STATIC and DYNAMIC ASSESSMENT and MINIMISATION of RISK FACTORS for FALLS in OLDER PEOPLE

Funded by Health and Community Services, Victoria

"Taking Injury Prevention Forward"

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The Alfred Healthcare Group of the Eastern Healthcare Network.
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Ms. K Connors, Physiotherapist, Extended Care Unit, CGMC;

Ms. J Stephens, Nurse Manager, Extended Care Unit, CGMC;

Staff at Extended Care units, Wards 11 and 12, CGMC;

Subjects and their families;

Ms G Powell and staff, Health Sciences Library, CGMC.

STAFFING

Dr. Andrew Nunn. Rehabilitation Consultant; Head of Amputee Unit & Clinical Director Rehab Tech,Monash University ,interested in the clinical application of Force Plate Technology.

Ms. Julie Graham. Research Physiotherapist. Employed by the H&CSV Grant, 2 days per week. This position has researched the various tests available for use in the elderly population, and presented them at meetings to assist with final decision making for the test protocol. The subjects are tested under the supervision of the therapist. This position is responsible for day to day functioning of the study and supervision of the following staff:

Dr Harold Flamer. Geriatrician Alfred Health Care Group,Monash University

Mr Nebojsa Tomasevic. Engineer,Research Assistant operating Bioware and Kistler Force Plate equipment, storing and recording information, and making calculations for subject comparison. Employed by the H&CSV grant.

Mr Shaun Feeley. Biophysics Student placed at Rehab Tech as the Maskiell Researsh fellow. Organised computer data base to store information collected in project. Assisted in supervision and recording of tests performed with subjects.

Mr Wynand van Schothorst, and Mr Rowald Franck, Mechanical (Biomedical) O/S Engineering students placed at Rehab Tech. These students will replace Shaun Feeley in February, and continue his duties, and are operating and assisting with video collection of some data.

Ms Sally Michael. Research Nurse employed to perform the Intervention program with subjects.
The research physiotherapist is also involved with the collation, analysis and report writing of the study.

REHAB TECH. This research project is conducted at this centre, part of the Centre for Biomedical Engineering at Monash University. The use of the mobility laboratory, Kistler Force Plate and additional computers were freely supplied.
Senior staff offered invaluable support to the Research Physiotherapist. The technical Research Officer has modified equipment for the project, and there was ongoing Administrative support.

Caulfield General Medical Centre.

Nursing staff and the Ward Physiotherapist assisted with the screening of subjects for the study.

INTRODUCTION

Falls in the elderly are a major public health and community problem with adverse physical, medical, psychological, social and economic sequelae. In Australia approximately 30% of the elderly in the community living at home have at least 1 fall and a significantly higher number in residential settings, especially nursing homes.

Age related changes and disease both have an impact on an older persons ability to balance.
Cognitive impairment, various medications, and changes in a persons environment all appear to contribute to increasing the risk of falling.

This study was undertaken to examine factors affecting balance and strength in the Nursing Home population, an at risk group that is traditionally difficult to study. It also sought to test if certain assessment tools were suitable for this population and verify the above.
There have been many tools developed to evaluate aspects of balance and function; various tools were put forward for use in this group and each was evaluated for suitability, practicality and reliability.

The population studied had a high incidence of dementia and tests needed to be reliable, simple and valid. All tests considered are discussed in this paper.
The literature (see bibliography in Appendix 9) revealed a variety of stability tests few relevant or tested with the frail elderly.

This pilot study was undertaken to develop and assess reliable tests appropriate for the frail aged, and to develop and evaluate various functional stability tests using the Kistler Force Plate.

DEVELOPMENT OF THE STUDY PROCEDURES

This initial phase was to research, setup, test and validate the protocol.
A literature search was performed to determine the type of tests that have thus far been used to study the frail aged.
A bibliography was prepared. The following instruments have been documented and were considered for use in this study:

Functional Reach. A measuring device is taped to the wall at shoulder height and the subject is asked to reach forward as far as possible in a plane parallel with the measuring device. He is instructed to reach forward as far as possible without taking a step. A test similar to Functional Reach is also used in the Berg Balance test. Studies show that a reach of less than 7 inches (17.5cm) is found in a population of frail aged who also demonstrate limited mobility skills, are slower ambulators, cannot stand on one foot for 1 second or longer, have most restricted activities of daily living. Functional reach correlates well with frailty rather than age. This measure will be examined in the Berg Balance test data.

Timed "Up and Go" test. The subject is observed while he rises from an armchair, walks 3 metres, and returns to the armchair. The score given is the time taken in seconds to complete the test. In the future this simple functional test can be given further consideration for use with the frail aged.

Self paced walk test. A timed walk over a central 10 metre of a longer path at the subjects choice of pace. Due to selection criteria for this study this test was omitted.

Pedometer measurements Over 24 hours patients in Nursing Homes appear to spend significant time sitting and some time walking about, either supervised or alone. We felt it would be extremely valuable to know exactly how far each subject walked in a 24 hour period and the relationship between that measure and leg muscle strength and functional balance.
Time was spent trialling commercially produced Pedometers, which use a built in pendulum to record each vertical movement of each step. It was found that these devices were totally unreliable in this group. This device was initially attached to the waistband of a garment that the subject was wearing. When that proved unreliable the pedometer was attached to the thigh then the knee and finally the the ankle but all positions were unsatisfactory. The pendular component was made as sensitive as possible but this proved ineffective.
On closer analysis of these subjects gait pattern we found that this group had very little vertical component to their gait cycle which was asymetric and inconsistent. A pendular based device would always prove to be an unsuitable measuring instrument for the frail aged.
Another way of measuring steps is to use a device in the shoe, triggered by a force sensitive resistor with adjustable sensitivity and a hysteresis circuit to minimise double counting. Despite this being useful in younger control patients even with this modified counter there are many problems. As a group and individually there is an enormous amount of variation in the gait pattern and loading.

Folstein Mini Mental State Examination. This is a cognitive assessment easily administered to this patient group to give an indication of the severity of dementia.

Muscle strength. Kin Com muscle testing machinery was evaluated for possible use in this age group. It was rejected because subjects would have difficulty positioning themselves on the equipment, had variable concentration and endurance, and retest reliability has as yet not been validated. A spring gauge was also considered. Many Sports equipment companies and medical institutions were contacted looking for a dynamometer suitable to measure the strength of the quadriceps at the knee but it appears that such an item is not readily available, though many helpful sales people assured us of such a product.
One of the assistant researchers developed equipment that is attached to the Kistler Force plate, strapped to the subjects leg, 20cm below the tibial tuberosity. The subject is instructed to attempt to straighten the knee and pull as hard as possible against the strap.

Berg Balance Scale This scale was developed by a physiotherapist for use with geriatric patients. It has been validated and tested for reliability. It appears highly suitable for the particular population in this study, and has been validated to an extent where it can be used as a reliable marker for other tests trialed. The test takes 15 to 30 minutes to conduct.

Tinetti Balance Scale. The Tinetti Balance Scale is a performance oriented assessment of balance. The tester records the response to various manoeuvers as normal, adaptive or abnormal. Some of the tasks overlap with those in the Berg Balance Scale. In this set of tests it was decided to only use the Berg.

Force Plate measurements. A Kistler Force plate is in situ in Rehab Tech. It measures 40 x 60 cm, and is positioned in the floor on a raised walkway. Using Specialised computer software it has the ability to yield information about a persons balance and postural control during certain manoeuvres. After studying the literature a set of tests was designed.

Up Timer. There is a measuring device on the market for measuring the time fraction spent vertical, but this does not measure distance travelled, and therefore does not really give a measure of exercise or work done each day.

Overhead Harness and Tracking System. Although this was available and used in other mobility studies with a significant safety benefit, it was found to encumber, elevate anxiety and affect performance, particularly if cognitive deficits were present. The presence and reassurance of two staff members enabled the best assessment of functional tasks. 0

METHOD

Subjects

CGMC has two interim care wards, each of 30 beds. The patients arrive here from acute care facilities or from home, to await Nursing home placement. On admission agreement was given by the admitting LMO for subjects to be considered for the study.

During the period of subject selection from 1/12/95 to 3/4/96 there were 167 patients screened and 36 admitted to the study.

The ward physiotherapist, or the sister in charge used the selection criteria to screen patients for entry to the study. [See Appendix 1.]

Patients who fulfilled these criteria were referred to the research physiotherapist. She sought subject consent, and informed the next-of-kin. Subjects were able to stop or withdraw from the project at any time during the testing procedure. [See Appendix 2.]

Of the 36 subjects selected 4 completed the initial testing program, and 17 entered and completed the pilot study; 4 refused to participate; 6 were discharged prior to testing; 2 died; 1 was under the guardianship board and consent not obtained; 1 had severe pain and was omitted, 1 had a lifelong intellectual impairment and was omitted.

Due to later discharges to Nursing Homes 4 subjects participated in the 4 week intervention and followup assessment.

Instruments and Apparatus

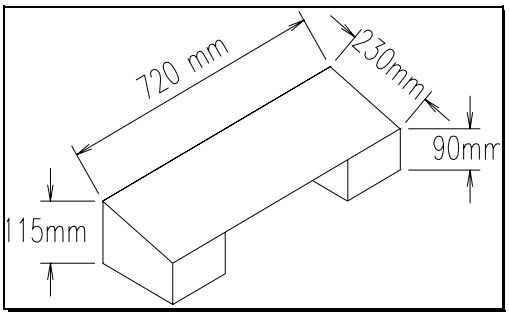
I. Berg Balance Scale

This scale was developed by a physiotherapist for use with geriatric patients and has been validated and tested for reliability. It appears highly suitable for the particular population in this study, and has been validated to an extent where it can be used as a reliable marker for the trialing of other tests.

The test takes 15 to 30 minutes to conduct. It consists of 14 items testing the subjects ability to maintain "positions of increasing difficulty by diminishing the base of support from sitting to comfortable stance to standing with feet together, and finally tandem standing, and single leg stance." The subject is given 3 attempts at each task in order to gain the maximum score of 4 for each item. [See Appendix 3.]

The chair used was an adjustable height swivel chair with arms. The castors were removed and the chair modified to prevent seat rotation and to ensure stability. When each subject initially sat on the chair the height was adjusted so that the knee angle was in 70 degrees flexion and the feet rested on the floor.

Task 12 requires the use of a foot stool for the subject to place each foot alternately on the stool and the dimensions of the stool are listed below



II. Mini Mental State Examination.

This is a cognitive assessment easily administered to this patient group to give an indication of the severity of dementia. [See Appendix 4.]

III. Force Plate measurements.

A Kistler Force platform (type 2812A1-20) and an 8 channel amplifier is in situ in Rehab Tech. It is a immovable plate, based on self calibrating quartz crystals, measuring 40 x 60 cm, and is positioned in the floor on a raised walkway.

The sampling rate was set at 100 Hz. Using Specialised computer software (Bioware, Biomechanical Software Analysis) it has the ability to yield information about a persons balance and postural control during certain manoeuvres.

A grid was superimposed onto the plate at 10 centimetre intervals.

A white board was positioned 5 metres from the front of the force plate, and in the centre of it was a 25 diameter yellow circle to allow visual fixation.

A set of 5 tests were devised for the project and recording sheets drawn up. [Appendix 5.]

For tests number 1,2,and 5 subjects were asked to look at this circle. The chair used was the same as the one used for the Berg Balance test.

IV. Muscle Test for Knee Extensors.

The Force plate has 4 anchor points. A strap was sewn that attached to two of these anchor points and hooked around the subjects right leg to a velcro band. The band was wrapped around the subjects leg 20 centimetres below the tibial tuberosity. The subject was positioned on the adjustable height chair at its maximum height. The chair was positioned so that the strap was taut when the subjects knee was flexed to 90 degrees. The computer software recorded the force vector in the direction of pull and this measure was used. [Appendix 5.5.]

Procedure

Following LMO consent each subject was considered for the study.

The MMSE was conducted in the ward following the interview with the subject. The interview included a full verbal explanation of the procedure and the two Explanatory Statements were given to the subject. The subject signed the consent form.

The Berg Balance test was conducted in the late morning or early afternoon of one day, and the following week on 2 consecutive days the force plate tests were done. Force plate tests were all conducted in the mornings. Subjects wore the same footwear for all sessions.
Each subject was brought to Rehab Tech by wheelchair.

The force plate was explained to each subject, and each task demonstrated prior to asking the subject to attempt the activity. Each test is performed 2 times with a seated rest between each activity. [Appendix 5.]

INTERVENTION - WALKING PROGRAM

Materials and Method

A chart was constructed to record walking time, rest time, and laps walked. [Appendix 7.]

An SEN was employed to supervise the subjects participating in the intervention and make the above recordings. To allow her to have hands free to assist with stability of each subject she wore a calculator on her wrist (used as a lap counter), attached a stop watch to a note pad around her neck. The note pad was used to record when each walk ended, and when each walk resumed.

The intervention consisted of a 15 minute walking session offered to all participants 5 days of each week, Monday to Friday.

A measured distance of 12 metres was used with a chair at each end of the length to allow for rests as required.

The subject was wheeled to area by worker prior to the commencement of walk.

The heart rate taken for 30 seconds.

The respiratory rate taken for 30 seconds.

The subject was encouraged to use his usual gait aid ,between measured length, until he requested a rest. He was then escorted to the chair at the end of that lap to rest for 60 seconds. The stop watch started when the subject took his first step, and the time was recorded when he stopped walking at each requested rest. After the subject was seated he was given 60 seconds rest.

The walk continued with 60 second seated rests as requested, until 15 minutes in total had elapsed.

On completion of the walk each day the heart rate and respiratory rate were taken for 30 seconds.

A recording was made of the time spent walking and the number of laps walked between each rest.

RESULTS

For the initial assessments and those performed following the intervention please refer to Appendix 6.These charts are the recording of the raw data.

The results for the intervention appear in Appendix 7.

Statistical analysis was requested and this was performed by the Statistical Centre at the Peter MacCallum Cancer Institute. Correlation was sought between the Force plate measurements, the MMSE, the Berg test, and number of recorded falls while an inpatient at CGMC.

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DISCUSSION

The analysis of data for this study used information collected in full from 18 subjects, a number consistent with a pilot project. A major part of this study involved the evaluation of the force plate in the use of assessment of the frail aged as a group. It was anticipated that there would be an outcome where a set of predicting factors were found to determine which frail aged person was at risk of falling.

Methods of Data Analysis

Statistical Analysis. As seen in the statistical analysis(Appendix 8) correlations were sought between the various forceplate tests and other known and proved balance tests.-:

1. A negative correlation was found between the Berg score and the Sway%bosAP and Sway%bosLAT ie the higher the performance with the Berg score the less sway the subject had when attempting to stand still.

2. There were a small number of subjects who recorded high Berg scores. When these subjects were excluded from the analysis the correlation between the Berg and these force plate figures was insignificant.

3. The same results were repeated when the Berg was compared with the Stability limits (Stability%bosAP, and Stability%bosLAT). Again when subjects scoring high in the Berg test were eliminated from the analysis there was no apparent relationship between results. The data showed no relationship between the Berg and the sit to stand forceplate results or the 360 degrees turn results.

4. It appears that the force plate is a sensitive and useful instrument when used with subjects who have a high performance ability and thus high scores in the Berg test. In the more frail aged section of the population who have increased disease associated with the normal aging process.studied here the force plate is not a sensitive enough instrument for predicting falls.

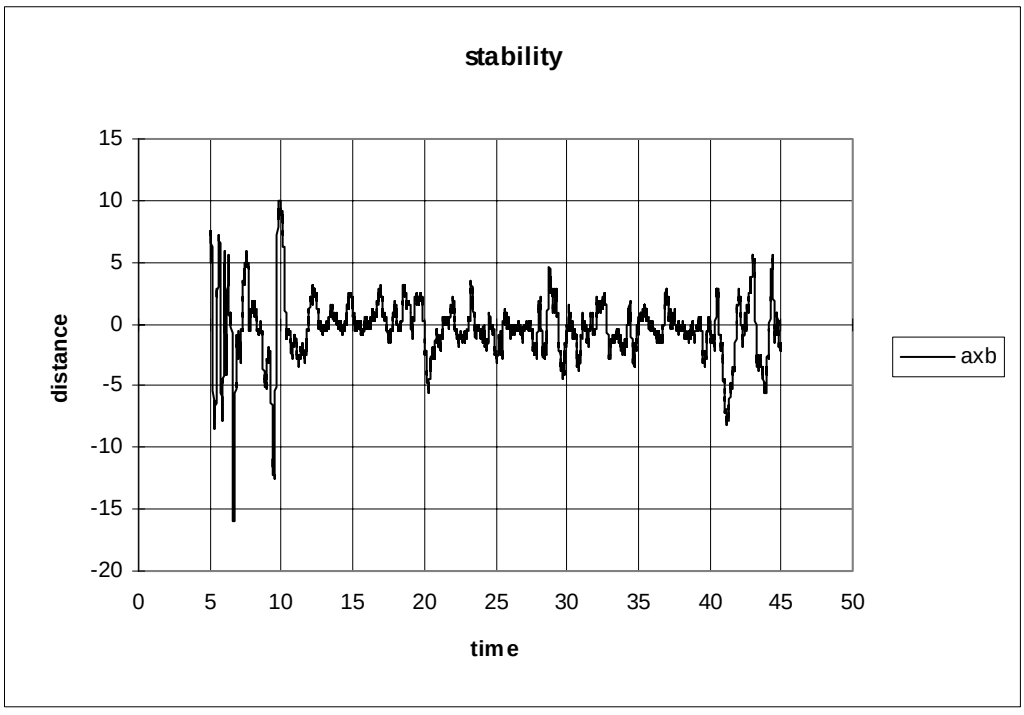
Visual Analysis Of Graphs. This was found to be a new and useful way of studying functional mobility in this group. Statistical analysis was performed comparing the various tools used. An analysis of the graphical representations recorded by the Bioware computer software was also found to be valuable. Statistically there was insufficient numbers in the intervention group to perform group analysis.

The Bioware computer software records graphically the force vectors in three directions. For all tests carried out in this study comments were written down during each test so that analysis of the graphs would be more reliable.

In analysis of some of the collected data there was still the possibility that the part of each graph used for analysis may not have corresponded to the exact time at which the subject performed the required test.

This particular problem can be overcome in the future, by using a time based video of the subject performance during each test and using the collected data together to process and analyse all the information. This would give better interpretation accurate results.

Stability Limits. To demonstrate the difficulties in interpreting the recorded results from the computer the following examples have been chosen. The data is collected each one hundredth of a second and with the sensitivity of the equipment the following curve was common for stability limits.

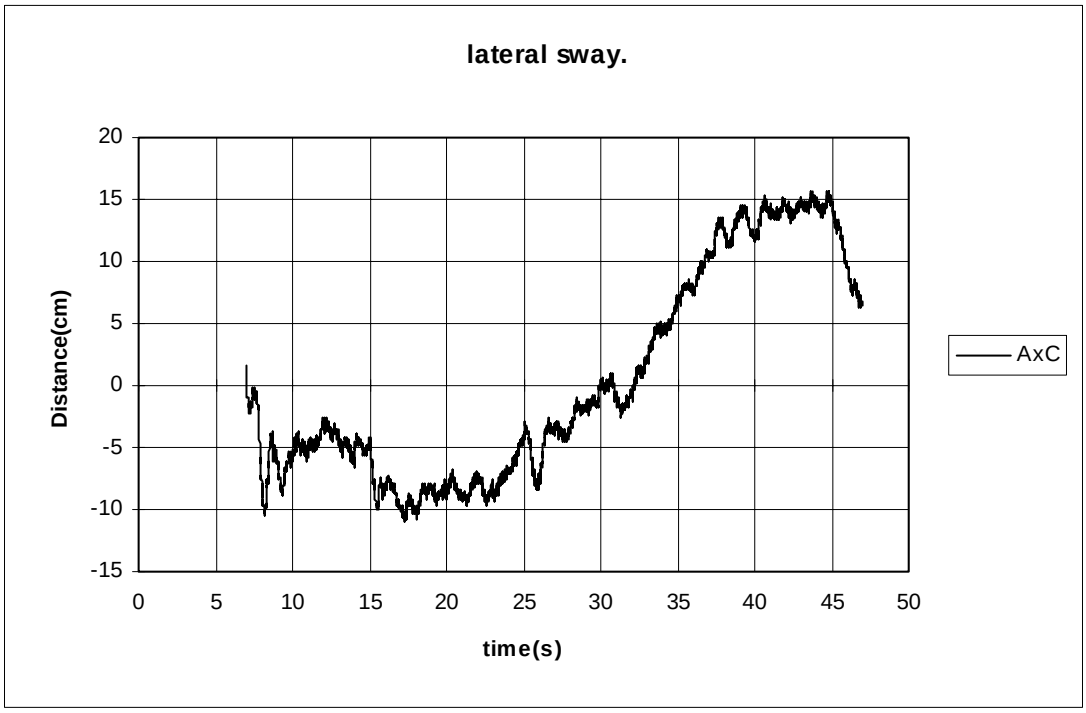


The computer is able to give an average measure for a set time period and this is the method used to calculate the amount of forward lean at 15-20 seconds and the amount of backward lean at 30-35 seconds. It can be seen from this particular example that the lean from the central position is small and there is great variability within each 5 second collection. This means that the interpretation of data is often difficult.

The waveform recorded during the standing stability test has been further studied looking at R.M.S characteristics but due to the complexity chaos theory may better explain these physiological phenomena. A masters engineering student is continuing this latter approach over 6 months.

Lateral Sway.

On the other hand a subject who scored highly on the Berg recorded a very clear graph for lateral sway.



This graph clearly shows the subjects ability to lean in certain directions when requested, and this graph is more reliabily interpreted.

Subjective Impact. There were various ways in which subjects responded to the participation in the testing program. Many subjects reported pleasure in the change of routine and environment, and enjoyed the social interaction that accompanied the program. Even though it was explained to the subjects that there may be no benefits to them, many felt that they were benefiting and that they were gaining insight into their own capabilities in physical performance. There also appeared to be an increased feeling of value and self worth, knowing that their participation could help others in the future.

Environmental Factors. Contrary to this for some of the subjects the change in environment was stressful. These subjects found the tests on the forceplate more difficult to perform and appeared more disorientated than usual during the tests. The same subjects did not appear so confused when performing the Berg test which was done in the ward. Ideally the less changes in these peoples environment during testing activities the more reliable one would expect the results to actually reflect that persons performance.

Perception of Performance. The Berg test showed that most subjects had good insight into abilities. When picking an object up from the floor most subjects felt reluctance where in fact the task was not safe for them to do unsupervised or without holding on. All tasks testing weight transference from one leg to the other required subtle balance control and most subjects found these tasks difficult.

Loss of Balance Mechanisms. Subjects generally have lost the ability to lean at the ankle and have a tendency to bend at the hips and look down at their toes. This is the result even after visual demonstration is done, and when verbal cues are given during the tests. This actually often results in a neutral or posterior shift of the centre of mass or the centre of pressure.

Asked to lean backwards over their heels subjects generally look up towards the ceiling and adopt a straighter posture. There was very little observed action in the feet dorsiflexor muscles.

Lateral stability, subjects appeared unable to shunt weight laterally and tend to lean sideways at the waist or hip region, with some anterior movement of their weight. Their eyes never appear level during this test.

Fatigue. Many of the subjects tired during each test session even though sessions were limited to 20 minutes in duration, and only one session was permitted on each day. Testing was performed in the morning in the hope that subjects would be fresh and the tests were done at the same time each day. Due to staff constraints the MMSE and the Berg test were performed one week before the force plate tests. In the intervening week the subjects could have improved or may have deteriorated. Ideally in an expanded study, to make results more comparable, the tests would all need to be performed during the same week.

Sit-to-stand test

The graphs produced from the test of sit-to-stand can be grouped depending on the shape of the curve recorded. These curves reflect the method used by a person to transfer body weight from a sitting position to a standing position.

There appear to be various but very individual and reproducible methods by which people stand up from a chair with armrests.

1. **Controlled sit-to-stand.** Strong healthy individuals do not generally use or rely on the armrests and depend totally on their legs and trunk to propel themselves into a standing position. Recordings on the forceplatform show the following shape in the graph for such a manoeuvre:

(a) subject positions feet on the forceplatform,

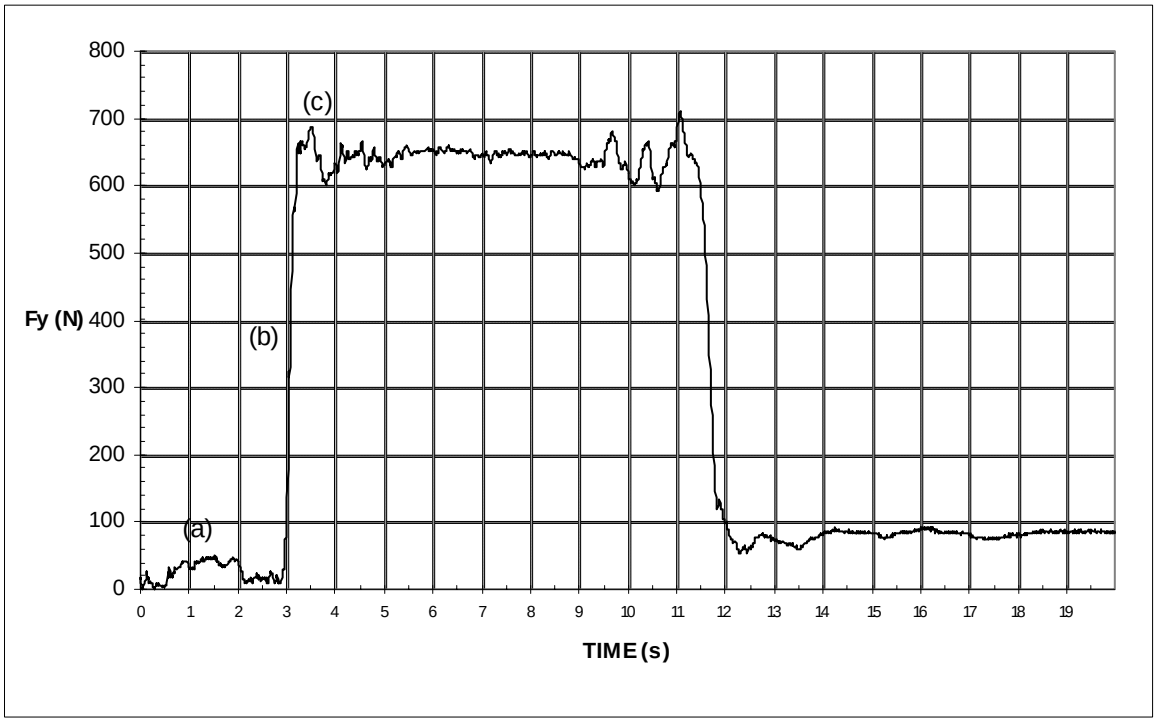
(b) subject transfers weight to legs using leg and trunk muscles,

(c) subject stabilises in the standing position.

The subjects able to stand in this manner all scored well on the Berg test.

Standing stability despite initial and late corrections associated with position change shows consistent stability with the waveform to be further analysed as above.

Stand to sit timing and method also requires ongoing study.Some subjects whose sitting is precipitous show poor control compared to controlled sitting in more adept subjects.This may be of particular importance given this rapid and unsafe change of position seems associated with falls.



2. **Poorer Control of sit-to-stand,** Some subjects used their arms to push up, as their leg muscles were unable to lift the body weight alone.

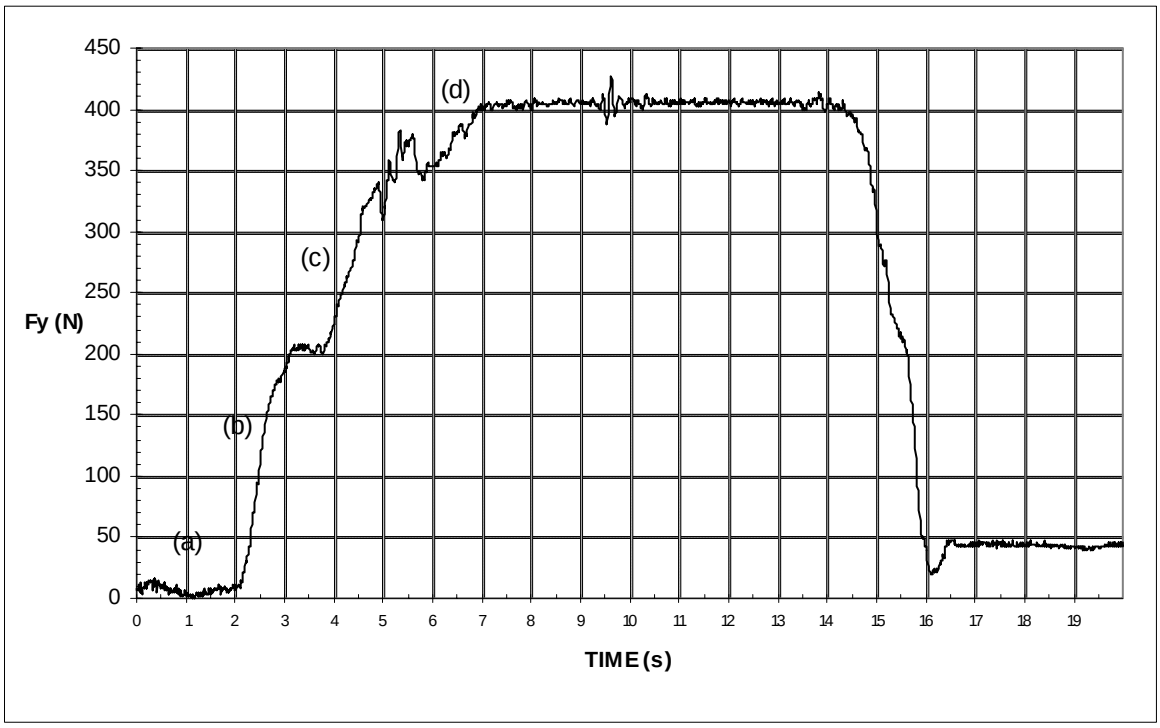
Below is an example of this method of standing up :

(a) subject positions feet on the forceplatform,

(b) subject attempts to rise using legs, then realises he needs arm assistance,

(c) subject uses arms and legs in a coordinated manner to raise self off the chair,

(d) subject transfers body weight to legs and stabilises in unsupported standing.



This group had great difficulty performing in unfamiliar environments, and some became apprehensive in a technical setting.

Intervention.

There were four subjects who participated in the full intervention program. Regrettably the other subjects tested who were eligible to participate only partially completed the four week program. All were moved to permanent accomodation settings during the time when the program was operating and this reduced the number of participants. The other limiting factor was that each subject required close supervision during each walk for recording of data and this took 30 minutes per subject. This time included transporting the subject to the program location and returning them. Thus the intervention was a labour intensive and time consuming process.

The numbers studied were not sufficient for statistical interpretation.
All the subjects in the intervention group were male. The research nurse supervising the subjects reported various changes in the subjects over the four week program. All subjects were enthusiastic to attend the sessions daily. As the subjects knew each other from the wards there was a growing feeling of comradery between the gentlemen. Each subject except one seemed to develop a greater insight into their physical abilities, and this had a positive affect on their daily activity level.

CONCLUSIONS.

1. Subjects who scored well in the Berg test also performed well on the force plate.

2. Although helpful in other populations, for the bulk of those studied, the frail elderly, the force plate did not offer any valuable additional data about the functional skills of this group.

3. However the force plate measure of sit to stand shows high reproducibility in the method each subject uses to stand up.

4. Though no statistically significant outcome resulted from a comparison of the time taken to stand and the Berg score, the method needs analysis.

5. Graphs of the forceplate performance are reproducible and seem to reflect functional ability. These sit-to-stand ,standing stability and stand to sit profiles warrant further study.

6. The pilot exercise intervention had significant positive subjective benefit and may produce objective improvement in functional stability in a larger group of the frail elderly

7. Study of functional tasks using the forceplate analysis has significant applications with a range disability groups.

APPENDIX 1

Subject Selection

Static & Dynamic Assessment & Minimisation of Risk Factors for Falls in Older People.

Attached is an explanation of a study that is to be carried out over the next few months.

Subjects who may be considered for the study must fulfil the following criteria:

: be able to walk 10 metres with or without a gait aid,

: be able to stand alone for 15 seconds,

: be able to follow a single command ,

: be able to understand basic English,

: be 60 years or older,

: with lower limbs in tact(not an amputee),

: be medically stable,

: have Interim status.

If, on admission , a patient fulfils the above criteria Karol Connors will initiate the enrolment of each subject for the study.

Bradma

APPENDIX 2

2.1 Falls Risk Study Check List

Patients Name.....

Date of admission.....

LMO Name..... ,

I consent to my patient to be involved in the Falls Risk Study.

Signed ..... Date.....

I refer this patient for a Medical assessment to Dr. .....

Signed ..... Date.....

Explanatory Statement given to subject [*Karol Connors*]

Signed..... Date .....

Subjects details entered into Study Book, (physio drawer, Ward 12) [*K. Connors*]

Signed..... Date.....

Consent Form [*By Patient or Guardian in presence of J Graham*]

Signed..... Date.....

MMSE Completed [*Julie Graham*]

Signed..... .....Date.....

Medical Assessment Completed [ ]

Signed..... Date.....

REHAB *Tech* Appointments

Date ..... Date .....

Time ..... Time .....

Date ..... Date .....

Time ..... Time .....

Incident Report of Falls

Date ..... Date .....

Time ..... Time .....

Date ..... Date .....

Time ..... Time .....

Contact : Julie Graham, **REHAB *Tech***, ext 6327.

FALLS RISK STUDY

2.2 Subject Registration

NAME..... DATE OF ADMISSION.....

Admitted from.....

Date of Birth.....Age.....

Ward..... Room..... Bed.....

LMO.....LMOConsent.....tel/written.....date.....

Next of Kin.....Relationshiptosubject.....

Tel..... Date of discussion with Nof K.....

Guardianship Board.No. ..... Guardian .....

Discussion with Guardian.....

Consent signed by subject..... date.....

Gait Aide .....

Medical Assessment .....

MMSE completed..... Score .....

BERG completed..... Score .....

KISTLER.completed (1)..... (2).....

Shoes worn during tests .....

2.3 Plain Language Statement

BALANCE STUDY

We would like you to participate in a study that is looking at balance and it's relationship to falling.

You will be escorted upstairs to our **REHAB** ***Tech*** centre, on a number of occasions over a number of weeks. A physiotherapist will conduct an assessment of balance involving turning, bending, reaching, and walking. Some of the tests will be performed on a special floor. At all times 2 staff members will assist you with each activity, in order to maintain your safety.

At any stage you may choose to end the session.

Thank you for agreeing to participate in this study

2.4 Explanatory Statement

THE ALFRED HEALTHCARE GROUP

Project Title: **Static and Dynamic Assessment and Minimisation of Risk Factors for Falls in Older People**

Names of researchers:

Dr Harold Flamer, Consultant Physician and Senior Lecturer in Geriatric Medicine

Dr Andrew Nunn, Head, Amputee Services, and Clinical Director, Monash REHAB *Tech*

Ms Julie Graham, Research Physiotherapist

Ms Jan Stephens, Nurse Manager, Extended Care Unit, Caulfield General Medical Centre

Associate Professor Ian Brown, Biomedical Engineer, Director, Monash REHAB *Tech*

Ms Karol Connors, Physiotherapist, Extended Care Unit, Caulfield General Medical Centre

Mr William Contoyannis, Rehabilitation Engineer, Manager, Monash REHAB *Tech*

Mr Nebojsa Tomasevic, Engineer, Monash REHAB *Tech*

Mr Shaun Feeley, Medical Physicist, Monash REHAB *Tech*

Dr Lisa Demos, Clinical Pharmacist, Alfred Healthcare Group

EXPLANATORY STATEMENT

Falls in the elderly are a major public health and community problem. Approximately 30% of people over the age of 65 living at home have at least one fall each year. This rate increases with age, and is higher in nursing homes.

There are a number of risk factors for falls, including medications (especially sedatives), gait and balance problems, muscle weakness, lower limb problems, reduced memory, and lack of confidence. We may be able to improve some of these factors, and so reduce the number of falls.

We invite you to participate in a research study to examine risk factors for falls, and then to assess different methods of improving these risk factors, to try to reduce the number and severity of falls. Your participation is entirely voluntary. You may withdraw from this study at any time without changing your medical care.

If you agree to participate in this study, you will have a thorough clinical assessment, including a complete physical examination, assessment of your memory and concentration, and a detailed examination of your medications. You may be asked to have some blood tests, depending on which medications you are taking. Where possible, these will be arranged with any other blood tests your doctor may ask for. Blood tests carry very little risk of local skin infection or bruising, and you cannot catch AIDS or hepatitis from them.

You will also have a detailed assessment of the way you walk and your balance, under different circumstances. For this, you will first be examined closely by a physiotherapist, while you stand and walk normally and also when you perform certain activities, including turning, reaching for items and bending over. Further testing will be performed in a specialised laboratory in the Monash University REHAB *Tech* Unit, located on the second floor of this building complex. This will involve stepping on a special platform (a Kistler Force Plate) which measures where you place your weight and how you keep your balance. You will also be asked to walk along a short path (about 10-20 paces) and perform a small amount of turning, twisting and bending. You may also be assessed to see how you recover your balance after being pushed gently. For your safety, for some tests you will wear a safety harness, which will prevent you from falling. This may be slightly uncomfortable, but should not feel much worse than wearing a seat belt over a heavy jacket. These exercises may also be videotaped for further analysis of your individual responses and your risk of falling. All these tests will be performed in the presence of a doctor. Many of these tests will be repeated a few weeks after you have undergone either a special light exercise programme or any suggested medication changes, to see if your balance and walking have improved.

2.5 Consent Form for Competent Subjects

THE ALFRED HEALTHCARE GROUP PART OF THE EASTERN HEALTH CARE NETWORK	SUBJECT IDENTIFICATION U.R. No..... NAME..... ADDRESS..... ..... DATE OF BIRTH.....

CONSENT FORM FOR RESEARCH PROJECT FOR COMPETENT SUBJECTS
PROJECT No. 54/95

TITLE Static and Dynamic Assessment and Minimisation of Risk Factors for Falls in Older People

CHIEF RESEARCHERS Dr Harold Flamer, Dr Andrew Nunn

1. 1, the undersigned..... hereby consent to my involvement in the above research project.
2.1 acknowledge that the nature, purpose and contemplated effects of the project so far as it affects me have been fully explained to my satisfaction by the researcher and my consent is given voluntarily.
3.1 have received the Explanatory Statement and am familiar with the nature of the study including the anticipated length of time the study will take, the frequency with which visits and tests will be performed, and an indication of any discomfort which may be expected.
4.Although I understand that the purpose of this research project is to improve the quality of medical care, it has also been explained that my involvement may not be of any benefit to me.
5.1 have been given the opportunity to have a member of my family or a friend present while the project was explained to me.
6.1 have been informed that no information regarding my medical history will be divulged to unauthorised persons and that the results of any tests involving me will not be published in such a way as to reveal my identity.
7.1 understand that my involvement in the project will not affect my relationship with my medical advisers in their management of my health. I also understand that I am free to withdraw from the project at any stage.
8.1 confirm that it has been explained to me that the hospital has an Ethics Committee which:
(a) has approved the above project
(b) ensures that explanations such as I have/received conform to ethical standards which this Hospital is required to observe, and
(c) has officers who may be authorised to contact me to check whether the proper standards are being observed and who are pledged to preserve the confidentiality of my involvement.

Signed..... this day..... /..... /.....

Witness Name..... Signature..... this day..... /..... /.....
Address.....

Researcher Name..... Signature.....

Copy - to **be filed** in patient record Original: to be kept **by** principal researcher

2.6 Acknowledgment by next of kin

THE ALFRED HEALTHCARE GROUP PART OF THE EASTERN HEALTH CARE NETWORK	SUBJECT IDENTIFICATION U.R. No..... NAME..... ADDRESS..... ..... DATE OF BIRTH.....

ACKNOWLEDGMENT BY NEXT-OF-KIN TO PATIENT PARTICIPATION IN RESEARCH

PROJECT No. 54/95

TITLE Static and Dynamic Assessment and Minimisation of Risk Factors for Falls in Older People

CHIEF RESEARCHERS Dr Harold Flamer, Dr Andrew Nunn

1.1.....

of..... hereby acknowledge

that I have been informed that..... is to be involved in

the above research project.

2.1 acknowledge that the nature, purpose and contemplated effects of the research project, especially as far as they may affect..... have been fully explained to my satisfaction.

3.1 acknowledge that the details of the procedures covered in the Explanatory Statement have been explained to me, including indications of risk, discomfort or anticipation of length of time and the frequency with which the
procedures will be performed.

4.1 have been told that the subject will be issued with a written Explanatory Statement when his/her health permits.

5.1 understand that my next-of-kin's involvement in the research project and/or the procedures may not be/have any direct benefit to him/her.

6.1 understand that my next-of-kin's rights and the responsibility of hospital staff to provide for his/her care are unaffected by his/her participation in this research.

I declare that I am over the age of 18 years.

Signed..... this day..... /..... /.....

Relationship to Patient.....

Doctor..... this day..... /..... /.....

Researcher Name.....

Signature.....

Copy - to **be filed** n **patient record** Original: to **be kept by** principal **researcher**

APPENDIX 3

Berg Assessment

TEST BATTERY OF FUNCTIONAL TASKS

General Instructions

* Each task should be demonstrated to the subject after the verbal instruction has been given.

* If the subject achieves a score of less than 4 for any task the task should be repeated with a maximum of three trials, allowing 30 seconds rest between trials.

Task 1: Sitting to standing

Instruction: Please stand up. Try not to use your hands for support.

0 Needs moderate to maximum assistance to stand

1 Needs minimal assistance to stand and stabilise

2 Able to stand using hands after several tries

3 Able to stand independently using hands

4 Able to stand, no hands and stabilise independently

Task 2: Standing unsupported

Instruction: Stand for 2 minutes without holding on.

0 Unable to stand for 30 seconds unaided

1 Needs several tries to stand 30 seconds unsupported

2 Able to stand 30 seconds unsupported

3 Able to stand 2 minutes with supervision

4 Able to stand safely for 2 minutes

If subject able to stand safely for 2 minutes, score full marks for sitting unsupported. Proceed to position change standing to sitting.

Task 3: Sitting unsupported feet on floor

Instruction: Sit with arms folded for 2 minutes.

0 Able to sit without support for 10 seconds

1 Able to sit 10 seconds

2 Able to sit 30 seconds

3 Able to sit 2 minutes with supervision

4 Able to sit safely and securely for 2 minutes

Task 4: Standing to sitting

Instruction: Please sit down

0 Needs assistance to sit down

1 Sits independently but has uncontrolled descent

2 Uses back of legs against chair to control descent

3 Controls descent by using hands

4 Sits safely with minimal use of hands

Task 5: Transfers

Instruction: Please move from chair and back again (one chair with armrests and one chair without armrests; chairs at 90 degrees, 30 centimetres apart)

0 Needs two people to supervise and assist

1 Needs one person to assist

2 Able to transfer with verbal cues and/or supervision

3 Able to transfer safely definite use of hands

4 Able to transfer safely with minor use of hands

Task 6: Standing Unsupported with Eyes Closed

Instruction: Close your eyes and stand still for 10 seconds

0 Needs help to keep from falling

1 Unable to keep eyes closed 3 seconds, but remains steady

2 Able to stand 3 seconds

3 Able to stand safely with supervision

4 Able to stand 10 seconds safely

Task 7: Standing Unsupported With Feet Together

Instruction: Place your feet together and stand without holding.

0 Needs help to attain position and unable to hold 15 seconds

1 Needs help to attain position But unable to stand 15 seconds

2 Able to place feet together independently but unable to hold for 30 seconds

3 Able to place feet together independently and stand for 1 minute with supervision

4 Able to place feet together independently and stand for 1 minute safely

Task 8: Reaching Forward With Outstretched Arm

Instruction: Lift arm to 90 degrees. Stretch out fingers and reach forward as far as you can.

0 Needs help to keep from falling

1 Reaches forward but needs supervision

2 Can reach forward >5 centimetres safely

3 Can reach forward >12.5 centimetres safely

4 Can reach forward confidently >25 centimetres

Task 9: Pick up Object from Floor

Instruction: Pick up the shoe/slipper which is placed in front of tour feet.

0 Unable to try/needs assistance to keep from falling

1 Unable to pick up and needs supervision while trying

2 Unable to pick up but reaches 3-5 centimetres from slipper and keeps balance independently

3 Able to pick up slipper but needs supervision

4 Able to pick up slipper safely and easily

Task 10: Turning to look Behind Over Left and Right Shoulders

Instruction: Turn to look behind you toward left shoulder. Repeat to the right.

0 Needs assistance to keep from falling

1 Needs supervision while turning

2 Turns sideways only but maintains balance

3 Looks behind one side only, other side shows less weight shift

4 Looks behind from both sides and shifts weight well

Task 11: Turn 360 Degrees

Instruction: Turn completely around in a full circle. Pause. Then turn a full circle in the other direction.

0 Needs assistance while turning

1 Needs close supervision or verbal cueing

2 Able to turn 360 safely and slowly

3 Able to turn 360 safely one side only <4 seconds

4 Able to turn 360 safely in < 4 seconds each side

Task 12: Placing Alternate foot on Stool

Instruction: Place each foot alternately on the stool. Continue until each foot has touched the stool four times.

0 Needs assistance to keep from falling/ unable to try

1 Able to complete >2 steps needs minimal assistance

2 Able to complete 4 steps without aid with supervision

3 Able to stand independently and safely and complete 8 steps >20 seconds

4 Able to stand independently and safely and complete 8 steps in 20 seconds

Task 13: Standing Unsupported in Stride Stance

Instruction: Place one foot directly in front of the other (heel to toe). If you feel that you cannot place your foot directly in front, try to step far enough ahead so that the heel of your forward foot is ahead of the toes of the other foot (but still in line).

0 Loses balance while stepping/ standing

1 Needs help to take a step but can hold 15 seconds

2 Able to take small step independently and hold 30 seconds

3 Able to place foot ahead of the other independently and hold 30 seconds

4 Able to place foot in tandem independently and hold 30 seconds

Task 14: Standing On One Leg

Instruction: Stand on one leg for as long as you can without holding.

0 Unable to try/ assistance needed to prevent fall

1 Tries to lift leg unable to hold 3 seconds but remains standing independently

2 Able to lift leg independently and hold >10 seconds

Berg Assessment Form

Name:				
Date: / /		Time:		
Assessment Of Balance	**Trial 1**	**Trial 2**	**Trial 3**	**Final Score**
Sitting to Standing				
Standing Unsupported				
Sitting Unsupported Feet on Floor				
Standing to Sitting				
Transfer				
Standing Unsupported With Eyes Closed				
Standing Unsupported With Feet Together				
Reaching Forward With Outstretched Arm				
Pick Up Object From Floor				
Turning To Look Behind Over Left and Right Shoulder				
Turn 360 Degrees				
Placing Alternate Foot on Stool				
Standing Unsupported In Stride Stance				
Standing On One Leg				
			Total	

APPENDIX 4

Mini Mental State

CLIENT_____D.O.B.___/__/__

ASSESSED BY:_____ DATE ASSESSED ___/__/__

SCORE

__/5 What is the: Year Time Date Day Month Season (5/6)

__/5 Where are we now: State Country Town Suburb Street (Current Location)

(? knowledge of home address)

__/3 **Name three objects (client repeats):** Tree Chair Happiness

__/5**Spell "WORLD" backwards *OR* Serial Sevens**

__/3**Ask for the three objects (repeat above)**

__/2**Name a pencil and a watch**

__/1 Repeat the following: "no ifs, ands or buts"

__/3 **Follow a three stage command:**

"take a paper- in you left hand, fold it in half, and put it on the- floor"

READ AND OBEY THE FOLLOWING (see over)

__/1 Close Your Eyes

__/ I Write Sentence

__/i Copy DesignOR Draw a Clockface

__/30 **TOTAL SCORE**

Assess Level of Consciousness (circle one): - Alert Drowsy Stupor Coma

COMMENTS:

Vision_____
Hearing_____

CLOSE YOUR EYES

WRITE SENTENCE

COPY DESIGN

DRAW A CLOCKFACE

APPENDIX 5

5.1 Force Plate tests

1. Postural Sway**.** The subject is assisted into standing and instructed to stand as still as possible, while looking at the yellow circle. Recordings are taken for 30 seconds.

2. Stability Limits test. The subject stands on the plate and is instructed to lean forward as far as possible while keeping feet still and hold for 5 seconds then stand straight for 10 seconds, and then is instructed to lean backwards as far as possible and hold for 5 seconds. The subject stands centrally to complete the test.
A further part to this test is to stand and lean first to the left as far as possible holding for 5 seconds, the n position self centrally for 5 seconds, and then to the right as far as possible holding for 5 seconds while keeping the feet stationary. This test is completed by standing centrally.

3. Sit to Stand. A recording is taken of the subject standing up from sitting on the chair, standing still for 10 seconds, then sitting down again.

4. Turn through 360 degrees. After becoming stable in a standing position on the plate the subject is instructed to take steps to turn through 360 degrees, first in an anti clockwise direction, then in a clockwise direction.

5. Standing Still. This is a repeat of test 1.
For all tests the assistant recorded the subjects feet position using a grid superimposed on the forceplate.

5.2 Force Plate Record Sheet

NAME.....DATE.....

TYPE OF TEST	TRIAL 1	TRIAL 2	TRIAL 3	
1. STANDING STILL.(3trials)				
2.STABILITY LIMITS. (for & back), 2 trials (left,then right), 2 trials				
3. SIT TO STAND. 2 trials				
4. TURN 360 DEGREES. (to left), 1trial, (to right), 1trial,				
5. STANDING STILL.,1 trial,				

5.3 Force Plate Analysis Sheet

Test 1 Sway	Trial 1	Trial 2	Trial 3
Base of Support			
Length of feet			
Heel Distance			
Toe Distance			
Fn Base of Supported			
Ant/Post displacement			
Lateral Displacement			
Standard Deviation A/P			
Standard Deviation Lat			
% Base of Support used			

Test 3 Sit To Stand	Trial 1	Trial 2
Time 1 Sit to Stand		
Time 2 Stand to Sit		
Time 1 SD		
Time 2 SD		

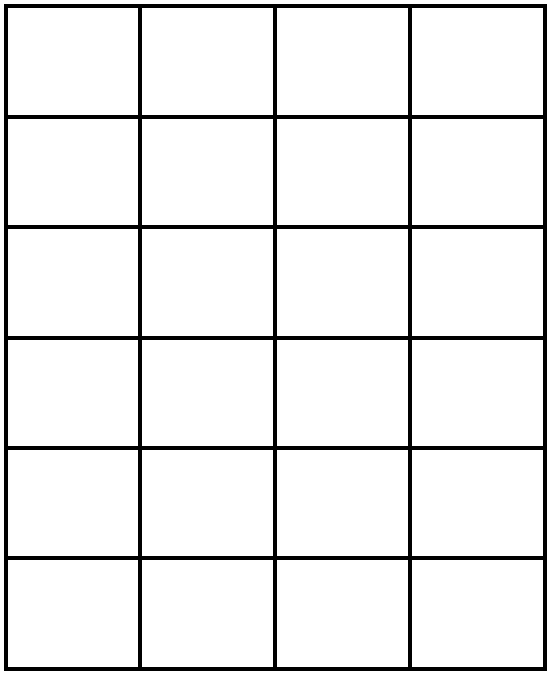
Test 2 Stability Limits	Trial 1	Trial 2	Trial 3
Feet Length			
Feet Distance			
Avg Forward sway			
Max Forward Sway			
Forward SD			
Avg Backward Sway			
Max Backward Sway			
Backward SD			
Avg Left Sway			
Max Left Sway			
Left SD			
Avg Right Sway			
Max right Sway			
Right SD			
% A/P			
% P			
% L			
% R			

Test 4 Turn 360 Degrees	Trial 1	Trial 2
Time of anticlock turn		
Time of clock turn		
No of steps anti		
No of steps clock		
Circle C of P Movement		
Diameter Anti		
Diameter clock		

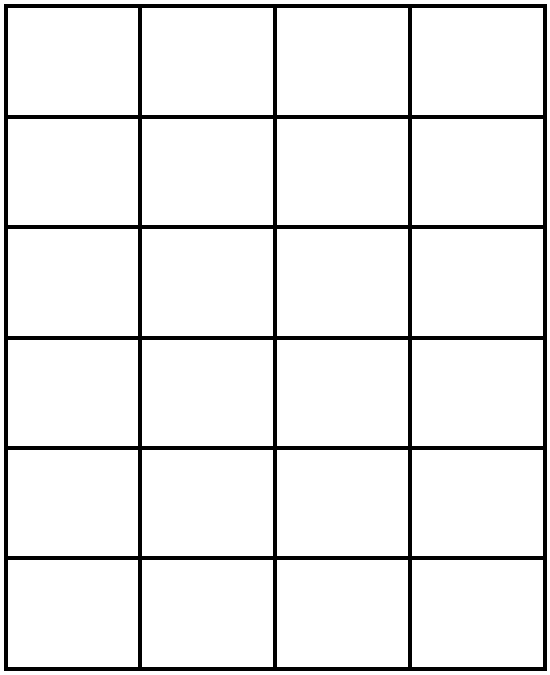
Test 5 Sway	Trial 1
Base of Support	
Fn Base of Support	
Ant/Post displacement	
Lateral Displacement	
Standard Deviation A/P	
Standard Deviation Lat	
% Base of Support used	
% A/P	
% Lateral	

5.4 Foot Positions

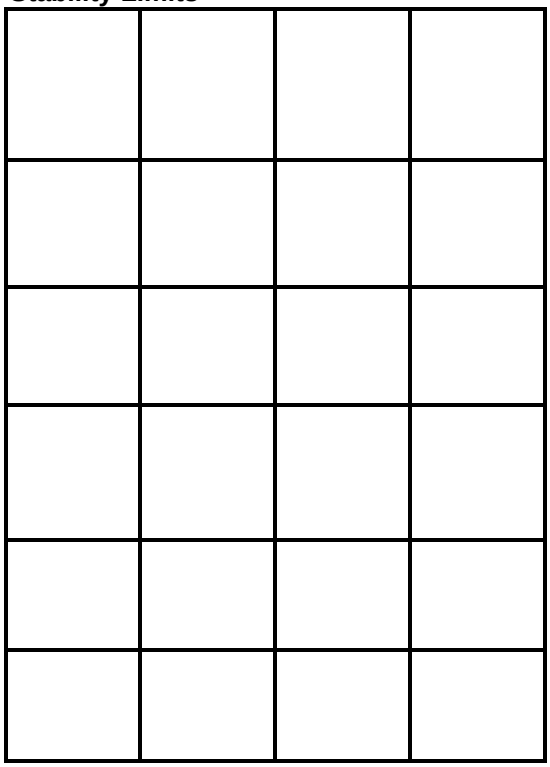
Standing Still



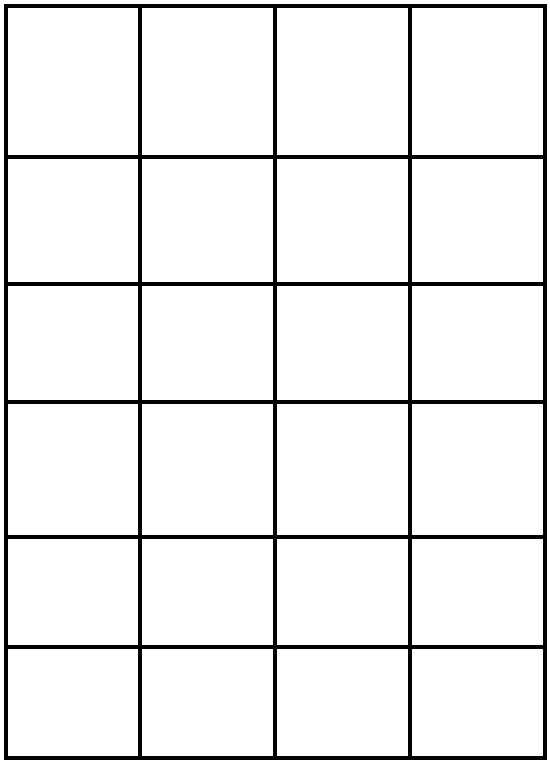
Stability Limits



Stability Limits

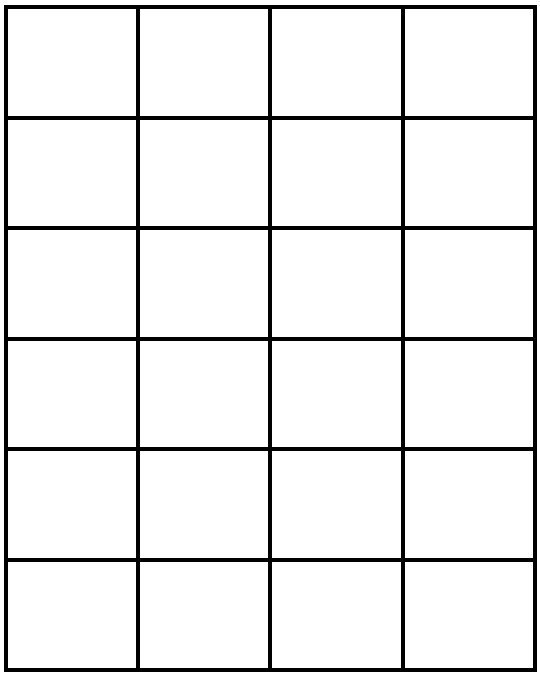


Sit To Stand



Foot Positions (cont)

Standing Still



Muscle Tests

Trial 1 . _____

Trial 2. _____

Trial 3. _____

Trial 1 . _____

Trial 2. _____

Trial 3. _____

5.5 Muscle Tests

BALANCE AND FALLS STUDY

NAME:_____

DATE:_____

TRIAL 1 ._____

TRIAL 2 .____

TRIAL 3._____

DATE : _____

TRIAL 1._____

TRIAL 2. _____

TRIAL 3. _____

5.6 Images of force plate tests

Force Plate tests



Above demonstrates the subject standing still on the forc plate, then asked to lean forwards as far as possible, and in the third image leaning behind as far as possible



The subject stands as straight as possible, then leans to the left in the second image, and finally leans to the right in the third image.

Images of force plate tests(cont)

Specially designed strap is attached to the force plate at two anchor points and measures the pull exerted by the subject when attempting to straighten his leg.

APPENDIX 6

6.1 Summary

NAME	AGE	SEX	RCI	MMSE	Berg	Foot	DAYS IN	FALLS	INJURY	DISCH
PW	73	M	3	8	55	300	127	0		NH
KM	78	M	3	5	43	280	83	2	bruise x2	NH
JW	85	F	3	19	44	290	50	0		NH
BB	85	M	3	13	41	270	63	2	cut scalp x2	NH
AB	87	F	3	20	24	270	16	1	cut leg	NH
EB	87	F	3	5	42	230	35	0		NH
KG	83	M	3	12	23	265	46	1	cut scalp	NH
EF	92	F	3	17	6	260	49	8	bruise kn x1	DEC
LT	91	F	3	22	31	260	129	0		NH
PD	92	M	5	23	50	260	83	0		Hostel
SN	81	M	3	29	34	260	93	0		NH
JS	89	M	3	23	32	270	63	0		NH
DO	91	F	3	24	35	250	45	0		NH
DF	78	F	3	10	34	280	26	0		NH
EC	97	F	3	23	35	280	28	1	bruise,back	NH
MC	80	F	3	12	38	‘220	34	0		NH

6.2 Berg Assessment Results

Name	Age	M/F	Gait Aid	MMSE	Berg	Sit to Stand	Stand Alone	Sit unsupported	Stand to Sit	Transfer	Stand Eyes Closed	Stand Feet together	Reach Forward	Pick Up Object	Turn Behind
PW	74	M	nil	8	55	4	4	4	4	4	4	4	4	4	4
KM	78	M	frame	5	43	4	4	4	4	2	4	4	1	4	4
JW	85	F	frame	19	44	4	4	4	4	2	4	4	3	4	3
AB	87	F	nil	20	24	2	4	4	3		4	3	1	1	2
EB	87	F	frame	5	42	3	4	4	4	2	4	4	4	4	4
LT	92	F	frame	22	31	1	4	4	4	1	4	4	2	3	4
DB	95	F	frame	17											
BB	85	M	frame	13	41	3	4	4	3	2	4	4	2	4	4
KG	83	M	nil	12	23	3	3	4	3	1	3		3	3	
PD	92	M	stick	23	50	3	4	4	3	4	4	4	3	4	4
SN	81	M	frame	29	34	3	4	4	3	3	4	4	3	3	2
EF	92	F	frame	17	6	3		2	1						
MC	80	F	nil	10	38	4	4	4	4	3	4	4	2	4	1
EC	97	F	frame	12	33	3	4	4	3	3	4	3	3	3	2
DF	78	F	nil	23	34	4	4	4	4	2	4	1	1	3	3
DO	91	F	frame	24	35	3	4	4	3	4	4	4	3	3	2
JS	89	M	frame	23	32	3	4	4	3	2	4	4	3	3	2

Berg Assessment Results (cont)

Name	Age	M/F	Turn 360	Alt Foot on Stool	Stride Stance	Stand One Leg
PW	74	M	4	4	4	3
KM	78	M	2	2	3	1
JW	85	F	4	3		1
AB	87	F				
EB	87	F	2	2		1
LT	92	F				
DB	95	F				
BB	85	M	1	3		3
KG	83	M				
PD	92	M	2	4	4	3
SN	81	M	1			
EF	92	F				
MC	80	F	2	2		
EC	97	F	1			
DF	78	F	2	2		
DO	91	F	1			
LS	89	M				

6.3 MMSE Results

Name	Age	Sex	Gait Aid	MMSE	Date	State	3 Objects	World/ 7's	Re 3 Objects	Pencil/Watch	no ifs	3 Stage command	Close eyes	Write Sentence	Copy / Draw
PW	74	M	nil	8	0	0	3	0	3	0	0	2	0	0	0
KM	78	M	frame	5	0	1	3	0	0	0	0	1	0	0	0
JW	85	F	frame	19	2	3	3	3	0	2	0	3	1	1	1
BB	85	M	frame	13	0	2	3	0	0	2	1	3	1	1	0
AB	87	F	nil	20	1	5	3	1	1	2	1	3	1	1	1
EB	87	F	frame	5	1	1	0	0	0	0	0	1	1	1	0
KG	83	M	nil	12	1	2	3	0	0	2	0	3	1	0	0
EF	92	F	frame	17	2	1	3	5	0	2	1	1	1	1	0
LT	92	F	frame	22	4	5	3	1	2	2	0	3	1	0	1
PD	92	M	stick	23	4	5	3	0	3	2	0	3	1	1	1
SN	81	M	frame	29	4	5	3	5	3	2	1	3	1	1	1
JS	89	M	frame	23	4	5	3	2	3	2	0	3	1	0	0
DO	91	F	frame	24	3	4	3	5	2	2	1	2	1	1	1
DF	78	F	nil	10	2	2	3	0	0	2	0	0	1	0	0
EC	97	F	frame	23	1	5	3	4	1	2	1	3	1	1	1
MC	80	F	nil	12	1	2	3	1	0	0	0	3	1	0	0
DB	95	F	frame	17	1	3	3	2	3	2	0	3	0	0	0

6.4 Muscle Test Results

Name	Age	Sex	Trial 1a	Trial 1b	Trial 2a	Trial 2b	Trial 3a	Trial 3b
PW	73	M	185.7	175.7	136.8	138.5		
KM	78	M	93.6	102.3	138.0	133.0	129.07	140.49
JW	84	F	165.8	124.0	136.6	134.0		
BB	85	M	25.0	25.0	31.0	33.6		
AB	87	F	82.0	85.8	129.3	115.7		
EB	87	F	20.0	20.0	34.9	28.6		
KG	83	M	98.0	100.0	27.1	79.1		
EF	92	F	30.0	85.0	53.8	79.2		
LT	91	F	26.9	38.6	43.6	25.3		
PD	92	M	183.9	183.3	179.4	191.0	165.0	180.2
SN	81	M	104.9	152.0	105.4	111.5	104.7	116.7
JS	89	M	129.33	127.81	116.72	167.73	117.0	83.7
DO	91	F	54.93	78.43	65.85	65.05		
DF	78	F	29	35	38	38		
MC	80	F	113	119	107	113		
RS	83	M	20	28	35	41		

6.5 Sway Results

Name	Age	Sex	AP RMS 10sec 1a	AP RMS 1b	AP RMS 2a	AP RMS 2b	AP RMS 3a	AP RMS 3b	LAT RMS 1a	LAT RMS 1b
PW	73	M	6.21	9.86	12.29	7.41			2.89	2.38
KM	78	M	9.00	8.12	7.77	5.69	12.28	6.42	7.34	6.13
JW	84	F	4.46	6.78	10.57	10.57			3.29	3.14
BB	85	M	2.58	2.96	2.35	6.09			2.60	2.06
AB	87	F	4.95	5.83	4.05	4.17			3.16	3.68
EB	87	F	5.06	4.29	5.46	4.52			3.35	4.64
KG	83	M	6.64	21.11	8.79	12.27			4.45	8.65
EF	92	F	18.79	5.34	7.72	5.45			17.58	8.98
LT	91	F	failed	failed	6.91	6.91				
PD	92	M	4.39	4.33	5.36	3.56	3.77	4.66	2.55	3.94
SN	81	M	4.21	3.06	4.01	3.26	5.37	4.95	2.22	4.06
JS	89	M	15.33	13.60	9.93	17.23	9.19	9.21	5.82	21.36
DO	91	F	5.38	3.16	3.23	3.13			2.49	1.69
DF	78	F	2.67	1.79	2.81	3.09			1.32	2.77
EC	97	F	2.62	1.78	2.79	2.68			1.10	1.17
MC	80	F	7.97	8.52	4.49	4.59			3.27	4.49
RS		M	5.53	4.42					5.18	4.79

SWAY RESULTS(cont)

Name	LAT RMS 2a	LAT RMS 2b	LAT RMS 3a	LAT RMS 3b	Sway %bosAP 1a	Sway %bosAP 1b	Sway %bosAP 2a	Sway %bosAP2b	Sway %bosAP 3a
PW	3.80	2.54			2.07	3.29	4.10	2.47	
KM	4.00	4.48	7.11	3.10	3.21	2.90	2.78	2.03	4.39
JW	3.76	3.76			1.54	2.34	3.78	3.78	
BB	1.43	1.73			0.99	1.14	0.84	1.96	
AB	1.79	4.34			1.83	2.16	1.50	1.54	
EB	5.55	5.49			2.11	1.87	2.60	2.15	
KG	8.68	5.29			2.37	7.54	3.26	4.72	
EF	7.40	4.07			6.96	1.78	2.86	2.02	
LT	2.95	2.95					2.56	2.56	
PD	3.97	3.04	2.29	3.49	1.63	1.55	1.91	1.27	1.35
SN	3.04	3.99	4.07	4.26	1.56	1.13	1.49	1.21	1.99
JS	4.86	5.70	5.33	8.09	5.68	5.04	3.31	6.38	2.78
DO	1.84	1.02			1.86	1.22	1.29	1.25	
DF	1.69	2.19			0.95	0.62	1.00	1.10	
EC	1.68	2.73			1.19	0.81	1.16	1.07	
MC	2.84	2.84			3.62	3.87	1.80	1.84	
RS					2.13	1.70			

SWAY RESULTS(cont)

Name	Sway %bosAP3b	Sway %bosLat 1a	Sway %bosLat1b	Sway %bosLat2a	Sway %bosAP2b	Sway %bosLat3a	Sway %bosAP3b
PW		1.28	0.82	1.38	0.82		
KM	2.14	3.41	2.72	1.86	2.24	2.68	1.29
JW		1.53	1.34	1.47	1.47		
BB		1.30	1.03	0.64	0.72		
AB		1.86	2.10	0.94	2.80		
EB		1.86	2.58	3.08	3.43		
KG		2.07	3.68	3.62	2.35		
EF		9.77	4.73	3.29	2.09		
LT				1.59	1.59		
PD	1.66	1.00	2.02	1.53	1.17	0.93	1.45
SN	1.77	0.78	1.53	1.19	1.70	1.89	1.89
JS	2.71	2.33	7.63	1.94	2.28	2.60	4.26
DO		1.61	1.02	0.92	0.57		
DF		0.63	1.23	0.75	1.02		
EC		0.39	0.43	0.76	1.44		
MC		1.26	2.09	1.26	1.54		
RS		3.45	2.40				

6.6 Stability Limits Results

Name	Age	Sex	AvgAntStL1a	AvgAntStL1b	AvgAntStL2a	AvgAntStL2b	AvgAntStL3a	AvgAntStL3b	MaxAntStL1a	MaxAntStL1b	MaxAntStL2a
PW	73	M	83.19	85.33	95.95	93.51			100.46	110.65	132.17
KM	78	M	15.27	25.02	6.11	27.86	19.39	24.82	37.33	53.48	49.69
JW	84	F	incomplete	11.29	fell	22.01				24.71	
BB	85	M	9.16	13.44	14.99	36.14			15.17	21.51	23.29
AB	87	F	17.56	16.77	27.72	31.12			28.89	43.69	47.41
EB	87	F	23.03	failed	34.25	25.04			51.60		41.93
KG	83	M	5.32	19.50	no try	no try			21.19	26.86	79.51
EF	92	F	26.73	failed	42.35	refused			39.33		63.27
PD	92	M	42.96	50.10	55.74	51.80	35.56	47.77	72.90	80.66	71.00
SN	81	M	9.77	16.56	11.63	10.02	15.45	15.02	22.83	32.62	30.49
JS	89	M	7.78	21.23	44.78	23.74	20.63	11.81	34.10	38.81	72.18
DO	91	F	10.48	16.29	6.61	9.19			17.13	23.80	13.94
DF	78	F	21.89	15.74	18.45	12.95			29.03	25.10	27.19
EC	97	F	21.83	12.38	17.54	20.20			26.28	23.92	29.63
MC	80	F	27.69	24.41	27.71	27.22			35.06	40.09	41.85
RS		M									

Stability limits (cont)

Name	Age	Sex	MaxAntStL2b	MaxAntStL3a	MaxAntStL3b	AvgPostStL1a	Avg PostStL1b	AvgPost StL2a	AvgPostStL2b	AvgPost StL3a	AvgPostStL3b
PW	73	M	130.20			24.70	38.87	42.49	47.82		
KM	78	M	61.88	46.36	48.55	7.21	6.81	9.80	11.08	18.78	23.72
JW	84	F	42.28				9.45		5.32		
BB	85	M	49.36			2.68	3.85	5.17	5.31		
AB	87	F	42.87			8.73	10.77	10.89	10.57		
EB	87	F	35.87			1.36		12.01	7.87		
KG	83	M	25.80				4.65	15.53	27.74		
EF	92	F				6.82		22.91			
PD	92	M	70.42	49.62	62.52	31.48	34.21	27.58	30.07	30.94	30.51
SN	81	M	31.15	27.60	24.50	11.65	8.73	6.66	4.72	5.96	10.94
JS	89	M	48.89	49.06	33.33	5.90	15.36	7.44	6.76	7.15	4.70
DO	91	F	16.04			8.20	14.14	3.90	3.93		
DF	78	F	18.77			6.23	10.77	3.18	4.13		
EC	97	F	27.07			14.24	3.44	12.40	7.39		
MC	80	F	44.64			5.30	8.61	16.40	7.18		
RS		M									

Stability Limits(cont)

Name	Age	Sex	Max PostStL1a	Max PostStL1b	MaxPostStL2a	MaxPostStL2b	MaxPostStL3a	MaxPostStL3b
PW	73	M	45.35	61.54	79.82	80.91		
KM	78	M	27.33	35.34	27.86	36.71	34.79	45.56
JW	84	F		22.76		16.56		
BB	85	M	11.46	11.76	11.31	19.48		
AB	87	F	18.25	17.14	25.47	18.57		
EB	87	F	21.11		29.07	35.08		
KG	83	M	19.02	13.10	24.15	39.21		
EF	92	F	33.79		44.05			
PD	92	M	48.15	42.21	53.77	46.60	50.43	58.96
SN	81	M	32.42	19.45	21.97		18.50	20.12
JS	89	M	37.16	39.25	33.29	36.44	22.35	17.93
DO	91	F	17.76	22.00	8.74	14.20		
DF	78	F	23.00	24.14	13.25	11.12		
EC	97	F	23.41	13.49	34.32	21.42		
MC	80	F	26.32	37.01	35.91	24.00		
RS		M						

Stability Limits (cont)

Name	Age	Sex	AP%BOS1a	AP%BOS1b	AP%BOS2a	AP%BOS2b	AP%BOS3a	AP%BOS3b	AVgLeftStL1a	AvgLeftStL1b	AvgLeftStL2a
PW	73	M	35.96	41.40	46.15	47.11			91.50	81.34	26.18
KM	78	M	7.25	9.95	5.68	12.98	13.16	16.74	11.28	14.39	12.93
JW	84	F		7.41		11.39			17.12		13.37
BB	85	M	4.39	6.40	7.47	15.35			16.57	19.25	18.44
AB	87	F	10.52	11.48	14.30	16.68			40.71	45.46	23.85
EB	87	F	12.20		20.11	12.19					11.56
KG	83	M	2.96	8.63						16.79	
EF	92	F	11.57		23.31				35.50	23.98	
PD	92	M	27.57	31.23	30.86	30.32	23.75	27.96	105.88	113.15	89.64
SN	81	M	7.93	9.37	6.53	5.26	7.65	9.27	36.95	26.48	25.15
JS	89	M	5.07	13.55	19.34	11.30	10.29	6.11	58.29	66.17	67.31
DO	91	F	7.18	11.70	4.20	5.25			22.30	30.55	28.07
DF	78	F	10.04	9.47	7.73	6.10			17.21	9.63	8.96
EC	97	F	16.40	6.33	12.48	11.50			27.50	32.80	36.57
MC	80	F	14.34	14.36	18.38	14.96			59.35	33.92	36.95
RS		M	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!					

Stability Limits(cont)

Name	Age	Sex	AvgLeftStL2b	AvgLeftStL3a	AvgLeftStL3b	MaxLeftStL1a	MaxLeftStL1b	MaxLeftStL2a	MaxLeftStL2b	MaxLeftStL3a	MaxLeftStL3b
PW	73	M	25.63			109.29	94.89	44.71	38.56		
KM	78	M	13.26	52.52	19.85	27.00	33.77	31.57	37.45	102.66	43.30
JW	84	F				23.93		27.12			
BB	85	M	44.49			23.20	24.47	29.60	50.02		
AB	87	F	32.82			50.38	62.99	38.12	48.18		
EB	87	F	23.61					21.17	35.49		
KG	83	M					27.03				
EF	92	F				50.86	30.77				
PD	92	M	87.69	83.29	87.03	139.55	148.23	142.77	132.81	115.36	114.92
SN	81	M	20.12	35.52	22.26	49.61	35.97	42.26	32.67	53.30	37.37
JS	89	M	72.55	17.36	22.44	90.83	88.64	105.07	111.19	32.42	34.76
DO	91	F	32.45			27.52	35.21	32.78	36.66		
DF	78	F	7.33			22.11	17.65	13.98	10.70		
EC	97	F	44.22			38.69	45.26	62.56	56.04		
MC	80	F	27.70			78.53	47.36	45.18	41.98		
RS		M									

Stability Limits (cont)

Name	Age	Sex	Avg RightStL1a	AvgRightStL1b	AvgRightStl2a	AvgRightStL2b	AvgRightStl3a	AvgRightStL3b	MaxRightStL1a	MaxRightStL1b	MaxRightStL2a
PW	73	M	91.91	73.89	33.69	25.96			103.47	99.74	40.38
KM	78	M	21.83	13.70	36.27	29.01	50.23	14.15	58.10	29.32	49.38
JW	84	F	14.37		14.78				23.91		20.45
BB	85	M	19.16	13.18	12.61	29.20			27.04	19.07	19.54
AB	87	F	35.00	43.35	25.89	37.09			48.76	54.25	44.35
EB	87	F			10.55	27.56					24.44
KG	83	M		11.88						18.10	
EF	92	F	28.79	16.58					48.73	27.81	
PD	92	M	103.34	103.50	87.69	82.35	88.37	83.64	141.20	154.44	129.15
SN	81	M	36.09	25.96	23.24	31.13	41.59	24.86	48.77	34.78	34.84
JS	89	M	52.13	33.80	36.91	39.94	23.86	14.20	128.13	57.68	62.47
DO	91	F	36.12	28.18	28.69	26.27			39.53	34.03	31.52
DF	78	F	18.95	11.23	7.83	8.19			35.14	16.94	15.85
EC	97	F	31.32	39.08	30.35	39.16			38.88	46.29	42.28
MC	80	F	53.13	27.89	36.51	26.57			65.62	43.16	46.06
RS		M									

Stability Limits (cont)

Name	Age	Sex	MaxRightStL2b	MaxRightStL3a	MaxRightStL3b	Lat%BOS1a	Lat%BOS1b	Lat%BOS2a	Lat%BOS2b	Lat%BOS3a	Lat%BOS3b
PW	73	M	39.34			70.54	66.06	23.03	19.84		
KM	78	M	58.03	71.03	42.17	15.05	12.77	19.68	23.48	46.70	15.45
JW	84	F				14.65		11.98			
BB	85	M	32.46			20.42	17.07	15.53	36.85		
AB	87	F	65.29			45.88	43.32	26.18	46.61		
EB	87	F	39.34					14.26	34.11		
KG	83	M					11.95				
EF	92	F				32.15	24.58	#DIV/0!	#DIV/0!		
PD	92	M	119.86	114.55	112.45	87.18	81.75	69.54	62.98	70.07	69.66
SN	81	M	43.76	53.87	39.51	21.80	23.84	23.60	21.81	33.53	26.93
JS	89	M	90.99	31.16	35.86	42.47	35.70	48.47	47.87	18.32	16.65
DO	91	F	32.17			29.96	29.37	29.11	29.36		
DF	78	F	11.05			15.39	8.34	8.19	7.22		
EC	97	F	56.16			29.41	35.06	33.46	41.69		
MC	80	F	41.73			46.87	25.75	31.94	27.14		
RS		M				#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		

6.7 Sit-To-Stand And Stand-To-Sit Results

Name	Age	Sex	Sit/Stand1a	Sit /Stand1b	Sit/Stand2a	Sit/Stand2b	Sit/stand3a	Sit/stand3b	Stand /Sit1a	Stand/Sit1b	Stand/Sit2a	Stand/Sit2b	stand/sit3a	stand/sit3b
PW	73	M	1.19	1.61	1.52	1.15			2.48	2.40	2.68	2.45		
KM	78	M	1.72	2.08	3.67	1.89	2.00	1.55	3.89	2.25	2.58	1.9	4.23	1.94
JW	84	F	3.31	4.86	6.10				3.39	2.75	3.05			
BB	85	M	3.85		4.76	3.85			7.55		14.12	9.73		
AB	87	F	5.25		2.73	2.67			1.41		2.93	3.06		
EB	87	F	8.88		1.76	1.49			2.08		1.39	1.66		
KG	83	M	18.35						6.49					
EF	92	F							6.49					
LT	91	F			4.13						2.38			
PD	92	M	1.89	2.14	2.67	2.35	2.19	2.12	2.93	3.04	3.05	3.05	1.76	1.77
SN	81	M	5.91	3.60	3.21	4.38	3.79	4.09	3.92	3.39	2.35	2.57	4.00	2.55
JS	89	M	3.21	3.21	9.30	5.40	6.13	5.26	2.94	3.97	4.39	4.02	1.72	3.00
DO	91	F	7.54	5.09	2.79	5.73			4.3	4.06	4.14	4.1		
DF	78	F	2.47	2.26	2.77	1.78			3.01	2.76	2.17	2.17		
EC	97	F	5.18	3.53	5.27	3.18			2.62	3.1	2.96	2.7		
MC	80	F	3.18	12.33	5.12	6.53			2.84	4.21	3.48	3.34		
RS		M	5.17	15.51										

6.8 Turn 360 Degrees

			Time clockwise seconds			Clockwise in seconds			Steps anticlockwise			Steps to turn clockwise		
Name	Age	Sex	Trial 1	trial 2	trial 3	trial 1	trial2	trial3	trial 1	trial2	trial3	trial1	trial 2	trial 3
PW	73	M	13.65	7.54		10.45	8.44		14	9		12	9	
KM	78	M	14.1	12.97	7.38	11.6	11.49	7.58	11	11	5	9	11	5
JW	84	F												
BB	85	M												
AB	87	F	11.8	13.44		12.78	12.46		8	8		7	7	
EB	87	F												
KG	83	M												
EF	92	F												
LT	91	F												
PD	92	M	13.77	8.3	7.17	10	7.28	7.07	12	6	8	9	6	8
SN	81	M	19.92	17.82		18.2	13.12		9	10		10	9	
JS	89	M	27.97	22.99		16.23	21.97		18	18		14	16	
DO	91	F		34.22			34.1			13			11	
DF	78	F	15.74	13.28		16.72	11.15		9	7		9	7	
EC	97	F	38.93	31.56		36.56	26.43		17	17		16	12	
MC	80	F	17.01	17		25.41	16.39		9	9		10	9	
RS		M												

APPENDIX 7

7.1 Intervention Form

Name: .....

Gait Aid used: nil / stick / frame (circle)

date	time	init. H.R.	init. RESP.	time at 1st rest	time at 2nd walk	time at 2nd rest	time at 3rd walk	time at 3rd rest	time at 4th walk	time at 4th rest	time at 5th walk	time at 5th rest	post walk H.R.	post walk RESP	total No of laps	total walking distance	total walking time

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7.2 Intervention Results

Name: Subject PD

Gait Aid used: Stick

date	time	init. H.R.	init. RESP.	time at 1st rest	time at 2nd walk	time at 2nd rest	time at 3rd walk	time at 3rd rest	time at 4th walk	time at 4th rest	time at 5th walk	time at 5th rest	post walk H.R.	post walk RESP.	total number of laps	total walking distance	total walking time
21.3		35	8	6.35	7.30	11.12	12.30	15.00					39	17	34	408	12.47
22.3		35	9	6.25	7.33	15.00							41	16	37	444	14.00
26.3		35	10	6.63	7.56	15.00							48	10	40	480	14.00
27.3		44	11	5.03	6.07	12.58	14.00	15.00					39	10	40.5	486	12.55
28.3		34	11	3.38	4.43	8.50	9.57	12.56	14.00	15.00			40	12	34	408‘	11.45
29.3		33	12	4.09	5.15	7.15	8.18	10.56	12.00	15.00			39	12	36	432	11.47
1.4		32	10	6.29	7.33	11.52	12.57	15.00					40	11	42	504	12.00
2.4		34	10	6.14	7.17	13.24	14.27	15.00					41	12	41	492	12.50
3.4		35	8	8.44	9.46	15.00							47	12	44.5	532	14.00
4.4		33	8	5.17	6.20	11.13	12.34	15.00					42	13	45	540	12.55
11.4		33	7	4.27	5.33	10.19	11.22	15.00					45	12	44	528	12.55
12.4		34	10	4.06	5.10	7.12	9.14	11.52	12.55	15.00			41	14	30	360	10.43
16.4		35	8	4.40	5.43	8.18	9.21	13.16	14.20	15.00			40	12	41.5	496	12.00
17.4		34	8	4.45	5.49	9.24	10.29	15.00					46	14	43	516	12.45

Intervention Results (cont)

Name: ..SN

Gait Aid used: frame

date	time	init. H.R.	init. RESP.	time at 1st rest	time at 2nd walk	time at 2nd rest	time at 3rd walk	time at 3rd rest	time at 4th walk	time at 4th rest	time at 5th walk	time at 5th rest	post walk H.R.	post walk RESP.	total No. of laps	total walking distance	total walking time
21.3		27	8	3.04	4.22	6.32	7.41	9.14	10.20	12.42	13.50	15.00	34	12	31	372	10.21
22.3		32	11	3.39	4.46	6.57	8.04	10.17	11.23	13.38	14.92	15.00	40	12	29	348	11.24
25.3		31	9	2.53	3.58	6.38	7.43	10.28	11.33	15.00			36	11	34	408	11.05
26.3		31	9	3.28	4.36	6.47	7.54	9.59	11.05	13.24	14.29	15.00	67	12	30	360	10.33
27.3		25	11	2.56	4.01	6.19	7.25	9.41	10.47	12.59	14.04	15.00	37	12	29	348	10.36
28.3		28	9	2.55	4.00	6.50	7.56	10.50	11.55	13.27	14.33	15.00	36	12	29.5	354	10.40
29.3		37	9	2.50	3.56	6.06	7.11	9.24	10.29	12.43	13.47	15.00	35	10	29.5	354	10.30
1.4		33	10	3.56	5.03	7.40	8.48	11.31	12.37	15.00			39	12	35.5	426	11.46
2.4		32	10	3.48	4.55	7.33	8.38	10.43	11.48	15.00			35	11	36	432	11.48
3.4		35	11	3.04	4.10	6.43	7.48	9.46	10.530	14.09			39	10	31	372	10.34
4.4		31	11	2.36	3.40	5.38	6.42	8.48	9.53	11.52	12.57	15.00	39	12	32	384	11.30
11.4		31	10	4.09	5.15	8.47	9.52	13.28	14.33	15.00			40	11	33.5	402	11.44
12.4		31	10	3.32	4.39	7.37	8.43	10.45	11.52	15.00			38	11	33.5	402	11.40
15.4		32	9	3.03	4.11	6.52	7.59	10.44	11.51	14.28			39	11	34	408	12.35
16.4		28	10	3.12	4.19	6.54	8.00	10.49	11.52	15.00			33	11	36	432	11.40
17.4		31	9	3.19	4.24	7.50	8.57	10.56	12.01	14.47			41	11	33	396	12.30
18.4		32	11	2.36	3.42	5.46	6.51	8.55	10.01	12.40	13.47	15.00	38	12	32	384	10.26
19.4		32	9	3.23	4.29	7.40	8.45	10.42	11.47	15.00			43	12	36	432	11.45
22.4		34	10	3.26	4.33	7.12	8.20	11.50	12.55	15.00			39	10	34.5	414	11.40
23.4		33	10	3.16	4.22	7.03	8.09	10.03	11.09	13.49	14.54	15.00	37	11	32.5	390	10.30
24.4		32	10	3.10	4.16	6.13	7.20	9.22	10.27	12.28	13.33	15.00	35	10	32.5	390	10.50
25.4		35	10	3.08	4.13	7.19	8.25	10.20	11.25	14.00			39	12	34	408	10.50

Intervention Results (cont)

Name: JS

Gait Aid used: frame

date	time	init. H.R.	init. RESP.	time at 1st rest	time at 2nd walk	time at 2nd rest	time at 3rd walk	time at 3rd rest	time at 4th walk	time at 4th rest	time at 5th walk	time at 5th rest	post walk H.R.	post walk RESP.	total No of laps	total walking distance	total walking time
21.3		30	9	6.40	7.46	12.35	12.40	15.00					37	12	7	96	13.50
22.3		27	11	3.31	4.38	7.08	8.11	11.40	12.43	15.00			34	14	10	120	11.50
25.3		25	11	3.27	4.31	7.42	8.47	9.48	10.53	13.37	14.40	15.00	38	12	11	132	11.50
26.3		29	10	3.29	4.33	7.36	8.39	12.53	13.56	15.00			40	11	11.5	138	11.40
27.3		33	11	2.59	4.02	6.55	7.58	12.01	13.04	15.00			38	12	12	144	11.55
28.3		28	10	2.40	3.44	6.40	7.44	9.37	10.40	12.31	13.34	15.00	39	12	12	144	11.10
29.3		30	11	1.33	2.36	4.08	5.11	8.17	9.19	11.29	12.33	13.26	38	12	13	156	9.50
1.4		31	10	2.24	3.28	6.13	7.16	9.28	10.31	11.52	12.54	15.00	42	11	15	180	11.30
2.4		29	9	3.19	4.22	7.05	8.07	10.55	11.58	14.07			37	11	15	180	10.40
3.4		30	10	4.32	5.34	9.31	10.33	15.00					35	10	11.5	138	13.00
4.4		32	10	5.07	6.10	10.04	11.09	15.00					36	10	10	120	13.00
15.4		28	11	5.01	6.04	11.40	12.44	15.00					35	11	10	120	13.00
16.4		28	11	4.21	5.25	11.48	12.51	15.00					36	11	8.5	102	12.50
17.4		27	11	4.01	5.05	10.28	11.32	15.00					32	11	9.5	114	12.50
18.4		29	11	5.33	6.36	9.11	10.14	15.00					36	11	9.5	114	13.10
19.4		32	10	6.02	7.06	10.48	11.51	15.00					37	10	10.5	126	12.50
22.4		27	11	7.07	8.10	12.27	13.31	15.00					33	11	9.5	114	12.30
23.4		34	11	5.51	6.54	9.46	10.48	14.47					40	11	9	108	14.40
24.4		30	11	6.23	7.26	10.01	11.05	15.00					38	11	10	120	13.03
25.4		35	10	5.24	6.27	9.05	10.08	15.00					41	12	9.5	114	13.10

Intervention Results (cont)

Name: KM

Gait Aid used: Holds rail

date	time	init. H.R.	init. RESP.	time at 1st rest	time at 2nd walk	time at 2nd rest	time at 3rd walk	time at 3rd rest	time at 4th walk	time at 4th rest	time at 5th walk	time at 5th rest	post walk H.R.	post walk RESP.	total No of laps	total walking distance	total walking time
12.4		35	8	8.38	9.40	15.00							47	9	46	552	14.00
15.4		35	9	8.29	9.31	15.00							43	11	43	516	14.00
16.4		35	10	4.22	5.25	10.45	11.47	15.00					45	11	43	516	13.00
17.4		36	10	4.22	5.25	15.00							45	11	42.5	510	14.00
18.4		32	9	4.56	5.59	11.03	12.05	15.00					45	11	43	516	13.00
19.4		35	9	4.57	6.00	10.27	11.29	15.00					44	11	43	516	13.00
23.4		32	9	6.20	7.23	13.32	14.35	15.00					40	10	45	540	13.00
24.4		31	9	5.44	6.47	10.41	11.45	15.00					40	11	47.5	570	13.00
25.4		36	9	6.18	7.19	10.26	11.28	15.00					42	10	49	588	13.00
26.4		35	9	5.50	6.52	10.36	11.38	15.00					45	10	52	624	13.00
29.4		32	9	6.42	7.44	11.17	12.19	15.00					42	10	50.5	606	13.00
30.4		33	9	5.47	6.49	11.30	12.32	15.00					42	10	52.5	630	13.00
1.5		32	9	6.17	7.18	11.12	12.15	15.00					42	10	52.5	630	13.00

APPENDIX 8

Statistics Report

1. Introduction

Statistical analysis was requested by Dr Andrew Nunn and Ms Julie Graham from the Caulfield General Medical Centre (CGMC). Measurements on a Kistler force platform in a group of 17 elderly patients were provided. The main objective was to correlate these measurements with the following results:

- Scores from the Mini Mental State Examination (MMSE) which is a cognitive assessment administered to the selected group of patients giving an indication of the severity of dementia. The maximum possible score for the test is 30. This examination was conducted in the ward following an interview with the subject in which the study was explained and consent was signed.

- Scores from a test using the Berg Balance Scale (BERG) which was developed for use with geriatric patients and has been validated and tested for reliability. The test consists of 14 items examining each subject's ability to maintain positions of increasing difficulty by diminishing the base of support. The maximum possible score for the test is 56. The test was performed one week prior to the tests on the force platform.

- The number of falls during their stay in CGMC. Since the duration of stay ranged from 16 to 129 days, the average number of falls per day (FALLS) was correlated with the force platform measurements. No adjustment has been made for the medical condition of each patient as the information was not available for analysis.

In general, each test on the force platform was performed twice (trials 1a and 1b) with a seated rest between each activity. The same test was repeated twice on the following day (trials 2a and 2b). Thus, a total of 4 measurements were recorded for each test if a subject completed all the trials successfully. A secondary objective was to compare these repeated measurements to find out if there was any statistical difference between the results.

2. The Data

The data were provided in two Microsoft Excel spreadsheet files. Inconsistencies in the coding of the data were checked and rectified with Ms Julie Graham. The following measurements obtained from the force platform were required for analysis:

- The average force used by the subject in a muscle test over a 5 second period to push the leg out as strongly as possible while it was attached to the force platform at 2 anchor points.

- The average of the magnitude of lateral displacement from the centre of pressure over a period of 30 seconds expressed as a percentage of the length of the foot (SWAY%bosLAT) and similarly, the average of the magnitude of displacement in the anterior/posterior position expressed as the percentage of the length of the foot (SWAY%bosAP). These are recordings from the sway test in which the subject was asked to stand still on the force platform looking straight ahead at a yellow circle. Thus, a lower percentage indicates a lesser degree of sway.

- The percentage of the base of support used in an anterior/posterior direction to establish stability (STABILITY AP%bos) and the percentage of the base of support used in establishing lateral stability (STABILITY LAT%bos). These are recordings from the stability limits test in which the subject was asked to keep feet still on the platform and lean forward as far as possible, and then backwards as far as possible. In the next part of the test the subject was asked to lean to the left side and then to the right side. Thus larger percentages indicate greater stability.

- The length of time the subject took to stand up from sitting on a chair (Sit/Stand). This was the result from a sit to stand test in which a recording was taken of the subject standing up from sitting on the chair, standing still for 10 seconds, then sitting down again.

- The time and number of steps taken to turn through 360 degrees in both anticlockwise (TimeAnti360, StepsAnti360) and clockwise (TimeClock360, StepsClock360) directions. In this test, the subject was instructed to take steps to turn through 360 degrees, first in an anticlockwise direction, then in a clockwise direction.

Subjects were requested to perform all the tests twice on the same day apart from the test requiring the subject to turn through 360 degrees. In the latter test, subjects were only requested to perform once. After the tests on the first day, subjects were asked to return on the following day to repeat each test.

Data on MMSE, BERG and FALLS were available in all subjects apart from subject RS.

3. Statistical Methods

The association between two measurements was examined using the Pearson correlation coefficient (r). The value of r always lies between -1 and +1. A positive value of r indicates that the measurements are positively correlated, that is, an increase in the magnitude of one measurement is associated with an increase in the magnitude of the other. On the other hand, a negative value of r indicates that the two measurements are negatively correlated, that is, an increase in the magnitude of one measurement is associated with a decrease in the magnitude of the other. For each r, a P-value was given which gives an indication of the statistical significance of the correlation coefficient. This value is dependent on the sample size. All tests of significance were based on a significance level of 0.05, that is, if the P-value was less than 0.05, then the correlation coefficient was deemed to be significantly different from zero. Note that, in determining the strength of a correlation, the magnitude of the correlation coefficient as well as the result of the significance test should be taken into account. The following is a guideline for determining the strength of a correlation based on the magnitude of r:

r	Strength of the correlation
<0.25	weak
0.25 - 0.49	mild
0.50-0.74	moderate
≥0.75	strong

Each pair of repeated measurements was compared using a 2-sided *t* test for matched pairs and a P-value of less than 0.05 was deemed to be significant.

The analyses were carried out using the BMDP statistical package (version 1993) and Microsoft Excel (version 5.0). No adjustments have been made for multiple comparisons.

4. Results

For each subject, the first available result for each quantity, that is, the first of the results from trials 1a, 1b, 2a and 2b, on the force platform was used to correlate with MMSE, BERG and FALLS (Table 1).

Correlations between MMSE, BERG and FALLS

The average number of falls (FALLS) was strongly correlated with BERG ($r = -0.75$, $P<0.001$, figure 1). The result suggests that subjects with higher BERG scores are less likely to fall. There was, however, no suggestion of an association of MMSE with FALLS ($r=0.005$, $P=0.98$) or with BERG ($r=-0.24$, $P=0.38$).

Correlations between MMSE and measurements from the force platform

The correlation coefficient for MMSE and the time to make a 360 degree anticlockwise turn was 0.53. However, the result of the statistical test was not significant ($P=0.12$, figure 2). For the remaining measurements, there was no suggestion of an association with MMSE (r ranging from -0.11 to 0.37).

Correlations between BERG and measurements from the force platform

The correlation between BERG and the muscle test score was significant ($r = 0.52$, $P=0.038$, figure 3). The result suggests that subjects with higher BERG scores will have higher scores in the muscle test. In figure 3, the 3 subjects with the top 3 BERG scores all had higher muscle test scores than the remaining subjects. However, among these remaining subjects, it does not appear that there was an association between the two scores. The correlation coefficient between BERG and the muscle test score was only 0.055 after excluding the above 3 subjects, thus suggesting no association overall between BERG and the muscle score. For results from the sway test, BERG was negatively correlated with both SWAY%bosAP ($r=-0.56$, $P=0.038$, figure 4) and SWAY%bosLAT ($r=-0.67$, $P=0.005$, figure 5). The results suggest that there will be smaller magnitudes of displacement from the centre of pressure for subjects with higher BERG scores than subjects with lower BERG scores. In figures 4 and 5, only the subject with the lowest BERG score had a much higher result than the remaining subjects for each quantity under study and among these remaining subjects, it does not appear that there was any association between the two results for each quantity. After excluding the particular subject, the correlation coefficient for SWAY%bosAP and SWAY%bosLAT became -0.14 and -0.09 respectively, thus indicating no association of BERG with either SWAY%bosAP or SWAY%bosLAT. For the stability results, BERG was positively correlated with STABILITY AP%bos ($r=0.51$, $P=0.051$, figure 6) but had a weaker correlation with STABILITY LAT%bos ($r=0.33$, $P=0.23$, figure 7). Again, figures 6 and 7 shows that only the two subjects with the top 2 BERG scores had much higher results than the remaining subjects for each quantity and among these remaining subjects, it does not appear that there was any association between the results. After removing the above 2 subjects, the correlation coefficient for STABILITY AP%bos and STABILITY LAT%bos became -0.048 and -0.32 respectively, thus indicating no evidence of association with BERG. The data did not suggest that there was any association of BERG with the sit to stand and the 360 degree turn results in which r ranged from -0.37 to 0.19.

Correlations between FALLS and measurements from the force platform

The only measurements on the force platform that were strongly associated with FALLS were results from the sway test, ie, SWAY%bosAP ($r=0.57$, $P=0.021$, figure 8) and SWAY%bosLAT ($r=0.87$, $P<0.001$, figure 9). The results suggest that subjects who were displaced more from the centre of pressure in the sway test would be more likely to fall. In figures 8 and 9, the subject who fell most

frequently had much higher sway scores than the remaining subjects and among these remaining subjects, it does not appear that there was any association between the 2 quantities. Removing the particular subject, the correlation coefficient for SWAY%bosAP and SWAY%bosLAT were only -0.21 and 0.15 respectively. There was a mild correlation between FALLS and the muscle test result which suggests that subjects with higher muscle scores will be less likely to fall (r=-0.34, P=0.19, figure 10). For other measurements on the platform, the correlation coefficient with FALLS ranged from -0.16 to 0.05.

Repeated measurements

For each trial, the mean and standard deviation of each measurement on the force platform are given in Table 2. The test which required the subject to make a 360 degree turn was not performed by nearly half of the number of subjects as the task was found to be too difficult to perform.

The following comparisons were made (Table 3):

- Testing if there was a difference between the 2 results on day 1, ie, trials 1a versus 1b
- Testing if there was a difference between the 2 results on day 2, ie, trials 2a versus 2b
- Testing if there was a difference between the first test result on both days, ie, trials 1a versus 2a

Results on STABILITY LAT%bos in trial 1b were, on average, lower than those obtained in trial 1a (P=0.038). However, the difference between the 2 test results on day 2 were not significant. The time to make an anticlockwise 360 degree turn on day 2 were shorter than the time needed on day 1 (P=0.015). On average, it took 3 seconds less to complete a turn on day 2. Similarly, for a clockwise 360 turn, on average, it took 3 seconds less to complete a turn on day 2 although results were not statistically significant (p=0.08). This may be an indication that the subjects were more capable of doing the turn on the following day. None of the remaining statistical tests were significant.

Table 1. Correlation of measurements on force platform with MMSE, BERG and FALLS

	MMSE	BERG	FALLS	Muscle	SWAY %bosAP	SWAY %BOSLA	STABILITY	STABILITY	Sit/Stand	TimeAnti360	Time Clock36	Steps Anti360	Steps Clock36
MMSE													
BERG	-0.24												
FALLS	0.005	-0.75***											
Muscle	0.11	0.52*	-0.34										
SWAY%bosAP	-0.017	-0.56*	0.57*	-0.007									
SWAY%bosLAT	-0.11	-0.67**	0.87***	-0.27	0.79***								
STABILITY AP%bos	-0.11	0.51	-0.11	0.52*	-0.12	-0.13							
STABILITY LAT%bos	0.21	0.33	-0.061	0.62*	0.09	-0.08	0.80***						
Sit/Stand	-0.077	-0.37	0.05	-0.30	-0.039	0.023	-0.30	-0.38					
TimeAnti360	0.53	-0.29	-0.035	-0.42	0.042	-0.23	-0.30	-0.31	0.66				
TimeClock360	0.37	-0.35	0.018	-0.58	-0.16	-0.37	-0.30	-0.38	0.67	0.86***			
StepsAnti360	0.22	0.19	-0.14	0.19	0.38	0.044	0.14	0.16	0.19	0.68*	0.30		
StepsClock360	0.24	0.083	-0.16	-0.001	0.23	-0.23	0.09	-0.037	0.50	0.80**	0.55	0.89***	

$0.01 < P < 0.05$ *
$0.001 < P < 0.01$ **
$P < 0.001$ ***

Table 2. Means and Standard Deviations (SD) for each trial of each measurement on the force platform.

		DAY 1		DAY 2	
		Trial 1a	Trial 1b	Trial 2a	Trial 2b
Muscle	n	17	17	17	17
	mean	83.4	91.7	85.0	91.7
	SD	57.7	51.5	48.6	51.1
SWAY%bosAP	n	16	16	16	16
	mean	2.48	2.44	2.27	2.33
	SD	1.67	1.80	1.03	1.46
SWAY%bosLAT	n	16	16	16	16
	mean	2.16	2.33	1.64	1.70
	SD	2.21	1.79	0.93	0.79
STABILITY AP%bos	n	14	13	13	13
	mean	12.38	13.95	16.66	15.42
	SD	9.18	10.44	11.91	11.50
STABILITY LAT%bos	n	13	13	13	12
	mean	36.29	31.97	27.31	33.25
	SD	22.23	21.43	16.57	15.07
Sit/Stand	n	16	14	15	14
	mean	4.88	4.46	4.72	3.75
	SD	4.20	3.60	3.91	3.84
TimeAnti360	n	9	-	10	-
	mean	19.21	-	17.91	-
	SD	8.84	-	9.10	-
TimeClock360	n	9	-	10	-
	mean	17.55	-	16.28	-
	SD	8.60	-	8.62	-
StepsAnti360	n	9	-	10	-
	mean	11.89	-	10.80	-
	SD	3.69	-	4.05	-
StepsClock360	n	9	-	10	-
	mean	10.67	-	9.70	-
	SD	2.83	-	2.95	-

Table 3. Comparisons of repeated measurements

	Trial 1b - Trial 1a				Trial 2b - Trial 2a				Trial 2a - Trial 1a			
	n	mean	SD	P	n	mean	SD	P	n	mean	SD	P
Muscle	17	8.3	21.5	0.13	17	6.8	19.4	0.17	17	1.6	29.9	0.83
SWAY%bosAP	16	-0.046	1.96	0.93	16	0.069	1.08	0.80	15	-0.26	1.60	0.54
SWAY%bosLAT	16	0.18	2.02	0.73	16	0.063	0.74	0.74	15	-0.43	1.85	0.38
STABILITY AP%bos	12	2.02	4.62	0.16	12	-0.35	4.92	0.81	13	3.55	5.98	0.05
STABILITY LAT%bos	12	-4.46	6.53	0.038*	12	4.66	10.30	0.15	12	-8.24	15.15	0.09
Sit/Stand	13	0.75	3.58	0.46	14	-0.15	3.09	0.86	14	0.0029	3.64	0.99
TimeAnti360	-	-	-	-	-	-	-	-	9	-3.11	3.04	0.015*
TimeClock360	-	-	-	-	-	-	-	-	9	-3.25	4.88	0.08
StepsAnti360	-	-	-	-	-	-	-	-	9	-1.33	2.50	0.15
StepsClock360	-	-	-	-	-	-	-	-	9	-1.11	2.15	0.16

$0.01 < P < 0.05$ *

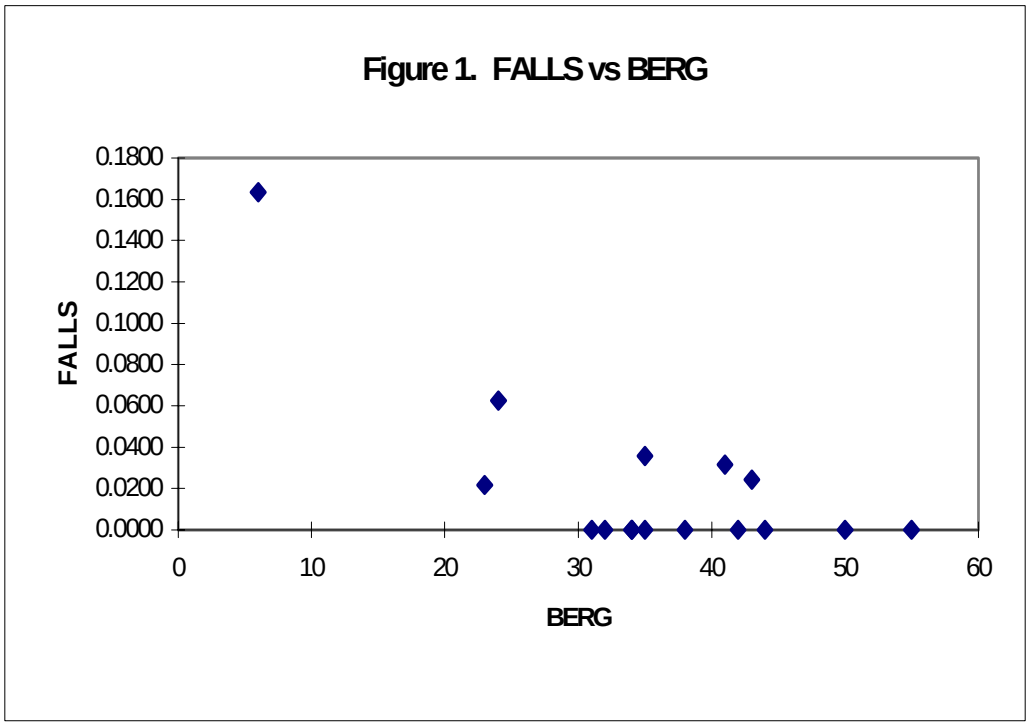


Figure 1. FALLS vs BERG
FALLS
0.1800
0.1600
0.1400
0.1200
0.1000
0.0800
0.0600
0.0400
0.0200
0.0000
0
10
20
30
40
50
60
BERG

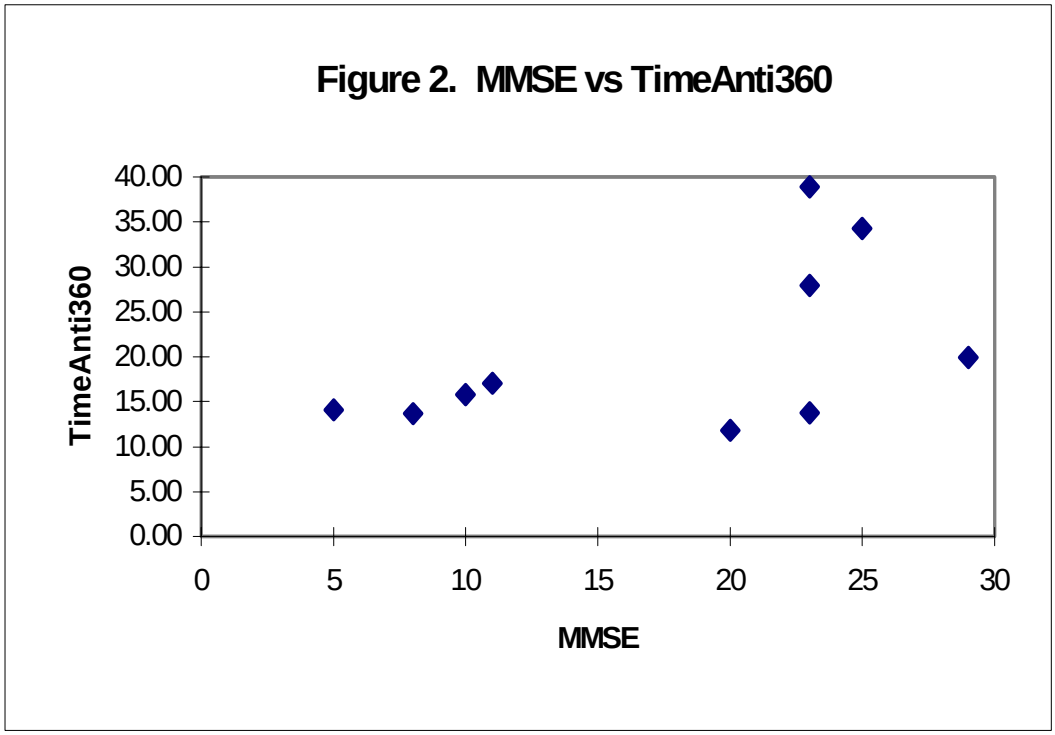


Figure 2. MMSE vs TimeAnti360
TimeAnti360
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
5
10
15
20
25
30
MMSE

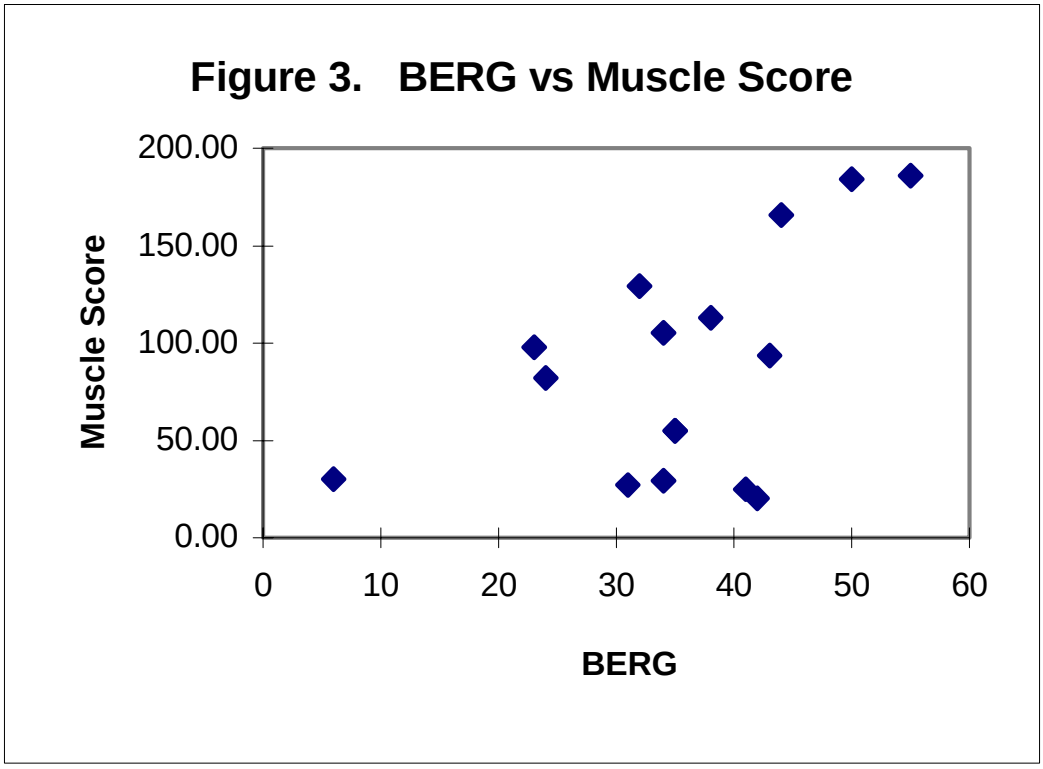


Figure 3. BERG vs Muscle Score
Muscle Score
200.00
150.00
100.00
50.00
0.00
0
10
20
30
40
50
60
BERG

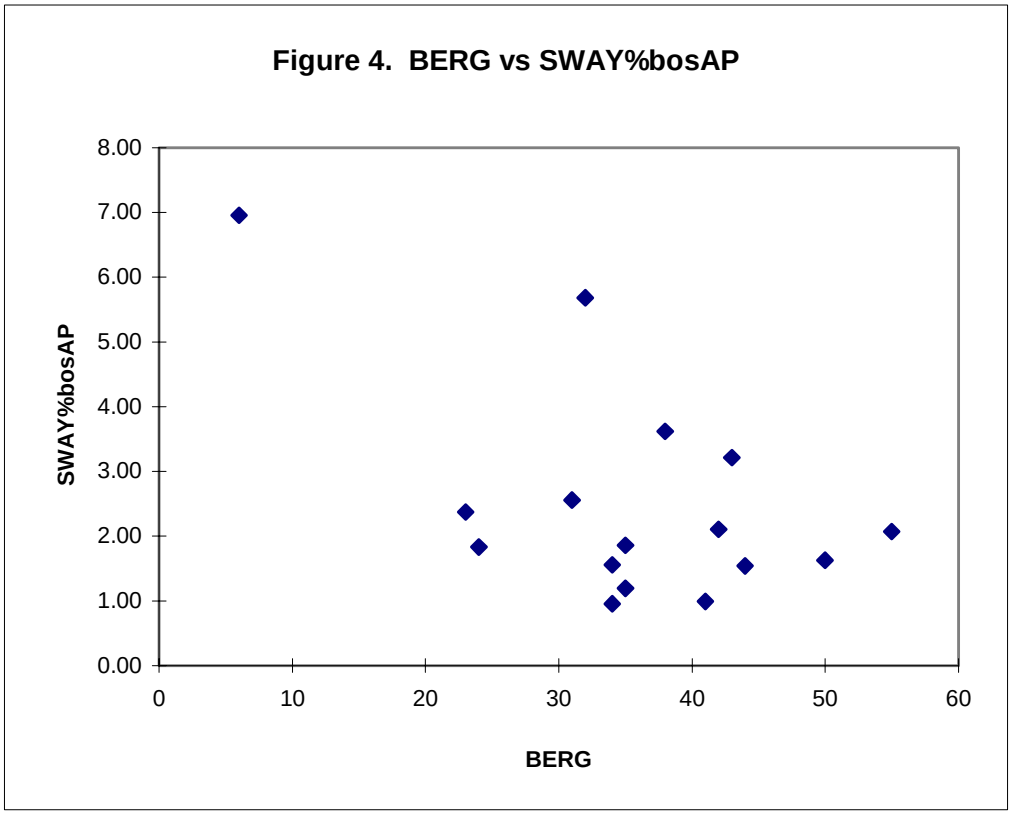


Figure 4. BERG vs SWAY%bosAP
SWAY%bosAP
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
10
20
30
40
50
60
BERG

Figure 5. BERG vs SWAY%bosLAT

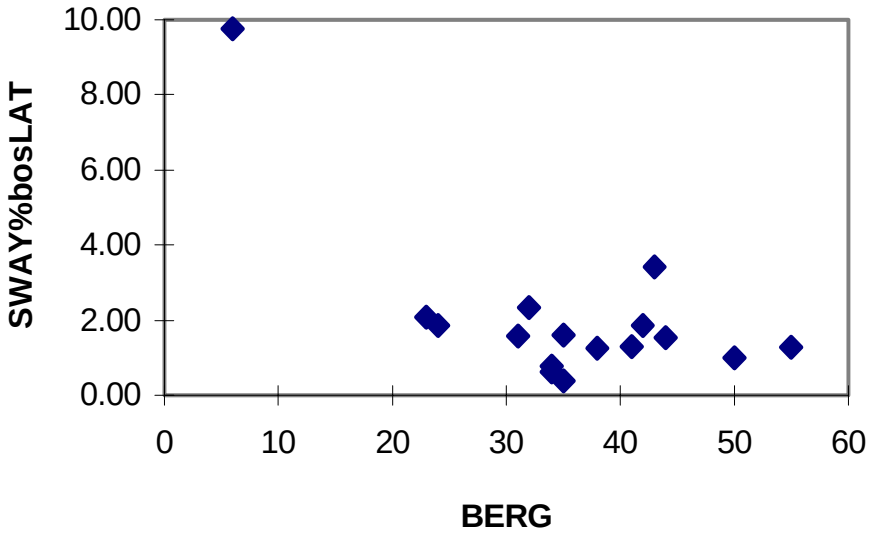


Figure 6. BERG vs STABILITY AP%bos

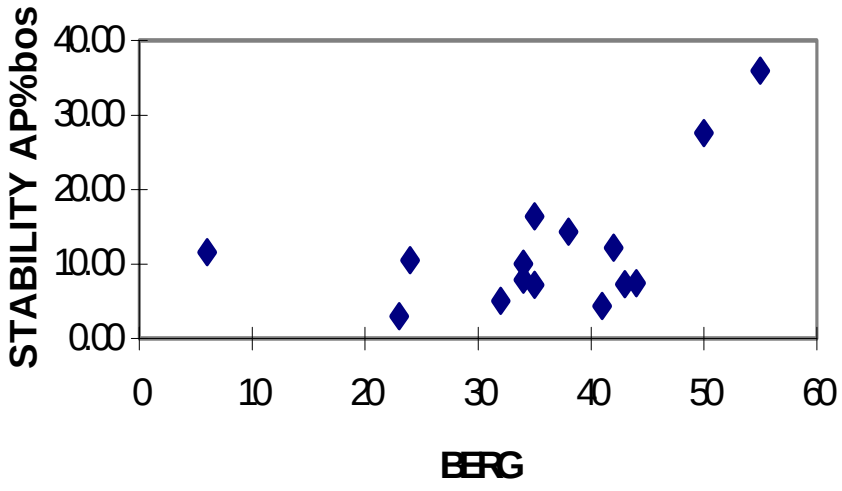


Figure 7. BERG vs STABILITY LAT%bos

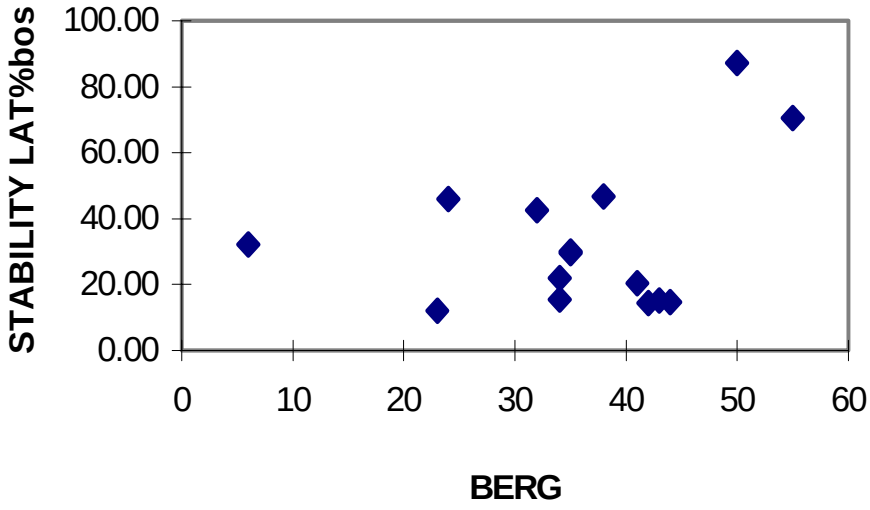


Figure 8. FALLS vs SWAY%bosAP

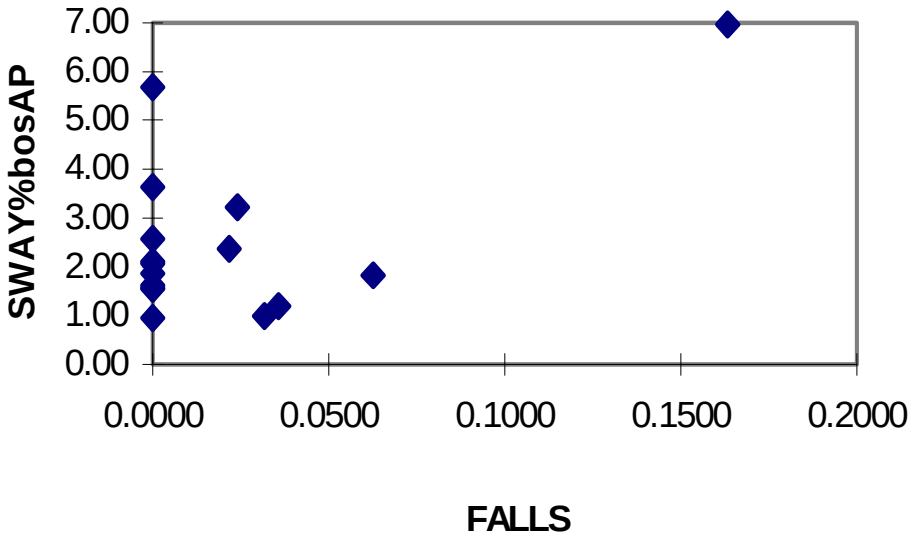


Figure 9. FALLS vs SWAY%bosLAT

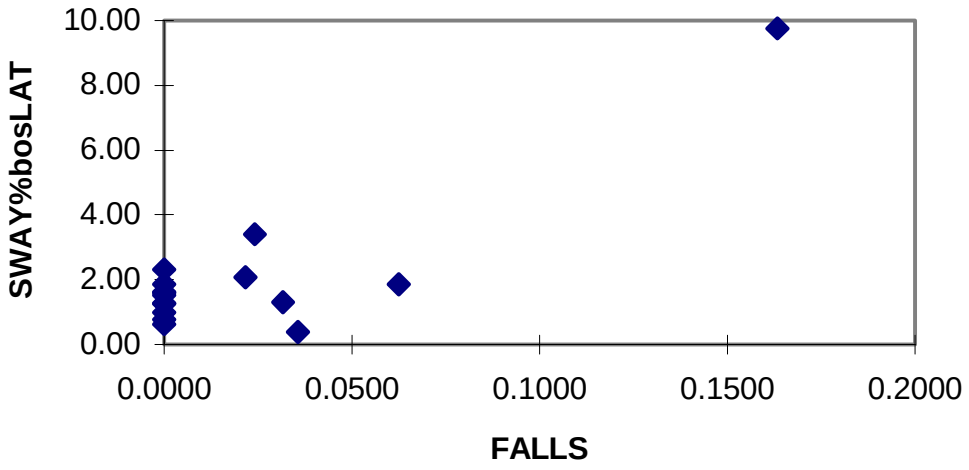
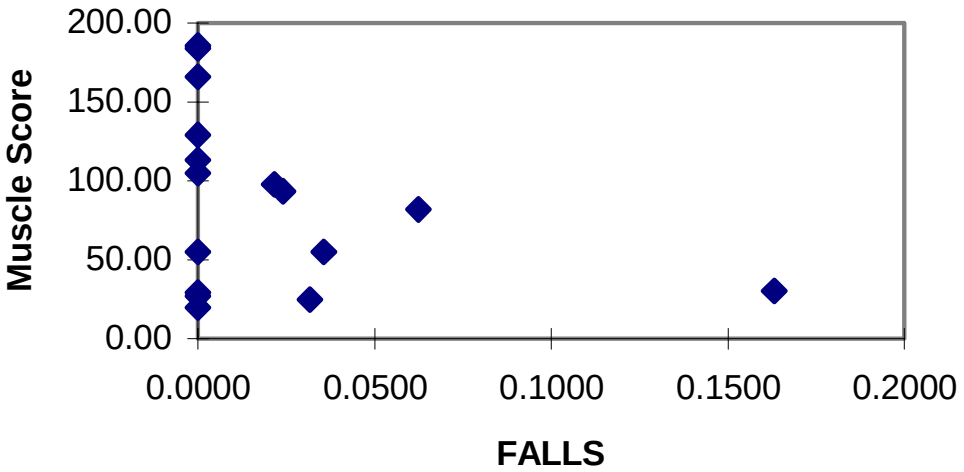


Figure 10. FALLS vs Muscle Score



APPENDIX 9

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