New South Wales
Health Promotion Demonstration
Research Grants Scheme

The Central Sydney Tai Chi Trial

A randomised controlled trial of the effectiveness of Tai Chi in reducing the risk of falls in older people

NSW HEALTH

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EXECUTIVE SUMMARY

Background

Preventing falls in older people is a public health priority. Not only do falls incur a major cost to the health system but they adversely affect the quality of life of older people and increase the risk of premature death.

Extensive research on the risk factors for falls has led to the development of several potential intervention strategies. The strategies that are most relevant to a population health approach are those that target healthy lifestyle changes; for example, physical activity. However, even though some types of physical activity address risk factors for falls, there is little published research on the effect of physical activity on preventing falls. The evidence that does exist suggests that activities focusing on balance and/or strength training are the most likely to be successful.

One clinical trial focusing on tai chi demonstrated a 47.5 per cent reduction in falls.[29] However, a major limitation of this trial, from a population health perspective, was that the tai chi classes were implemented within a clinical context with 2 free classes per week, daily practice at home, and a single tai chi instructor running all classes. In a typical community setting, older people would most likely attend only one class per week. In addition, older people would be enrolled in classes with different instructors and varying cost. Also, instructors would have different teaching styles and varying levels of skill and experience.

Methods

The Central Sydney Tai Chi Trial was a randomised control trial investigating the effectiveness of an introductory tai chi program in reducing the risk of falling among community-dwelling people aged 60 years or over. Participants were recruited into the trial through advertisements in local papers. People were excluded if they: were younger than 60 years; had a degenerative neurological disease, such as Parkinson's or Alzheimer's disease; had experienced a severely debilitating stroke, metastatic cancer, or severe arthritis; or could not walk across a room independently. Eligible participants (n = 702) were then randomised into either a control group (n = 347) or an intervention group (n = 355) for 6 months. The intervention consisted of a one-hour tai chi class per week for 16 weeks.

The main outcome variable was falls recorded concurrently throughout the 6-month trial period. Intermediate outcome variables were: balance, leg strength, ankle flexibility, daily functioning, and fear of falling. These were measured at baseline and again at the conclusion of the intervention tai chi classes.

Results

Results indicate that an introductory 16-week tai chi program reduces the risk of falling by 35 per cent in people aged 60 years and over living independently in the community. The 16-week program also improves aspects of balance, although the exact relationship between balance and falls is not clear. Participants who continued with classes beyond the trial period did so because they enjoyed the classes or because they felt they were getting something out of doing tai chi.

Conclusion

The trial showed that a relatively simple community-based program of an introductory tai chi consisting of a one-hour class per week reduces the risk of falling by 35 per cent in people aged 60 years and over living independently in the community.

BACKGROUND

In New South Wales, demand on health resources due to falls in older people is increasing. If death rates remain the same, by 2051 the proportion of people aged 65 years and over in New South Wales will increase from 13 per cent to 25 per cent.[1] With better health care and more effective population health strategies, people will be living for longer resulting in an even greater increase in the size of the population 65 years and over.[2]

Falls in people aged 65 years and over are a major cause of all injury-related hospitalisations. Using current population projections, it has been estimated that by 2051 New South Wales will require over 440,000 public hospital bed days per year to cope with fall injuries in older people—the equivalent of 4 new 200-bed acute care facilities and 1,200 new nursing home places—and the cost to the health system will be over $640 million, which is more than 3 times the current cost of falls to the health system.[3–7] The cost of falls nationwide has been estimated at $3 billion annually.[8] Injuries from falls are a leading cause of avoidable mortality and morbidity in New South Wales.[9] Between 1996 and 2000 injury was the 4th highest cause of mortality overall and the 3rd highest in males.[9]

However, the falls that result in hospitalisation are only a fraction of the number of all falls experienced by older people. In 2003, the New South Wales Population Health Survey found that among people aged 65 years in the previous 12 months, 23.5 per cent in the state had fallen.[10] Of those people, about 32.0 per cent required medical treatment and about 28.5 per cent required hospitalisation.[10] People aged 75 years and over reported higher rates of falls than those aged 65–74 years and women reported higher rates of falls than men.[10]

The most common fall-related injuries include bruising and open wounds; and, more seriously, fractures and brain injury.[11] With increasing age, these injuries can lead to medical complications, which can further lead to death.[3,4] It is not only the injuries resulting from falls but falls themselves that pose a significant risk to the health and wellbeing of older people. Even without a serious injury, falls can result in a loss of confidence resulting in detrimental effects on the quality of life. A fall or fall injury can lead to a decline in functional status, social activities, and physical activities,[11] all of which increase the risk of falling.[4]

The causes of falls have been studied extensively. Over 400 individual risk factors for falls have been identified.[4,,12–15] A systematic way of categorising these risk factors makes use of Haddon's Injury Prevention Matrix (Table 1), which compares 3 categories (human, factor or vector, and environment) with 3 periods (pre-event, event, and post-event).[16]

Table 1
Haddon's Injury Prevention Matrix (including injuries resulting from a fall)

	Human	Factor or vector	Environment
Pre-event	Impaired balance Visual acuity Postural hypotension Depression Low socioeconomic status Low level of physical activity Fear of falling	Slippery shoes Poorly fitting shoes Psychotropic medication Bifocals	Slippery surface Slippery rugs and mats Poor lighting Exposed electrical cords Small pets (cats and dogs)
Event	Low muscle-strength (leg) Poor reaction time		Hand rails 'Size' of stair in relation to foot size
Post-event	Poor health and fitness Age	Medical emergency 'beeper'	Emergency services Social connectedness

Source: Baker S. Where Have We Been and Where are We going With Injury Control? *Injury Prevention and Control*.[16]

There have been several interventions focusing on reducing some of these risk factors. These interventions have focused on multiple risk factors.[6,13,17,18] as well as single risk factors.[15,19] The latest Cochrane systematic review of falls prevention suggests more research is required before we have sufficient evidence for effective falls interventions.[20] Of the multiple risk factor interventions, the ones that are likely to be effective are those focusing on both physical activity and vision (reduction in risk of falling of 16 per cent).[20] Single-factor interventions, such as withdrawal of psychotropic medication (reduction in risk of falling of 66 per cent), and home modification strategies (reduction in risk of falling of 34 per cent), are also effective in reducing the risk of falling.[20] The most promising single intervention involves physical activity.[20] Muscle strength training and tai chi have been shown to be effective in reducing falls by 20 per cent and 49 per cent respectively.[20]

From a population health perspective, multiple risk factor interventions are relatively expensive and complicated to implement as they involve a variety of health professionals and health behaviours. Interventions focusing on single risk factors, particularly those interventions that can be incorporated into everyday life and that have multiple benefits, such as physical activity, are the strategies most likely to be widely adopted.

It has been recommended that a regime of physical activity of 30-minutes duration on at least 5 days a week is sufficient to maintain current levels of health.[21] Overall, it is estimated that about 34 per cent of people aged 65 years and over in New South Wales engage in adequate levels of physical activity.[10] For people aged 65–74 in New South Wales it is estimated that about 40 per cent engage in adequate levels of physical activity, while only about 27 per cent of people aged 75 years and over are adequately active.[10] (An adequate level of physical activity is estimated here using leisure time physical activity only.)

Several studies have looked at the effect of exercise on risk factors for falls rather than falls themselves and demonstrated improvements in balance, gait, muscle strength,[22–25] functional capacity, and reduction in fear of falling.[19,26] Exercise that addresses muscle strength and balance such as tai chi, weight training and yoga have been shown to reduce falls in older people whereas walking and running has been shown to increase falls and other forms of exercise such as swimming are of unknown benefit.[20]

The lack of evidence for the effectiveness of different types of physical activity in preventing falls is not from a lack of research. In 1999, Brown reviewed this research and concluded that many trials investigating exercise programs were either ineffective or inconclusive in providing evidence in reducing falls due to their having insufficient: duration (length of time engaged in the physical activity); intensity (how vigorous the activity is); or frequency (how often the physical activity is engaged in).[15]

Previous research has demonstrated that tai chi is a particularly promising intervention for falls prevention. Tai chi is a gentle form of martial art that originated in China where it is predominantly practised by older people. In China, reports claim many psychological and physiological benefits from practising tai chi.[19] In the west, where the psychological and physiological benefits of tai chi have not been studied in great detail, the value of tai chi as an exercise promoting dynamic balance is recognised.[19] In particular, the appropriateness of tai chi for older people has been partly attributed to its safe, tranquil and achievable low impact moves, its improved breathing techniques, and its ability to produce increased feeling of wellbeing.[27] Tai chi has been shown to be effective in not only addressing some risk factors, such as balance and gait, but also in reducing the number of falls experienced by older people.[19,28,29]

The Atlanta FICSIT Study (FICSIT = Frailty and Injuries Cooperative Studies of Intervention Techniques) on tai chi showed an improvement in balance as well as a reduction in falls of over 47.5 per cent.[19,29] In addition, the FICSIT Study showed that tai chi can help reduce fear of falling, which in turn increases confidence to participate in daily activities, thereby increasing the amount of incidental physical activity.[29]

The Atlanta FICSIT Study was a clinical trial where participants were required to attend free tai chi classes twice a week as well as practise at home every day. In addition, one tai chi instructor conducted all classes. It could be argued that any beneficial results from the tai chi could be at least partly attributed to the skill or teaching style of the instructor. While this is acceptable from a clinical perspective, replicating these results at a population level, especially if results are dependent on the skill of a particular tai chi instructor, is impractical. The question to ask is whether these results could be seen in a community-based setting.

Several key factors differentiate tai chi programs conducted in the community from tai chi programs used in research trials to date. There are many different people conducting programs in the community and there are no universally recognised qualifications for instructors. This makes it difficult for the general public to recognise an appropriately qualified instructor. Another factor differentiating community-based programs from those used in trials is that there are 4 main styles of tai chi and each style has a number of variations. These factors limit the generalisability of the results of previous trials to the particular instructors and style used in the trials.

PROPOSAL

Aims

To investigate the effectiveness of a community based tai chi program for people over 65 in reducing the time to first fall, and in improving balance.

Objectives

By the end of the project there will be:

- a significant reduction in the time to first fall in the intervention group compared to the control group at the end of the study period (2 months after the intervention classes end);
- a significant reduction in the average number of falls in the intervention group compared to the control group at the end of the study period;
- a significant improvement in balance in the intervention group compared to the control group at the end of the intervention period (that is, at the end of the intervention classes);
- a significant reduction in the fear of falling and increase in functionality in the intervention group compared to the control group at the end of the intervention period.

Research design

A randomised controlled trial of community tai chi classes will be used. Subjects will be randomly allocated to either an initial-intervention group or a waiting-list control group. The intervention will consist of 16 weeks of tai chi classes (one class per week). The control group will be given tai chi classes after the initial 16-week intervention period plus another 8 week follow-up period (for a total of approximately 6 months).

Subjects and recruitment

The people targeted in this trial will be community dwelling older people aged over 65 living in the Central Sydney Area Health Service. Consistent with the Atlanta FICSIT Study,[19,29] exclusion criteria will include people who have neurological disease (such as Parkinson's or stroke), metastatic cancer, severe arthritis or who cannot walk across a room independently or with a cane. In addition, people with dementia, cardiovascular disease and who take medications known to impair balance will also be excluded.[30]

A pilot study conducted by the Central Sydney Health Promotion Unit in 1999 indicated that a very effective way of reaching the target population is through a social marketing campaign using local and community newspapers.[31] The social marketing strategies and messages of this trial will be based on the earlier pilot study and will be refined to accommodate the research components of the trial. Ads will be placed in local papers to market the tai chi classes. People interested in taking part in the classes will then contact the project officer who will explain in more detail what will be required from

participants (including information about the falls calendars, physiological testing, and the random allocation to an intervention or waiting-list control group). At this point an initial screening of eligibility for inclusion in the study will be conducted. Older people who have passed through the initial screening will then be asked to complete a medical information form and attend a second screening process. During this time pre-testing will also occur. At this point participants will be randomly allocated into either a control or intervention group.

Classes will initially be free (5 week period), after which participants will pay a minimal fee of A$4 per class. At the end of the free classes, participants' participation rate in tai chi will be monitored for a further 6–8 months. Participants will then be asked to provide feedback to determine what the motivating factors for continuing or dropping tai chi are.

Sustaining the participants in the tai chi classes both during and after the 16-week trial period will be ensured by a number of mechanisms. First, in our experience with water-based exercises for older people, as well as in the experience of one of our tai chi partners, it is common to see a fall in the drop-out rate as participant numbers increase. Also, the project will develop and support a network of older people in tai chi.

The pilot tai chi classes indicated that participants typically dropped out due to prior commitments. Relatively few participants dropped out because of the tai chi itself. So, from initial contact with the tai chi project officer, it will be emphasised to potential participants that a 16-week commitment is important. In this way participants will be able to block out a period of time for the tai chi classes.

However, if it appears that we are not recruiting sufficient participants, due to a higher than anticipated drop out rate, we can over-recruit from an adjoining area health service (which we have already had preliminary discussions with), or increase advertising.

Sample size

This study was designed to detect a 40 per cent relative reduction (from 24 per cent to 15 per cent) in the risk of falling. A sample size of 284 per group (α = .05; power = 80 per cent) was required to detect such a difference in a 6-month period.[32] A drop-out rate of 25 per cent was estimated for this trial, which in turn requires an over-sampling of 95 per group, or a final sample size of *n*=379 per group. However, the drop-out rate for this study was less than anticipated. By the end of the trial there were approximately 350 participants per group thus increasing the power of statistical tests to enable detection of a relative reduction in fall rates as small as 37 per cent.

Intervention

The intervention will consist of 16 weeks of modified tai chi instruction provided by experienced instructors. Tai chi consists of over 108 movements, which experience suggests is too much to teach older people in a 16 week program.[19,31] The Central Sydney Health Promotion Unit, in partnership with tai chi providers, will contract instructors who have worked with older people before. They will be asked to provide a modified form of tai chi that will be easier for older people to follow and remember, keeping in mind there will initially be only be 16 weeks of instruction. Each instructor will be asked to be available for at least 2 x 16 week programs for older people over a 12-month period.

Each class will consist of one-hour instruction. In addition, participants will be encouraged to practice at home for at least 10 minutes a day. As this is a community trial, consistency regarding style or form of tai chi will not be enforced, as the style and form of tai chi offered in the community varies. However, a core set of movements and principles common to most tai chi styles will be expected to be taught by instructors (Appendix 5). In order to achieve the required sample size, there will be several classes being conducted throughout the Central Sydney Area Health Service at any one time throughout the 2–3 year period.

Outcome measures

The primary outcome measures will be time to first fall and balance.[19,30] Falls will be recorded using a falls calendar adapted for the trial.[33] Falls are defined in accordance with the FICSIT trials as 'Unintentionally coming to rest on ground, floor, or other lower level; excludes coming to rest against

furniture, wall, or other structure'.[22] Participants will be asked to record on the calendar whether or not they have fallen that day. At the end of each month all participants (both intervention and control) will be asked to send the information to the project officer (using pre-paid postage). The records held by the research officer will identify missing data, which will be subsequently followed up.

Dynamic balance will be measured using tests of maximal balance range and coordinated stability that assess subjects' ability to adjust balance in a smooth and coordinated way while placing them near or at the limits of their equilibrium (Appendix 6).[34] This test of dynamic balance is readily accepted by older people, and has high external validity and test–retest reliability.[35–37] Balance will be measured before the participants begin tai chi, at 16 weeks and at 24 weeks follow-up.

Secondary outcome measures will be fear of falling and functionality. Fear of falling will be measured using the Falls Efficacy Scale, as developed by Tinetti et al.,[38] which is a reliable and valid method for measuring fear of falling. Functionality will be measured using the Lawton version of Instrumental Activities of Daily Living, which measures complex self-care activities.[39] Both secondary outcomes will be measured before the participants begin tai chi, at 16 weeks and at 24 weeks follow-up.

Other measures

A questionnaire will be used to collect information on falls history and any related injury. In addition, physical activity levels will be accounted for during the intervention period using a simple questionnaire. Subjects' participation rates in tai chi will be followed up for approximately 12 months after starting the classes. Participants will then be asked to provide feedback on reasons for maintaining or dropping tai chi.

Qualitative data

Qualitative data will be collected through the baseline and follow-up questionnaires and also a posted questionnaire to be conducted towards the end of the trial. The qualitative data from the baseline questionnaire will investigate what motivated participants to enrol in a tai chi program. The follow-up questionnaire will investigate what participants thought of the program and what if any benefits they enjoyed from the program. The mail-out questionnaire will investigate what factors kept participants in classes beyond the study period.

Analysis

The data will be analysed on an intention-to-treat basis to minimise retest bias and provide a more realistic indication of the generalisability and effectiveness of the intervention using STATA 8.2 statistical software.[43] In the primary analysis, the number of falls in the 2 groups will be compared by calculating incidence ratio rates using a negative binomial regression model. A multivariate negative binomial regression analysis will also be conducted adjusting for age, gender, falls history, and any differences at base-line.

Time to first fall and time to multiple falls will also be examined using the Anderson-Gill modification of the Cox proportional hazards model while adjusting for potential confounders. Multiple falls will be examined by dichotomising data into 0 or 1 fall versus 2 or more falls and then analysed using logistic regression. While logistic regression is used to analyse dichotomous variables it also produces an odds ratio. However, a hazards ratio (HR) can be used to approximate a risk ratio (RR) by using the Anderson-Gill modification of the Cox proportional hazards model while adjusting for potential confounders. Interactions effects will also be examined in the multivariate analyses for falls.

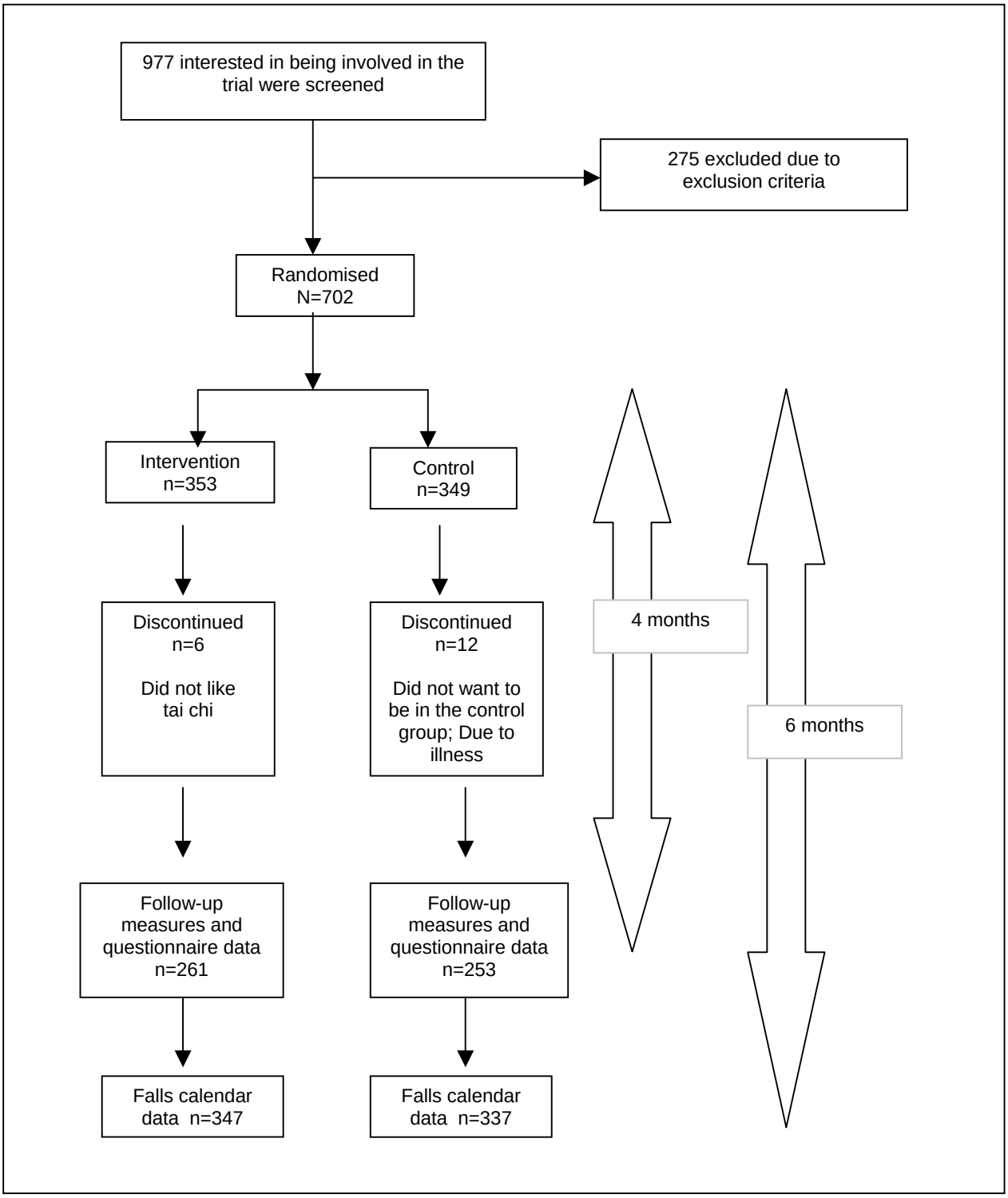
Baseline–follow-up differences in balance and other measures at the 16-week retest will be compared by forced entry multiple linear regression analysis, with experimental group included as the independent variable, age and gender included as confounding variables in the models. Non-parametric techniques will be used where necessary. Qualitative data will be analysed using techniques borrowed from thematic analysis.

RESULTS

Baseline characteristics

A total of 702 people were randomised into the study, 353 into the intervention group and 349 into the waiting list control group (Figure 1).

Figure 1
Flow-chart of participation in the trial



The average age of participants was 69 years (standard deviation of 6.5 years and a maximum of 96 years). Overall there were 591 (84 per cent) female participants in the study, and 34 per cent (213/628) of participants had experienced a fall in the past year. In both the intervention and the control group slightly less than half reported their health to be at least excellent or very good and were able to walk for at least an hour without stopping. About a third were adequately physically active.

The distribution of scores on the Falls Efficacy Scale questionnaire was highly positively skewed. Out of a possible range of scores between 10 and 100, where the higher the score the less the confidence in the ability to avoid a fall, scores in this trial ranged from 10 (total confidence in ability to avoid a fall) to 59 (moderate confidence in ability to avoid a fall), with 50 per cent of participants scoring a perfect 10 and a mean of 14, and 90 per cent of participants scoring between 10 and 20. Scores on the Instrumental Activities of Daily Living range from 0 (very high ability) to 8 (very low ability). For participants in this trial Instrumental Activities of Daily Living scores were highly negatively skewed, ranging from 3 to 8, with 90 per cent of participants scoring a perfect 8. There were no significant differences between groups on either of these scales.

Table 2 shows baseline characteristics according to group allocation. One variable was distributed unevenly across the groups: sway on compliant surface (worse in the intervention group).

Exercise adherence and dropout

A total of 18 participants dropped out of the trial and did not undertake the balance retests or complete any falls calendars. Those that dropped out of the intervention group (n=6) reported that they did not like some aspect of the tai chi class, while those that dropped out of the control group (n=12) did so either as a result of being placed in the waiting-list control group or due to ill-health. Trial dropouts, on average, reported having fallen more frequently in the past year (Table 2). Within the intervention group, approximately 50 per cent (173/322) of participants attended 13 out of 16 tai chi classes, with 75 per cent (243/322) attending at least half of the classes.

Falls data from the intervention and control groups

Ninety-five percent of participants (663/684) completed 164 days of falls data out of a required 180 days, indicating a good compliance rate for completion of falls data. A total of 155 participants fell (83 from the control group, 72 from the intervention group); however, there was a total of 217 falls (130 falls in the control group, and 87 in the intervention group) (Table 3). A cross-tabulation indicates that there were significantly less falls in the intervention group (χ^2_5 = 14.76, p=0.01). The data also indicates that there were significantly more multiple falls in the control group compared to the intervention group (RR=0.52, 95% CI: 0.23–0.96, χ^2_1=4.61, p=0.03).

Table 2
Baseline measures by groups and drop-outs

Variable	Mean (95% CI)			
	Intervention *n*=353	Control *n*=349	p	Discontinued *n*=18
Age	69 (68.7–70.1)	69 (68.5–69.9)	0.62	68
Gender (% female)	85.0% (80.8–88.5)	83.0% (79.1–87.2)	0.56	94%
Health Status SF-36 (% reporting excellent or very good health)	75.7% (70.2–80.7)	74.8% (69.2–79.9)	0.81	67%
Fallers in past year	30.1% (25.7–36.1)	37.0% (31.5–42.5)	0.10	33%
Fall requiring medical treatment	47.5% (37.3–57.8)	39.4% (30.2–49.3)	0.24	33%
Falls resulting in a fracture	18.4% (11.2–27.5)	16.8% (10.3–25.3)	0.77	33%
Adequate Physical Activity	31.0% (26.0–36.3)	25.0% (19.8–29.7)	0.07	14%
Walking ability (% able to walk > 1hr)	41.8% (36.4–47.4)	44.7% (39.1–50.4)	0.46	43%
Instrumental Activities of Daily Living (% scoring 16/16)	67.4% (62.3–72.3)	66.8% (61.6–71.7)	0.85	39%
Average score Falls Efficacy Scale[a] : Median (IQR)	11 (5)	10 (3)	0.12	10
Sway on floor (mm)*	72 (67.4–75.9)	67 (64.1–71.5)	0.15	79
Sway on mat (mm)*	187 (177.7–195.8)	172 (164.2–180.9)	0.02	180
Lateral stability (mm)*	19 (17.2–19.9)	17 (15.9–18.5)	0.15	41
Leaning balance (mm)	154 (138.8–151.0)	159 (144.1–157.2)	0.20	178
Coordinated stability[a] Median (IQR)	12 (14)	11 (14)	0.39	13
Choice reaction time (ms)	1098 (1116.7–1079.3)	1106 (1084.6–1127.6)	0.58	1214
Unipedal stance (1 min %)	20.2% (16.1–24.9)	19.5% (15.4–24.1)	0.80	36%
Quad strength (kg)	22 (21.4–23.6)	22 921.1–23.4)	0.77	18
Ankle flexibility (^{o}) - Left - Right	32 (31.6–33.0) 33 (31.9–33.3)	32 (31.0–32.3) 33 (31.9–33.2)	0.22 0.85	30 31

Notes:
a : analysed using a Mann-Whitney 2-sample test
* : denotes geometric means used
Source: The Central Sydney Tai Chi Trial.

Table 3
Frequency of falls during the 6-month trial period by group

Participants	Falls						Total	
	0	1	2	3	4	5	Persons falling	Falls
Falls								
Intervention	275	57	15	0	0	0	72	87
Control	254	55	14	11	1	2	83	130
Total	529	112	29	11	1	2	155	217

Source: The Central Sydney Tai Chi Trial.

During the study period 529 participants did not fall, 113 fell once, and 43 participants fell twice or more. Unadjusted negative binomial regression analysis showed a statistically significant 35 per cent reduction in the incidence rate of falls in the intervention group compared to the control group (incidence rate ratio or IRR=0.65, 95% CI: 0.47–0.89, p=0.008) (Table 4). The IRR was virtually unchanged after adjusting for multiple falls risk factors (IRR=0.64, 95% CI: 0.46–0.89, p=0.012).

The unadjusted hazard rate for 2 or more falls in the intervention versus the control group was 0.52 (95% CI: 0.28–0.97, p=0.035). The adjusted hazard rate was 0.40 (95% CI: 0.19–0.87, p=0.036) (Table 5), indicating a 60 per cent reduction in the hazard or risk of multiple falls in the intervention group compared to the control group after adjusting for falls history and sway on the compliant surface at baseline.

Table 4
Falls in the 6 month trial period

Falls	**Intervention** (n=347)	**Control** (n=337)	**Risk** (95% CI)
N (rate/100 000 population)	87 (149.1)	130 (233.4)	0.64# (0.47–0.89)
One or more	72 (20.7%)	83 (24.6%)	0.84~ (0.64–1.11)
Two or more	15 (4.3%)	28 (8.3%)	0.52~ (0.23–0.96)

Notes: # incident rate ratios calculated for comparing the rate of falls between groups;
~ relative risks calculated for comparing number of intervention and control subjects who experienced falls.

Source: The Central Sydney Tai Chi Trial.

Table 5
Univariate and multivariate analyses of falls data

Variable	**Unadjusted IRR** (95% CI)	p	**Adjusted IRR** (95% CI)	P
Number of falls	0.65 (0.47–0.89)	0.008	0.64* (0.46–0.89)	0.012
	Unadjusted HR (95% CI)	p	**Adjusted HR** (95% CI)	P
0,1 versus multiple falls	0.52 (0.28–0.97)	0.035	0.40* (0.19–0.87)	0.036

Notes: * adjusted for age, gender, previous 12 months falls history and baseline sway on mat.

Source: The Central Sydney Tai Chi Trial.

Balance, fear of falling and daily activities outcome measures

Statistics for the follow-up–baseline differences in balance, fear of falling and daily activities variables, are summarised in Table 6. After adjusting for age and gender, regression analysis indicated that 4 of the 6 variables showed statistically significant improvement in the intervention group compared to the control group (sway on floor p=0.04; sway on foam mat p=0.001; lateral stability p=0.04; coordinated stability p=0.005).

Table 6
Summary of analysis of change in intermediate outcome measures (follow up–baseline) across groups

	Baseline		Follow up		
	Intervention (*n*=271)	Control (*n*=256)	Intervention (*n*=271)	Control (*n*=256)	p[3]
Sway: Mean mm (SD)[1] Floor, eyes open Foam, eyes open	 70 (47) 189 (105)	 66 (38) 168 (89)	 70 (40) 168 (82)	 72 (41) 174 (94)	 0.03 0.005
Lateral stability: mm (SD)[1]	19 (25)	17 (19)	17 (13)	17 (19)	0.008
Leaning balance: mm (SD)[1]	157 (48)	161 (49)	167 (45)	165 (43)	0.6
Coordinated stability score: median errors (IQR)[2]	12 (14)	11 (14)	9 (13)	11 (14)	0.004
Reaction time: mean ms (SD)[1]	1094 (207)	1100 (239)	1081 (172)	1100 (235)	0.03
Unipedal stance (s): median errors (IQR)[2]	22 (43)	16(37)	22 (41)	21 (46)	0.4
Strength: mean kg force (SD)[1] Dominant Quadriceps	23 (10)	23 (11)	23 (10)	23 (10)	0.2
Ankle flexibility (^{0}) (SD)[1] Left	 32 (6)	 32 (6)	 32 (6)	 31 (7)	 0.4
Right	33 (7)	33 (6)	32 (6)	32 (6)	0.09
FES: median errors (IQR)[2]	10(4)	10 (3)	10 (2)	10 (3)	0.09
IADL: median errors (IQR)[2]	16 (1)	16 (1)	16 (0)	16 (0)	0.5

Notes:
1. Analysed using multiple linear regression on change_in_scores (follow-up – baseline) by forced entry adjusting for age and gender.
2. Change_in_scores (follow-up – baseline) values analysed using the Mann Whitney U test for non-normal data.
3. p-values based on corresponding analysis (see notes 1 and 2).
4. High scores on the sway, lateral stability, coordinated stability and choice reaction time tests, and low scores in the leaning balance and quadriceps strength tests indicate impaired performance.

Source: The Central Sydney Tai Chi Trial.

Motivating factors for commencing tai chi

At baseline, all participants were asked the question 'Why did you decide to take these classes?' Of the 702 eligible participants, 634 answered this question. Participants' reasons for commencing tai chi were categorised into 3 broad themes: absence of barriers, influences, and quality of life (Table 7).

Table 7
Reasons for commencing tai chi

Absence of barriers	Influences	Quality of life
• affordability • timing • location of classes	• health professional • family member • friend • older person who still does tai chi	• general health • fitness • overall wellbeing • relief from back pain • flexibility • independent living

Source: The Central Sydney Tai Chi Trial.

Perceived benefits of tai chi

At follow-up, 261 participants in the intervention group were asked an additional question 'Did you benefit from doing the tai chi?' If participants responded that they had, they were then asked to elaborate. Participants' perceived benefits from tai chi were categorised into 4 broad themes. Tai chi was believed to have psychological, physical and social benefits as well as benefits to a general sense of wellbeing (Table 8).

Table 8
Perceived benefits of tai chi

Psychological benefits	Physical benefits	Social benefits	Wellbeing
• helping manage depression • relieving anxiety • becoming more relaxed	• relieving arthritic pain • controlling blood pressure • more flexible • more mobile	• positive social environment • meeting new people	• improved breathing • more restful sleep • healthier lifestyle

Source: The Central Sydney Tai Chi Trial.

Motivating factors for continuing tai chi

In July 2003 a mailout questionnaire was sent to 344 participants who completed the trial within the previous 12 months. Of these, 273 (79 per cent) responded to the questionnaire. Participants continuing with the tai chi classes beyond the intervention period of 4 months (108 participants, 39.6 per cent) constituted 2 groups: a group continuing with tai chi for a year or more (43, 39.8 per cent of those continuing beyond the trial), and a group continuing for less than a year. When asked 'Why did you continue [tai chi classes]', the 2 groups did not differ in the answers given. Participants identified 2 main reasons for continuing classes': enjoyment and health benefits (Table 9).

Table 9
Reasons for continuing tai chi after the trial

Enjoyment	Health benefits
• Social interaction • Tai chi movements • engaging tai chi instructors • making new friends	• helped with my thyroid condition • helped with osteoarthritis medication • increased sense of wellbeing • having more energy for daily activities' • increased mobility • increased strength • feeling more relaxed

Source: The Central Sydney Tai Chi Trial.

For those people continuing with the tai chi classes but for less than one year, the reasons given for discontinuing tai chi were due to circumstances beyond their control. Generally, the reasons participants could not continue with tai chi could be categorised into 4 broad themes: class availability, transport, health problems or other commitments.

DISCUSSION

This trial showed that a 16 week tai chi program of one hour per week was successful in reducing falls in people aged 60 years and over living independently in the community. In particular, the program was most effective in reducing the rate of multiple falls. The results also indicate that tai chi had modest effects on improving balance.

In previous studies, participants attended classes more frequently and received a standardised program delivered by a single instructor. The current trial required participants to attend one class per week and used a variety of instructors teaching a variety of styles. Yet, our findings are comparable to the 2 tai chi studies showing an effect on falls in community-dwelling people.[19,42] Our once-a-week trial was most effective in reducing the overall number of falls rather than the number of people who fell.

Unlike other studies that have reported inconsistent effects of tai chi on balance,[5] we found significant improvements in 4 of the 5 standing balance measures in the intervention group, with no significant changes evident in the control group. This indicates that the program was of sufficient duration and the exercise stimulus was sufficiently intensive to result in improved balance control. In contrast, tai chi had no beneficial effects on choice stepping reaction time. Thus, the intervention effects were 'task-specific' in that greater effects were seen for abilities targeted by the slow and controlled set of balance transfers that comprise tai chi.

A limitation of studies about accidental falls lies in the self-reporting of falls. Whatever measures are taken to clarify what is meant by a fall it is inevitable that some events will be misreported as a fall and other events that are falls will be missed. However, the more serious falls, such as those leading to injury, are more likely to be recorded,[43] so that self-reported falls data could be potentially skewed towards containing a higher proportion of falls leading to injury. This trial did not record fall-related injuries.

Lessons learnt

There are many older people in the community ready to participate in tai chi classes, and perhaps in other forms of physical activity as well, but are restricted by the number of appropriate classes available. Appropriate classes are classes that are held during the day, preferably before noon, are easily accessible by public transport, and are affordable.

Trying to meet demand for classes relevant to older people can be difficult due to lack of qualified instructors and appropriate venues in which to hold classes. Creating new classes where existing classes are unsustainable is counter-productive.

In the Central Sydney Area Health Service the trial was not resource intensive as tai chi was already being offered to a limited degree. The trial research, however, was incredibly resource intensive. The 3-year trial required 2 full-time positions dedicated solely to implementing and managing the research. Unfortunately, for the current trial the grant only allowed for one such position. This effectively reduced the Central Sydney Health Promotion Unit by one full-time equivalent for the duration of the trial, and as this was one of 2 research and evaluation positions it severely reduced the capacity of the unit to conduct other research activities.

Despite these limitations, the trial greatly increased the research capacity of the unit. The unit now has practical experience in conducting experimental studies, more experience in managing medium sized datasets, greater proficiency in using the NSW Department of Health's Health Outcomes Information Statistical Toolkit (HOIST) database, and greater experience in managing research assistants. In addition, the biostatistical skills of the unit, particularly applied in a health promotion context, have increased considerably. In general, the trial has helped illustrate the value of evidence-based health promotion practice and, more importantly, the evaluability of health promotion practice.

CONCLUSION

The Central Sydney Tai Chi Trial showed that even with a modest investment of one class per week the risk of older people falling multiple times can be significantly reduced after only 16 weeks. Focusing on older people who have previously had a fall, or those with poorer balance, is likely to maximise the effect of tai chi on reducing the risk of falls.

The results from this study have important implications for public health strategies aimed at reducing falls in older people. Tai chi, promoted at a population level, can potentially have a significant impact on preventing falls in older people. The results suggest that a relatively modest investment, such as one tai chi class per week, may reduce the number of overall falls, if not the number of people who fall, and that strategies targeting improving standing and leaning balance may comprise effective strategies for falls prevention.

Our findings indicate that participation in weekly tai chi classes prevents people falling multiple times and improves balance in community dwelling older people. As the trial used existing community facilities it provides a model for an effective and sustainable public health intervention.

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APPENDICES

1: Ethics approval

Telephone: (02) 9515 6766
Facsimile: (02) 9515 7176

Reference: X00-0254

CENTRAL SYDNEY AREA HEALTH SERVICE

29 June 2001

Mr A Voukelatos
CSAHS Health Promotion Unit
Level 4, Building 42
Royal Prince Alfred Hospital

Dear Ms Voukelatos,

Re: **Protocol No X00-0254 - "Tai Chi and falls prevention in older people: an investigation into the effectiveness of Tai Chi as a falls prevention strategy"**

The Executive of the Ethics Review Committee (RPAH Zone), at its meeting on 28 June 2001, considered your correspondence of 25 April 2001, and gave its approval for the study to proceed.

Yours sincerely,

pp Lesley Townsend
Secretary
Ethics Review Committee (RPAH Zone)

HERC\EXCOR01-07 (p34)

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- Concord Repatriation General Hospital
- Canterbury Hospital
- United Dental Hospital
- Balmain Hospital
- Division of Population Health
- Rozelle Hospital
- NSW Institute of Forensic Medicine

2: Information, consent and clearance forms

Participant information

You are invited to take part in a research study that will investigate the effectiveness of tai chi on falls prevention in older people. The study is being funded by the NSW Department of Health and is conducted by Alex Voukelatos, Chief Investigator; Andrew Metcalfe, Project Officer; Chris Rissell, Director Health Promotion Unit, Central Sydney Area Health Service; and Robert Cumming, Associate Professor, Department of Public Health and Community Medicine, University of Sydney.

If you agree to participate in this study, you will be randomly allocated to a tai chi class or a waiting list: that is, you will have a 50–50 chance of either starting tai chi classes immediately or in 6 months time. The classes will be held for one hour per week for 16 weeks and you will be encouraged to practise the exercises at home for at least 10–15 minutes every day.

You will also be asked to undergo some simple assessments on 2 occasions: now, and in 4 months time. The assessments will look at your balance, quadricep strength, flexibility and reaction time. The tests are straightforward and have been readily accepted by other older people. Altogether there will be 8 brief tests. The strength test will simply examine the strength in your thigh muscles by asking you to extend your leg while seated. The test looking at reaction time involves stepping on lighted panels as quickly as possible, while the flexibility test will look at your ankle flexibility by getting you to bend your ankle as far as possible. The balance testing will involve several very simple tests. Three of these tests will require you to stand as still as possible for 30 seconds. Another balance tests will require you to trace a pattern with a pen tied to your waist, while in a final balance test you will be required to lean forward and backward as far and as safely as possible. All tests are very safe and fun and will be supervised. You will also be interviewed for approximately 20 minutes. Questions asked will assess your physical activity levels and your risk of falling.

At the end of the session you will be given falls calendar. We will ask you to record on this calendar, daily, whether you have had a fall or not. At the end of each month you will be asked to post the calendar to the researchers. Each calendar has pre-paid postage, so it will not cost you anything to post it, just place it in a post-box. By returning the appropriate calendar each month, you will automatically enter a draw for a A$50 shopping voucher.

If you have experienced a fall during this time you will be contacted via telephone and asked what health services (for example, general practitioner, hospital admissions, etcetera) you have used *after* the fall has occurred. This is an additional part of the research lead by Marian Shanahan, Christine Pollicino, and Rosalie Viney from the Centre for Health Economics Research and Evaluation (CHERE). You can decline to participate in this research. Declining to take part in this research will not affect your involvement in the larger study

If you agree to participate in this part of the study you will be free to withdraw at any time. You will be asked to complete a diary of health services use. The diary will ask you to record your use of health services each month. These diaries will take approximately 10 minutes to complete. The research nurse may telephone you to remind you to complete them. At the end of each month you will be asked to post the diary back to the researchers. We have provided addressed envelopes with postage pre-paid so that you will not have to pay anything. If you have a fall that requires hospitalisation the researchers may need to obtain some information about your hospital stay from hospital medical records. We will seek your permission before accessing your hospital records.

All aspects of the study, including results, will be strictly confidential and only the investigators named above will have access to information on participants. A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report.

Participation in this study is entirely voluntary. You are in no way obliged to participate and, if you do participate, you can withdraw at any time.

When you have read this information, Alex Voukelatos or an associate will discuss it with you further and answer any questions you may have. If you would like to know more at any stage, please feel free to contact Alex on (02) 9515 3358. This information sheet is for you to keep.

This study has been approved by the Ethics Review Committee of the Central Sydney Area Health Service. Any person with concerns or complaints about the conduct of a research study can contact the Secretary on 9515 6766.

Participant consent

I, …… *[name]* of

…….. *[address]* have read and understood the Information for Participants on the above named research study and have discussed the study with the Alex Voukelatos (chief investigator) or one of his associates.

I have been made aware of the procedures involved in the study, including any known or expected inconvenience, risk, discomfort or potential side effect and of their implications as far as they are currently known by the researchers.

I freely choose to participate in this study and understand that I can withdraw at any time.

I also understand that the research study is strictly confidential.

I hereby agree to participate in this research study.

NAME:

SIGNATURE:

DATE:

NAME OF WITNESS:

SIGNATURE OF WITNESS:

Medical clearance

The information that is written on this form is confidential. It will help the tai chi instructor plan the class and be alert to possible medical problems. By signing this form you are agreeing that participation in this class is entirely your own responsibility.

Do you have a history of any of the following medical conditions? *(Please circle Yes or No)*		Are you taking any medications for any of these conditions? *(Please specify)*
Asthma	Yes–No	
Diabetes	Yes–No	
Epilepsy	Yes–No	
Arthritis–Rheumatism	Yes–No	
Anxiety or Depression	Yes–No	
High blood pressure	Yes–No	
Low blood pressure	Yes–No	
Heart problems	Yes–No	
Hip replacements	Yes–No	
Back pain	Yes–No	
Other		

Do you wear a medical alert bracelet? *(Please circle)* Yes–No

Medical Alert No.

Medical Alert Information

In my opinion, there is no medical reason why I should not take part in a tai chi for preventing falls program. I understand that all safety precautions will be observed but I agree to accept responsibility for injuries that may be sustained while taking part in this course.

Name Date

Signature

3: Baseline, follow-up and mail-out questionnaires

Baseline questionnaire

Interviewer: Date: Time: Testing centre:

Thank you for agreeing to be part of this research. I will ask you a few questions. Then my colleagues will take you few a few simple tests looking at your balance, strength and flexibility. All of this information is strictly confidential. There is no way anyone will know any of your results because we are not recording your name on the results. If you would like something explained to you at any point please ask. Remember there are no right or wrong answers. Do you have any questions at this point?

1. ID No. _____

2. Gender

$_1$Male $_2$Female

First I'd like to ask you some background information.

3. Age

4. a) Main language spoken at home **b) What country were you born in?**

5. What is your highest level of education? (Please circle)

$_1$ No formal education
$_2$ Primary
$_3$ Intermediate–Leaving
$_4$ Secondary–High school
$_4$ TAFE–Apprenticeship–College
$_6$ Undergraduate
$_7$ Postgraduate

6. How did you get here today? (Please circle)

$_1$ Walk
$_2$ Bus
$_3$ Car
$_4$ Taxi
$_5$ Other

7. Why did you decide to take these classes?

8. What do you think of tai chi? (Prompt: How easy or difficult does it look? Does it look like fun or hard work?)

Now I will ask you about physical activity.

9. On an average day, how long can you walk for before you need a rest? (If participant answers 1/2 hour seek to clarify and failing more specific response, mark as 15–29 minutes NOT 30 minutes to almost an hour)

1 Less than 5 minutes
2 5–9 minutes
3 10–14 minutes
4 15 to 29 minutes
5 30 minutes to almost 1 hour
6 1 hour to almost 2 hours
7 2 hours or more

10. How often do you go on planned walks for exercise? (That is, walking in the park, along the beach, in the streets, walking the dog, etcetera) (Please circle)

1 Every day
2 Three or more times a week
3 Twice a week
4 Once a week
5 Once a month
6 Once or twice a year
7 Never

11. In these planned walks how long do you walk for? (If participant answers 1/2 hour seek to clarify and failing more specific response, mark as 15–29 minutes NOT 30 minutes to almost an hour)

1 Less than 15 minutes
2 15–29 minutes
3 30 minutes to just under 1 hour
4 More than 1 hour

12. How much time do you spend in the following activities in an average week? Consider only the time you were engaged in planned physical exercise in which you planned yourself or organised with others. (Walking only included if planned)

a. Do you do any of the following activities? How often do you participate in this activity per week?

	None	1	2	3	4+
Bowls	[ ]	[ ]	[ ]	[ ]	[ ]
Golf	[ ]	[ ]	[ ]	[ ]	[ ]
Tennis	[ ]	[ ]	[ ]	[ ]	[ ]
Swimming	[ ]	[ ]	[ ]	[ ]	[ ]
Dancing	[ ]	[ ]	[ ]	[ ]	[ ]
Jogging	[ ]	[ ]	[ ]	[ ]	[ ]
Bicycling	[ ]	[ ]	[ ]	[ ]	[ ]
Aerobics	[ ]	[ ]	[ ]	[ ]	[ ]
Ball games	[ ]	[ ]	[ ]	[ ]	[ ]
Other (specify)	[ ]	[ ]	[ ]	[ ]	[ ]

b. How long do you spend on [the activity] (in minutes) each time you do it?

	Less than 30	30–45	45+
Bowls	[ ]	[ ]	[ ]
Golf	[ ]	[ ]	[ ]
Tennis	[ ]	[ ]	[ ]
Swimming	[ ]	[ ]	[ ]
Dancing	[ ]	[ ]	[ ]
Jogging	[ ]	[ ]	[ ]
Bicycling	[ ]	[ ]	[ ]
Aerobics	[ ]	[ ]	[ ]
Ball games	[ ]	[ ]	[ ]
Other (specify)	[ ]	[ ]	[ ]

13. In addition to the exercise you mentioned above, how much time do you spend each day doing other physical activity such as climbing stairs, walking or gardening? (If participant answers 1/2 hour seek to clarify and failing more specific response, mark as 15–29 minutes NOT 30 minutes to almost an hour)

1 Less than 15 mins/day
2 15–29 mins a day
3 30–59 mins a day
4 1 to just under 2 hours a day
5 more than 2 hours/day

I will now ask you about any falls you may have experienced and any resulting injuries.

14. Did you have a fall in the previous 12 months? (For this questionnaire a fall is defined as: 'Unintentionally coming to rest on ground, floor, or other lower level; excludes coming to rest against furniture, wall, or other structure') (Please circle)

1 No, I have not fallen
2 Yes, I have fallen

a. If yes, were any of these falls in the past 6 months?

1 Yes / 2 No / 3 N/A

b. How many times did you fall in the past 6 months? (Specify)

c. Did you visit a doctor as a result of any of these falls?

1 Yes / 2 No / 3 N/A

d. Did you suffer a fracture or broken bone as a result of these falls?

1 Yes / 2 No / 3 N/A

e. If yes, which bone(s) did you break? (Specify)

15. In general, would you say your health is: (please circle)

Excellent 1 Very good 2 Good 3 Fair 4 Poor 5

16. Do you think your risk of falling is: (Please circle)

1 Low 2 Moderate 3 High

Now I will ask you about your ability to perform certain activities.

Please tell me which of the following statements is most true about you (Please circle) (Note: Do not ask men Q.19–21)

17. Ability to use telephone

1 You operate the telephone on your own initiative: for example, look up and dial a number
2 You dial a few well-known numbers
3 You answer the phone but not dial
4 You do not use the phone at all

18. Shopping

1 You take care of all shopping needs independently
2 You shop independently for small purchases
3 You need to be accompanied on any shopping trip
4 You are completely unable to shop

19. Food preparation (Do not ask men this question)

1 You plan, prepare, serve adequate meals independently
2 You prepare adequate meals if supplied with ingredients
3 You heat and serve prepared meals, or prepare meals but does not maintain adequate diet
4 You need to have meals prepared and served

20. Housekeeping (Do not ask men this question)

1 You maintain house alone or with occasional assistance
2 You perform light daily tasks: for example, dishwashing, bedmaking
3 You perform light daily tasks but cannot maintain acceptable standards of cleanliness
4 You need help with all home maintenance tasks
5 You do not participate in any housekeeping tasks

21. Laundry (Do not ask men this question)

1 You do personal laundry completely
2 You launder small items: rinse socks, stockings, etcetera
3 All your laundry must be done by others

22. Mode of transport

1 You travel independently on public transport or you drive your own car
2 You arrange your own travel via taxi but do not otherwise use public transport
3 You travel on public transportation when assisted or accompanied by another
4 Your travel is limited to a taxi or car with assistance of another
5 You do not travel at all

23. Responsibility for own medications

1 You're responsible for taking medication in correct dosage at correct time
2 You take responsibility if medication is prepared in advance in separate dosages
3 You are not capable of dispensing your own medication

24. Ability to handle finances

1 You manage financial matters independently (budgets, writing cheques, paying rent, bills, go to the bank), collects and keeps track of income
2 You manage day-to-day purchases, but need help with banking, major purchases, etcetera
3 You're incapable of handling money

25. How confident are you that you can … without falling?

	Very confident									Not confident at all
01 Take a bath or shower	1	2	3	4	5	6	7	8	9	10
02 Reach into cabinets or closets	1	2	3	4	5	6	7	8	9	10
03 Prepare meals not requiring carrying heavy objects	1	2	3	4	5	6	7	8	9	10
04 Walk around the house	1	2	3	4	5	6	7	8	9	10
05 Get in and out of bed	1	2	3	4	5	6	7	8	9	10
06 Answer the door or telephone	1	2	3	4	5	6	7	8	9	10
07 Get in and out of a chair	1	2	3	4	5	6	7	8	9	10
08 Get dressed and undressed	1	2	3	4	5	6	7	8	9	10
09 Light housekeeping	1	2	3	4	5	6	7	8	9	10
10 Get on and off the toilet	1	2	3	4	5	6	7	8	9	10

Thank you.

Follow-up questionnaire

Interviewer: Date: Time: Testing centre:

Once again, thank you for agreeing to be part of this research. I will ask you a few questions. Then my colleagues will take you few a few simple tests looking at your balance, strength and flexibility.
All of this information is strictly confidential. There is no way anyone will know any of your results because we are not recording your name on the results. If you would like something explained to you at any point please ask. Remember there are no right or wrong answers.
Do you have any questions at this point?

ID No. _____

6. How did you get here today? (Please circle)

1 Walk
2 Bus
3 Car
4 Taxi
5 Other

7. Why did you decide to take these classes?

8. What do you think of tai chi? (Prompt: How easy or difficult does it look? Does it look like fun or hard work?)

Now I will ask you about physical activity.

9. On an average day, how long can you walk for before you need a rest? (If participant answers 1/2 hour seek to clarify and failing more specific response, mark as 15–29 minutes NOT 30 minutes to almost an hour)

1 Less than 5 minutes
2 5–9 minutes
3 10–14 minutes
4 15 to 29 minutes
5 30 minutes to almost 1 hour
6 1 hour to almost 2 hours
7 2 hours or more

10. How often do you go on planned walks for exercise? (That is, walking in the park, along the beach, in the streets, walking the dog, etcetera) (Please circle)

1 Every day
2 Three or more times a week
3 Twice a week
4 Once a week
5 Once a month
6 Once or twice a year
7 Never

11. In these planned walks how long do you walk for? (If participant answers 1/2 hour seek to clarify and failing more specific response, mark as 15–29 minutes NOT 30 minutes to almost an hour)

1 Less than 15 minutes
2 15–29 minutes
3 30 minutes to just under 1 hour
4 More than 1 hour

12. How much time do you spend in the following activities in an average week? Consider only the time you were engaged in planned physical exercise in which you planned yourself or organised with others. (Walking only included if planned)

a. Do you do any of the following activities? How often do you participate in this activity per week?

	None	1	2	3	4+
Bowls	[ ]	[ ]	[ ]	[ ]	[ ]
Golf	[ ]	[ ]	[ ]	[ ]	[ ]
Tennis	[ ]	[ ]	[ ]	[ ]	[ ]
Swimming	[ ]	[ ]	[ ]	[ ]	[ ]
Dancing	[ ]	[ ]	[ ]	[ ]	[ ]
Jogging	[ ]	[ ]	[ ]	[ ]	[ ]
Bicycling	[ ]	[ ]	[ ]	[ ]	[ ]
Aerobics	[ ]	[ ]	[ ]	[ ]	[ ]
Ball games	[ ]	[ ]	[ ]	[ ]	[ ]
Other (specify)	[ ]	[ ]	[ ]	[ ]	[ ]

b. How long do you spend on [the activity] (in minutes) each time you do it?

	Less than 30	30–45	45+
Bowls	[ ]	[ ]	[ ]
Golf	[ ]	[ ]	[ ]
Tennis	[ ]	[ ]	[ ]
Swimming	[ ]	[ ]	[ ]
Dancing	[ ]	[ ]	[ ]
Jogging	[ ]	[ ]	[ ]
Bicycling	[ ]	[ ]	[ ]
Aerobics	[ ]	[ ]	[ ]
Ball games	[ ]	[ ]	[ ]
Other (specify)	[ ]	[ ]	[ ]

13. In addition to the exercise you mentioned above, how much time do you spend each day doing other physical activity such as climbing stairs, walking or gardening? (If participant answers 1/2 hour seek to clarify and failing more specific response, mark as 15–29 minutes NOT 30 minutes to almost an hour)

1 Less than 15 mins/day
2 15–29 mins a day
3 30–59 mins a day
4 1 to just under 2 hours a day
5 more than 2 hours/day

I will now ask you about any falls you may have experienced and any resulting injuries.

14. Did you have a fall in the previous 12 months? (For this questionnaire a fall is defined as: 'Unintentionally coming to rest on ground, floor, or other lower level; excludes coming to rest against furniture, wall, or other structure') (Please circle)

1 No, I have not fallen
2 Yes, I have fallen

a. If yes, were any of these falls in the past 6 months?

1 Yes / 2 No / 3 N/A

b. How many times did you fall in the past 6 months? (Specify)

c. Did you visit a doctor as a result of any of these falls?

1 Yes / 2 No / 3 N/A

d. Did you suffer a fracture or broken bone as a result of these falls?

1 Yes / 2 No / 3 N/A

e. If yes, which bone(s) did you break? (Specify)

15. In general, would you say your health is: (Please circle)

Excellent 1 Very good 2 Good 3 Fair 4 Poor 5

16. Do you think your risk of falling is: (Please circle)

1 Low 2 Moderate 3 High

Now I will ask you about your ability to perform certain activities.

Please tell me which of the following statements is most true about you (Please circle) (Note: Do not ask men Q.19–21)

17. Ability to use telephone

1 You operate the telephone on your own initiative: for example, look up and dial a number
2 You dial a few well-known numbers
3 You answer the phone but not dial
4 You do not use the phone at all

18. Shopping

1 You take care of all shopping needs independently
2 You shop independently for small purchases
3 You need to be accompanied on any shopping trip
4 You are completely unable to shop

19. Food preparation (Do not ask men this question)

1 You plan, prepare, serve adequate meals independently
2 You prepare adequate meals if supplied with ingredients
3 You heat and serve prepared meals, or prepare meals but does not maintain adequate diet
4 You need to have meals prepared and served

20. Housekeeping (Do not ask men this question)

1 You maintain house alone or with occasional assistance
2 You perform light daily tasks: for example, dishwashing, bedmaking
3 You perform light daily tasks but cannot maintain acceptable standards of cleanliness
4 You need help with all home maintenance tasks
5 You do not participate in any housekeeping tasks

21. Laundry (Do not ask men this question)

1 You do personal laundry completely
2 You launder small items: rinse socks, stockings, etcetera
3 All your laundry must be done by others

22. Mode of transport

1 You travel independently on public transport or you drive your own car
2 You arrange your own travel via taxi but do not otherwise use public transport
3 You travel on public transportation when assisted or accompanied by another
4 Your travel is limited to a taxi or car with assistance of another
5 You do not travel at all

23. Responsibility for own medications

1 You’re responsible for taking medication in correct dosage at correct time
2 You take responsibility if medication is prepared in advance in separate dosages
3 You are not capable of dispensing your own medication

24. Ability to handle finances

1 You manage financial matters independently (budgets, writing cheques, paying rent, bills, go to the bank), collects and keeps track of income
2 You manage day-to-day purchases, but need help with banking, major purchases, etcetera
3 You're incapable of handling money

25. How confident are you that you can … without falling?

	Very confident									Not confident at all
01 Take a bath or shower	1	2	3	4	5	6	7	8	9	10
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04 Walk around the house	1	2	3	4	5	6	7	8	9	10
05 Get in and out of bed	1	2	3	4	5	6	7	8	9	10
06 Answer the door or telephone	1	2	3	4	5	6	7	8	9	10
07 Get in and out of a chair	1	2	3	4	5	6	7	8	9	10
08 Get dressed and undressed	1	2	3	4	5	6	7	8	9	10
09 Light housekeeping	1	2	3	4	5	6	7	8	9	10
10 Get on and off the toilet	1	2	3	4	5	6	7	8	9	10

Questions 26–27 to be asked only to intervention class people.

26a. Tell me a little about what you thought about the classes? (Prompt: Did you like them? Was it fun?)

26b. Did you attend all the classes? If not, why?

26c. Did the tai chi classes meet your expectations?

Yes–No

26d. Can you tell me why this was the case? (Prompt: how did they meet your expectations? Why didn't the classes meet your expectations?)

26e. Will you be continuing tai chi classes? (Either here or elsewhere?)

Yes–No

27a. What do you think of tai chi? (Prompt: How easy or difficult does it look? Does it look like fun or hard work?)

27b. Did you benefit from doing the classes? (Prompt: In what way?)

Thank you.

Mail-out questionnaire

Dear tai chi participant

Thank you very much for all your support over the past 2 years. The Central Sydney Tai Chi Trial is coming to an end within the next 6 months, and I am happy to say it has been a very successful endeavour. We have had close to 800 people come through our introductory tai chi program, most of whom contributed invaluable data for our research. Now I ask for a little more information to help us with our research. I ask you to be very honest in your responses: the more genuine your feedback, the better we can plan future health program. Once you complete the questions on the reverse side of this page, please place it into the pre-paid self-addressed envelope provided and send it back to us by 1st August 2003.

Questions

1. **Did you continue tai chi after your introductory 16 week program?**
   (Either with your original instructor or elsewhere) (Please circle)

   Yes–No

2. **If yes, for how long?** (Specify)

3. **What motivated or inspired you to continue?** (Specify)

4. **If you didn't continue, why was that the case?** (Specify)

Appendix 4: Falls calendar

PROJECT CALENDAR INSTRUCTIONS

Tai Chi

CSAHS
Central Sydney Area Health Service

1. At the end of each day, write:
   N in the box if you **did not fall** or
   F if you **did fall**.
   For example:

JAN 2003

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
			1	2	3	4
5	N	N	N	F	N	N

2. On the **last day of each month** detach the calendar for that month and drop it in the mailbox, **no postage is necessary**.

Thank you, your help is appreciated.

0401

FEB 2003

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	MAIL CARD PLEASE

Any questions, call: Health Promotion at CSAHS on
02 9515 3194 (Mon-Fri 9-5)

Appendix 5: Principles for tai chi instructors involved in the trial

Risk factors for falls

BALANCE

Balance has been shown to decrease with age.
Relaxation → relaxes muscles → lowers centre of gravity
Lowered centre of gravity → increases load on lower limbs → over time increases sensation and awareness of lower limb movement.

Transfer of weight

Shifting body weight from leg to leg through incremental movements.
Start with a small range of movement and gradually build up to a wide, square base stance.

MUSCLE STRENGTH

Muscle bulk and therefore strength decrease with age.
A bent knee stance and movement works to strengthen lower limb muscle (particularly the quadricep muscles).

Reaction time

Many older people fall because they do not have sufficient muscle strength or neurological reaction to compensate for loss of balance in time to prevent a fall. Balance and strength are important elements in reaction time. By addressing issues of balance and strength training in tai chi also addresses the issue of reaction time.

INSTABILITY

This involves issues such as increased body sway, low mobility, and postural instability. Increasing age is also associated with reduced sensation in lower limbs and is consequently associated with a loss of righting reflexes and an increase in body sway which can lead to falls.

Gait

Decreased stepping height and decreased stride length.
Women tend to have a narrow walking and standing base, closer foot placement, erect posture → difficult re: stepping down from stools and benches.
Men small-stepped gait wider walking and standing base, stooped posture.
Tai Chi addresses gait problems by teaching 'correct' movement of lower limbs. This is done by lifting lower limbs from the knee rather than the foot, lifting lower limbs without misaligning the pelvis, teaching to place heel down first when moving forward (toes first when moving back). Also, teaching movement with appropriate weight transfer, posture and slightly bent knees improves stride length.

Posture

Tai chi also teaches participants to maintain a relaxed posture with an elongated spine.

Coordination and mobility

Tai chi consists of a moving from one stance to another in a slow, coordinated and smooth way. This trains students in improved mobility and increased body awareness.

PSYCHOSOCIAL FACTORS

Fear of falling

Tai chi reduces fear of falling by building peoples confidence in mobility, and by strengthening their lower limbs and improving balance.
Other factors in tai chi increase confidence. Maintaining a relaxed and upright posture, maintaining eye contact straight ahead rather than looking at the ground all increase confidence.

Depression

Physical activity in general has been shown to help alleviate depression. In addition tai chi offers relaxation techniques, deep breathing exercises and a meditative physical activity

Social isolation

The nature of the tai chi classes promotes interaction with the tai chi instructor. But in addition tai chi instructors can encourage other people to interact with each other as well.

Appendix 6: Physiological tests: Balance, leg strength and ankle flexibility

Test procedures

All the following tests need to be done without shoes.
If subject chooses to wear socks or stockings during testing please be aware of risk of slipping.

NB: For all of the tests, subject must refrain from talking, moving, or laughing during the testing period. If they do not, restart the test.

Test 1: Sway test: solid surface
Make sure adjustable table is at a height that allows the sway meter to be at just at or below the horizontal.
Attach sway-meter securely to the subject at waist level so that the pen extends onto the table.
Subject to face away from table, and look straight ahead at eye-level. Subject walks on the spot for 5 seconds or so then stands with feet placed at hip width.
Explain to subject that they are to stand as still as possible for at least 30 seconds, but if they start to lose their balance it is okay to take a step if needed. Let them know that in any case you will be there to make sure that they do not fall while doing the test.
After asking subject to 'start' wait a second or two while subject settles. Gently place the pen onto the graph paper in the appropriate condition, gently (as you would place an old phonograph needle on a vinyl record). Wait for 30 seconds then lift the pen off. Wait till the pen is completely off the graph paper before you tell them they can stop.

Measure: (Diagram A5-1)
- Maximal front-back and side-to-side movement of pen
- How many grid squares does the line go through
- End the test if the S takes a step and make a note of that

Test 2: Sway test: compliant surface (15 cm foam mat)
Follow exactly the same procedures as in Test 1, except subject stands on a 15 cm foam mat (Photograph A5-1).

Photograph A5-1: Demonstration of Sway mat on compliant surface: balance test

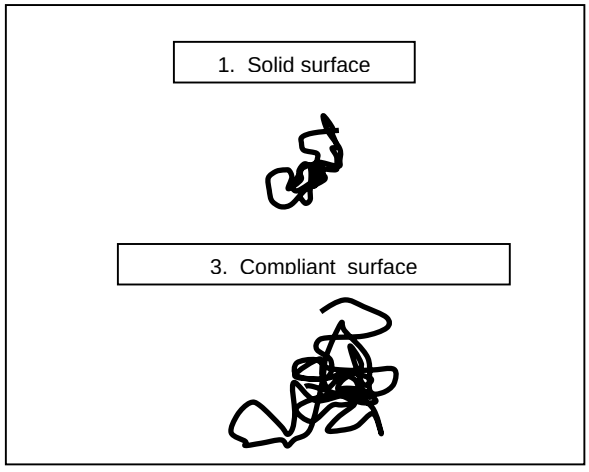


Diagram A5-1: An example of the type of data obtained from the sway tests.

Test 3: Lateral stability

Leave the table as in previous test. Move the sway meter so that it is now on the side of the subject. Subject is now side-on to the table. Subject to look straight ahead at eye-level.

Subject walk on the spot for 5 seconds or so then stand with feet placed about at hip width. Then ask subjects to place their favoured foot in front of the other (heel of front foot in line with toe of other foot). Once again subject needs to stand as still as possible, for at least 30 seconds, but if they start to lose their balance it is okay to take a step if needed. Let them know that in any case you will be there to make sure that they do not fall while doing the test.

After asking subjects to 'start' wait a second or two while subject settles. Gently place the pen onto the graph paper in the appropriate condition, gently (as you would place an old phonograph needle on a vinyl record). Wait for 30 seconds then lift the pen off. Wait till the pen is completely off the graph paper before you tell them they can stop. Subject can move their legs and feet between testing

Measure

- Maximal lateral movement
- End the test if the subject takes a step and make a note of that

Test 4: Leaning balance (Photgraph A5-2)

Leave the table as in previous test. Move the sway meter so that it is on the front of the subject. Subject to face the table. Subjects walk on the spot for 5 seconds or so then stand with feet placed at hip width.

Explain to subject that they are to lean forward from the ankles as far as possible without moving the feet and keeping a straight back (to the point where they can just retain balance). Subjects then come back to centre and similarly lean backwards.

NB: Be very wary of subject losing balance if they lean too far forward or backward. Be ready to steady the participants if this occurs and remind them they can take a step to steady themselves if needed. If subject lose their balance re-start the test.

Gently place the pen onto the graph paper in the middle of the cross, gently (as you would place an old phonograph needle on a vinyl record).

Now ask subject to lean forward taking their time. When they come back to the upright position the pen should be near the middle of the cross. Ask them to lean backwards as far as possible. Repeat this two other times, encouraging them to beat their previous record.

Measure: The score recorded was the maximal anterior-posterior distance moved. (Diagram A5-2).

Photograph A5-2: Demonstration of Leaning Balance test

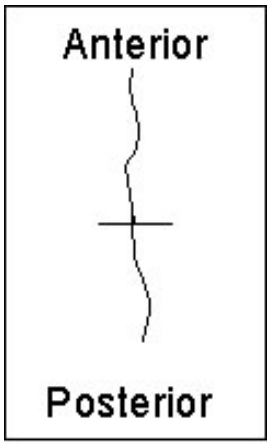


Diagram A5-2: An example of the type of data obtained from the Leaning Balance test

Test 5: Coordinated Stability Test (Diagram A5-3)

Leave the Subjects and other equipment as in previous test.

Place the pen in the start of the 'track' paper. Explain to Subjects that they are now to take their time in moving the pen around the track as indicated. They can bend their knees, lean forward, move their hip as required to make the pen move, but they are not to take a step.

Subjects can 'cut corners' if they need to, especially if they are having trouble. However, encourage them to try to keep within the track as much as possible. Allow Subjects to have a practise run through the track, discard this sheet. Now ask them to try again. Keep this sheet.

Measure: (Diagram A5-4)

If subject cuts corners they score 5 error points for each corner.

If the pen comes outside the track (that is, if you can see the white paper between the line of the pen and the line of the track) they score 1 error point.

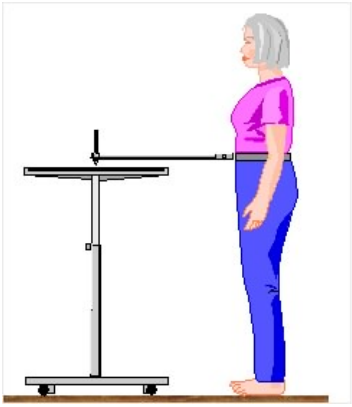


Diagram A5-3: Stance for coordinated stability test

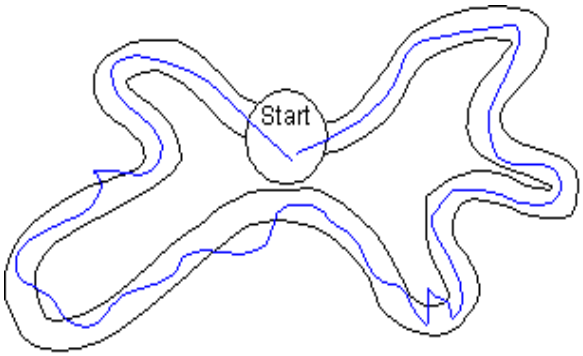


Diagram A5-4: Typical data obtained from the coordinated stability test

Test 6: Standing on one leg

Remove sway meter from subject. Move adjustable height table away from subject.

Subject to walk on the spot for 5 seconds or so to loosen up.

Explain they are to stand on their preferred leg for as long as possible (up to one minute).

Once again be aware of subject over-balancing. Be ready to steady them.

Measure

Time how long subjects can stand on one leg before placing foot on the ground or taking a step. Up to one minute maximum.

Test 7: Ankle flexibility

Protractor (Photograph A4-3) to be placed perpendicular against a wall or other support. Subject is asked to stand by one side of the protractor with the ankle joints aligned with the origin.

You may mark the head of the fibula on leg to be tested with pen or sticky circle. Subject bends the knee as far as they can towards the ground with the knee closest to the protractor until the point where the heel starts to lift (if can manage this far). Note the nearest angle this marks on the protractor.

Move subject to other side of protractor and repeat this procedure on the other leg.

Measure

Angle marked off by mark on the head of fibula.

Photograph A5-3: Protractor used for Ankle flexibility test.

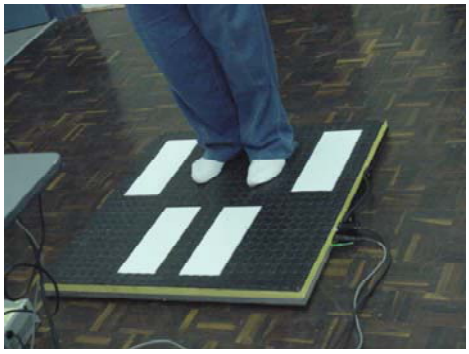
Test 8: Quadriceps strength (Photgraph A5-4)
Subject to be seated in the high chair, making sure lower back is sitting as far back into the chair as possible. Check to see that the subject's hip and knee are at a 90° angle
Subject to identify strongest or favoured side.
Arrange spring gauge behind favoured leg, hooked to the back of the chair's legs.
Place an ankle strap about 10 cm above subject's ankle. (Make sure that the soft material is placed around subject's ankle prior to strapping the ankle with the guage)
Ask subjects to straighten their leg as far as possible. They can use the chair's seat as a support.

Measure
Repeat this twice more, encouraging Subjects to beat their previous record. Record best attempt. in kilograms.

Photograph A5-4: Demonstration of the Quadriceps strength test

Test 9: Choice stepping reaction time (CRT)
(Photograph A5-5)
Subject stands on the CRT platform. Explain that subject is to step on the lighted panel as quickly as possible without losing their balance. Go through a practise turn, where panels are lighted sequentially.
Now go through the test and record times in the table provided. The panels will be lighted at random.

Measure
Time it takes for subject to step on lighted panel after panel was light.



Photograph A5-5: A demonstration of the choice stepping reaction time test**.**