 5.6	81.9 ± 4.1
Weight (kg)	61.1 ± 11.7	61.9 ± 13.5
Mini mental state	14.7 ± 7.6	18.0 ± 5.4

Values are expressed as mean ± SD.

Table 2. Initial test values before training

	Training group $n = 10$	Control group $n = 10$
Distance 'chair sit and reach' (cm)	11.4 ± 7.1	10.3 ± 8.0
Time to perform 10 metres (sec)	60.6 ± 49.9	63.4 ± 51.1
Time to perform 'up and go' (sec)	67.6 ± 38.9	39.4 ± 17.7
S0 (mm^2)	398.7 ± 229.6	292.3 ± 94.5

Values are expressed as mean ± SD.
S0 = Postural sway of the centre of gravity in condition 'open eyes'.

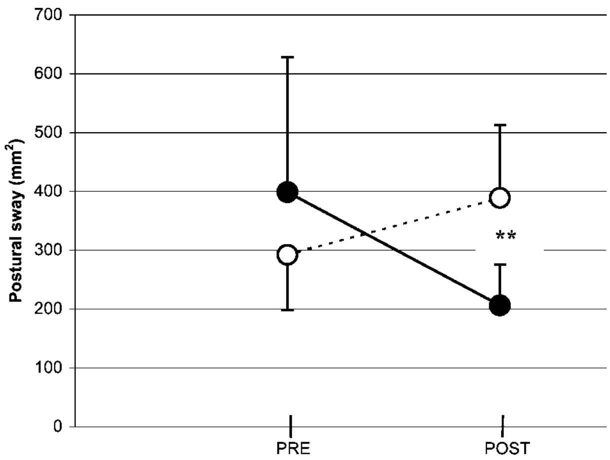

Figure 2. Comparison of mean elliptical areas (mm^2) before and after 16 weeks, for the two groups in the condition 'open eyes'. ○, CG; ●, TG. *$P<0.05$ difference intra-group after 16 weeks. **$P<0.01$ difference intra-group after 16 weeks.

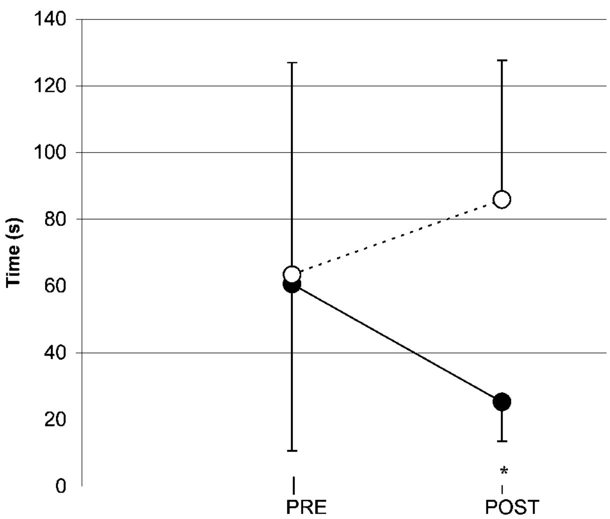

Figure 3. Mean times required to cover 10 m before and after 16 weeks for the two groups. ○, CG; ●, TG. *$P<0.05$ difference intra-group after 16 weeks.

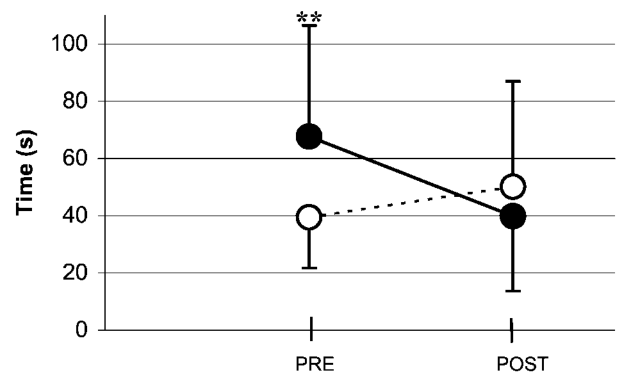

Figure 4. Mean times required to perform the 'get up and go' test before and after 16 weeks for the two groups. ○, CG; ●, TG. *$P<0.05$ difference intra-group after 16 weeks. **$P<0.01$ difference intra-group after 16 weeks.

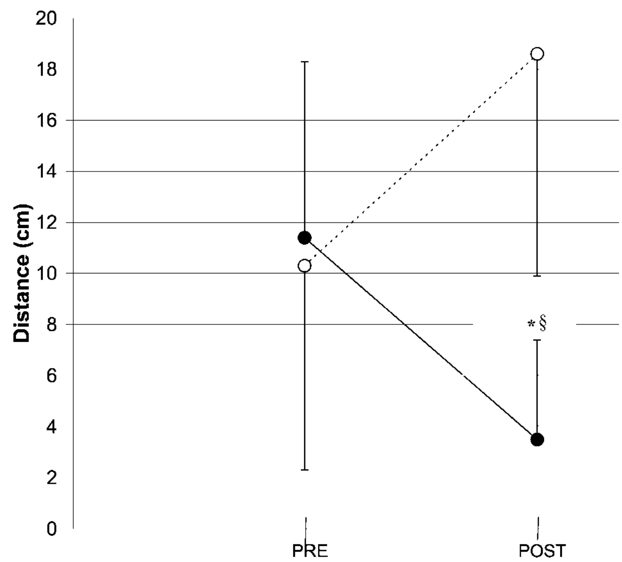

Figure 5. Flexibility (cm) before and after 16 weeks for the two groups. ○, CG; ●, TG. §$P<0.01$ difference inter-group after 16 weeks. *$P<0.05$ difference intra-group after 16 weeks.

significantly decreased by 40% ($P=0.006$) for the TG, whereas there was no change in the CG (Figure 2).

The TG walked significantly faster (+23%) in the 10 metre walking test ($P=0.015$) and in the get up and go test, +41% ($P=0.001$). There was no change in the CG performance of the two tests (Figures 3 and 4).

Flexibility was significantly improved after training ($P=0.0002$). The distance between fingers and toes was significantly decreased by 69% in the TG ($P=0.02$), whereas it was significantly increased by 44% in the CG, demonstrating a loss of flexibility (Figure 5).

The MMS of the TG was unchanged after training, but it had significantly decreased by 13% in the CG ($P=0.03$) (Figure 6).

The TG subjects did not fall during the 16 weeks, while the control subjects fell 6 times during the same period. However, the TG started to fall again after the training: 2 falls in the first month, 2 falls in the second month, 1 fall in the third month, 7 falls in the sixth month.

Discussion

General physical training significantly improved walking, mobility, flexibility, balance and prevented new falls in dependent and cognitively impaired patients with a history of falling, while there was no alteration in the control group.

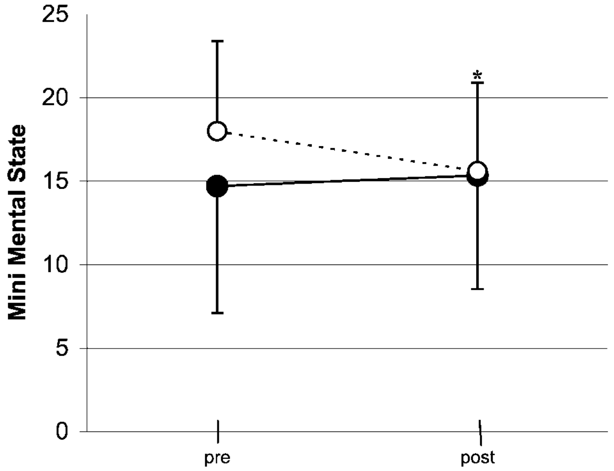

Figure 6. Mini mental state before and after 16 weeks for the two groups. ○, CG; ●, TG. $^{*}P<0.05$ difference intra-group after 16 weeks.

Training and evaluation were simple because the subjects were mentally dependent, as indicated by a mean Folstein mini mental state of <21. Simple instructions were used in training and evaluation so that the subjects could perform the physical activities and evaluate themselves. This kept the subjects motivated.

The subjects in the training group regularly took part in training and became enthusiastic during the training sessions, although they could not remember any session or the name of their instructors. This enthusiasm affected their behaviour: they laughed, and spoke with little or no coherence. They caught things that were thrown (balls, hoops, etc). However, the subjects always had difficulty understanding the instructions in a subsequent session, even if the exercises were performed regularly. However, their walking improved after 8 weeks, despite their lack of improvement in comprehension of instruction. Subjects occasionally refused to participate in an exercise during one session, although agreeing to perform the same exercise in the previous session. We did not insist, but suggested another exercise a few minutes later. This type of refusal only occurred occasionally.

The elliptical areas covered by the moving centre of gravity in the condition 'eyes open' were significantly decreased after training. Lord *et al.* [7–9] and Maki *et al.* [26] demonstrated that a reduction in the area results in improved stability and balance in normal elderly subjects. Perrin *et al.* [27] and Lazowski *et al.* [18] also showed that physical training based on flexibility and muscular strength has a positive effect on the static balance of frail, mentally normal elderly non-fallers. The present study demonstrates that general training can also improve the stability and static balance of elderly, frail, demented patients with a history of falling.

We found significant increases in mobility and in walking in the training group, with no change in the control group. Ades *et al.* [28] showed that physical training based on muscle building increases muscle strength in frail elderly non-fallers. McMurdo *et al.* [29] similarly demonstrated an increase in quadriceps strength and walking area with seated exercise in institutionalised elderly subjects. We did not measure muscle strength because of the dementia of the subjects. However, like McMurdo *et al.* [29] and Ades *et al.* [28], we used exercises to develop muscle strength. Thus the increased walking speed was probably due to increased muscle strength, which can also explain the absence of new falls.

The training group showed significant shorter distances for the 'chair sit and reach' test after training, indicating better flexibility of the legs of the training group. This was probably due to the specific exercises used in training and the increased mobility produced by the general training. Shephard [30] demonstrated that the loss of flexibility with age is the cause of decreased mobility. We also found a significant increase in static balance, again in agreement with Shephard [30], who showed that the decrease in flexibility is related to the decrease in stability with age.

Nashner and Cordo [31] demonstrated that the number of falls associated with ageing was due to decreased muscle strength and flexibility. This decrease results in the centre of gravity lying in front of the ankle axis, which favours falls. The improved flexibility may cause the centre of gravity to move up the ankle axis, giving better balance. This could have improved balance and prevented new falls in the TG.

The MMS score of the TG was not modified, whereas it had significantly decreased for the CG. This difference could be due to a 'group effect' for the training group. The fact of meeting twice a week for training could have influenced this result. Cognitive losses can be exacerbated by the inactivity that accompanies institutional living [29]. Secondly, the subjects had to pay attention to instructions during the training sessions, and they expressed themselves verbally, which was not the case when they were in their bedrooms. Neely and Backman [32] showed that mobilising attention and language stimulated cognitive function. They measured a significant increase in cognitive function after mental training based principally on language and attention. Thirdly, Molloy *et al.* [33] have demonstrated that the MMS of active elderly patients is significantly improved after physical training. However, McMurdo *et al.* [29] showed that the MMS of institutionalised elderly subjects remained stable after regular seated exercise and was the same in trained and control groups. This result could be because the control group took part in control reminiscence therapy, including group discussions and social interactions. In summary, physical exercise, mental stimulation and social interaction all seem to influence the maintenance or progression of cognitive abilities of demented elderly subjects, as assessed by the MMS. Exactly how remains to be defined.

We conclude that general physical training can have a positive effect on the balance of dependent, cognitively impaired, elderly fallers. It resulted in a reduced elliptical posturography area and an absence of new falls in the trained group. Physical training significantly improved walking, mobility and flexibility, which can reduce falls and help maintain autonomy. An absence of stimulation in the control group led to more falls, and hence to a loss of autonomy.

Key points

- The balance of frail, demented, elderly patients with a history of falling can be improved by training.
- The greater results among frail elderly could be the improvement of walking, mobility, flexibility and static balance in the training group, but not in the controls, and an absence of new falls in the training group during the trained period contrary to the control group.

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References

1. King MB, Tinetti ME. A multifactorial approach to reducing injurious falls. Clin Geriatr Med 1996; 12: 745–59.

2. Robbins AS, Rubenstein LZ, Josephson KR, Schulman BL, Osterweil D, Fine G. Predictors of falls among elderly people. Arch Intern Med 1989; 149: 1628–33.

3. Tinetti ME, Franklin T, Mayewski R. Fall risk index for elderly patients based on number of chronic disabilities. Am J Med 1986; 80: 429–34.

4. Dolinis J, Harrison JE. Factors associated with falling in older Adelaide residents. J Pub Health 1997; 21: 462–8.

5. Sheldon JH. On the natural history of falls in old age. Br Med J 1960; 1685–90.

6. Shepard NT. The clinical use of dynamic posturography in the elderly. Ear Nose Throat J 1989; 68: 943–50 and 955–7.

7. Lord SR, Clark RD, Webster IW. Physiological factors associated with falls in an elderly population. J Am Geriartr Soc 1991; 39: 1194–200.

8. Lord SR, Sambrook PN, Gilbert C *et al.* Postural stability, falls and fractures in the elderly: results from the Dubbo Osteoporosis Epidemiology Study. Med J Aust 1994; 160: 688–91.

9. Lord SR, Clark RD. Simple physiological and clinical tests for the accurate prediction of falling in older people. Gerontol 1996; 42: 199–203.

10. Bloëm BR, Gussekloo J, Lagaay AM, Remarque EJ, Haan J, Westendorp RGJ. Idiopathic senile gait disorders are signs of subclinical disease. J Am Geriartr Soc 2000; 48: 1098–101.

11. Hakim AA, Petrovitch H, Burchfiel CM *et al.* Effects of walking on mortality among non-smoking retired men. N Engl J Med 1998; 338: 94–9.

12. Blocker WP Jr. Maintaining functional independence by mobilizing the aged. Geriatrics 1992; 47: 42–56.

13. Connelly DM, Vundervoort AA. Effects of detracting on knee and extensor strength and functional mobility in a group of elderly women. J Orthop Sports Phys Ther 1997; 26: 340–6.

14. Cape E. Activity and independence: issues in the implementation of activity programs for institutionalized elders. Can J Aging 1983; 2: 185–95.

15. MacRae PG, Asplund IA, Schnelle JF, Ouslander JG, Abrahamse A, Morris C. A walking program for nursing home residents: effects on walk endurance, physical activity, mobility, and quality of life. J Am Geriatr Soc 1996; 44: 175–80.

16. Myers AM, Huddy L. Evaluating physical capabilities in the elderly: the relationship between ADL self-assessments and basic abilities. Can J Aging 1985; 4: 189–200.

17. Binder EF. Implementing a structured exercise program for frail nursing home residents with dementia: issues and challenges. J Aging Physical Activity 1995; 3: 383–95.

18. Lazowski DA, Ecclestone NA, Myers AM *et al.* A randomized outcome evaluation of group exercise programs in long-term care institutions. J Gerontol A Biol Sci Med Sci 1999; 54: M621–8.

19. Rubenstein ZL, Josephson KR, Trueblood PR *et al.* Effects of a group exercise program on strength, mobility, and falls among fall-prone elderly men. J Gerontol Med Sci 2000; 55: M317–21.

20. Pomeroy VM. Immobility and severe dementia: when is physiotherapy treatment appropriate? Clin Rehabil 1994; 8: 226–32.

21. Pomeroy VM, Warren CM, Honeycombe C *et al.* Mobility and dementia: is physiotherapy treatment during respite care effective? Int J Geriatr Psychiatry 1999; 14: 389–97.

22. Folstein MF, Folstein SE, Mc Hugh PR. 'Mini Mental State', a practical method for grading the cognitive state of patient for the clinician. J Psychiat Res 1975; 12: 189–98.

23. Podsiadlo D, Richardson S. The timed 'up and go': a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc 1991; 39: 142–48.

24. Jones CJ, Rikli RE, Max J, Noffal G. The reliability and validity of a chair sit-and-reach test as a measure of hamstring flexibility in older adults. Res Q Exerc Sport 1998; 69: 338–43.

25. Bohannon RW. Gait performance of hemiparetic stroke patients: selected variables. Arch Phys Med Rehabil 1987; 6: 771–81.

26. Maki BE, Holliday PJ, Topper AK. A prospective study of postural balance and risk of falling in an ambulatory and independent elderly population. J Gerontol 1994; 49: M72–84.

27. Perrin PP, Gauchard GC, Perrot C, Jeandel C. Effects of physical and sporting activities on balance control in elderly people. Br J Sports Med 1999; 33: 121–6.

28. Ades P, Ballor D, Ashikaga T, Utton J, Nair K. Weight training improves walking endurance in healthy elderly persons. Ann Intern Med 1996; 124: 568–71.

29. McMurdo MAT, Rennie LM. Improvements in quadriceps strength with regular seated exercise in the institutonalized elderly. Arch Phys Med Rehabil 1994; 75: 600–3.

30. Shephard RJ. Management of exercise in the elderly. Can J Appl Sport Sci 1984; 9: 109–20.

31. Nashner LM, Cordo PJ. Relation of automatic postural responses and reaction-time vuluntary movements of human leg muscles. Exp Brain Res 1981; 43: 395–405.

32. Neely AS, Backman L. Long term maintenance of gains from memory training in older adults: two 3½-year follow up studies. J Gerontol Psychol Sci 1993; 48: 233–7.

33. Molloy DW, Beerschoten DA, Borrie MJ, Crilly RG, Cape RDT. Acute effects of exercise on neuropsychological function in elderly subjects. J Am Geriatr Soc 1988; 33: 29–36.

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