THE EFFECTS OF A LOWER BODY RESISTANCE-TRAINING PROTOCOL ON STATIC
BALANCE AND WELL-BEING IN OLDER ADULT WOMEN

by

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We accept this thesis as conforming to the required standard

UNIVERSITY OF BRITISH COLUMBIA

April 2002

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Date April 24 / 02
ABSTRACT

Studies in the area of balance have shown that the hip girdle musculature is involved in one of the main strategies employed in regaining balance. It has also been shown that 12-week strength training programmes undertaken at any age can show modest improvements in strength and profound effects in functional independence. **PURPOSE:** To examine the relationship between lower body function in the muscles associated with the hip girdle, static balance and well-being in a 12 week training programme. **METHODS:** Using a quasi-experimental design, forty-four women aged 70 and older volunteered into the control (n_c=22, Mean Age = 76.10 ± 3.54 (SD)) or training group (n_T=22, Mean Age = 76.16 ± 4.24). Subjects were tested on 2 functional lower body tests; a Timed Two-Legged Squat (TLS) and Timed Chair Stand (TCS). Static balance was assessed using timed platform stability under 3 different conditions with eyes open and closed and well-being was assessed using a self-report questionnaire. Subjects in the training group were allotted to supervised training workouts consisting of 1 hour stretching and strengthening programmes 3x/wk for 12 weeks. Subjects in the control group were asked to maintain their daily routines and not participate in additional activities. **RESULTS:** Thirty-eight women completed the study (n_c=20, n_T = 18) and a 2x2 ANOVA with repeated measures on one factor demonstrated a statistical significant effect in the TLS (p<0.001), and TCS (p<0.001). As well, of the six conditions tested for balance, only one condition (Eyes closed, psi=4.0) demonstrated a significant difference (p=0.026) between groups. Other statistically significant results were demonstrated only within the training group from weeks 0-6 (p=0.044) in condition B (Eyes open, psi=2.5) and from weeks 6-12 (p=0.019) in condition F (Eyes closed, psi=4.0). Results of the questionnaire from the training group were all positive and suggest that undertaking a strength-training programme can improve one’s well-being.
CONCLUSION: These results suggest that a lower body resistance training programme can improve lower body function, well-being and static balance. Further research, with larger sample sizes, is warranted to assess the effects on varying aspects of balance under different conditions.
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INTRODUCTION

The prevalence of falls in the elderly is a growing concern. The elderly population will double in the next 20 years due to the baby boomer generation aging and being the largest cohort. Research has shown that one-third of people aged 65 years or older fall each year and that about one-half of all people aged 80 or older fall at least once per year [1-4]. Consequently, more research is being conducted in order to identify the potential risk factors for falls and fall related injuries as well as strategies to prevent those falls. The risk factors for falls and fall related injuries are multifactorial and range from nutritional deficits and muscle atrophy to poor balance and osteoporosis ([5]).

Poor balance has been identified as a risk factor for falling [4, 6]. Balance itself is composed of 3 main inputs: visual, vestibular and somatosensory. To utilize these three inputs to their potential, one must maintain certain baseline strength. As one ages, one loses muscle mass and consequently strength [7, 8]. The question then arises; if one improves or maintains strength with age, will one improve or maintain balance as well? To answer this question many components must be separated and individually researched. Specifically, one could look at the muscles involved in maintaining balance while utilizing the hip fall prevention strategy, which is most widely used by the elderly population. The hip fall strategy is employed when the centre of gravity (COG) remains within the limit of stability, but is shifted, in a direction opposite to the hip because of the inertia of the trunk. Coordination and activation of the lower extremity muscles about the ankle, knee and hip joints resist destabilization and the abdominals are activated to flex the hip and move the COG backward [9].

Strength training programmes undertaken at any age can induce modest improvements in strength and profound effects in functional independence [8, 10, 11]. However, like any training protocol, the principles of specificity apply and benefits of training only accrue to the muscles
trained. Accordingly, when discussing balance, one must investigate the primary muscles associated with balance; when discussing the elderly those muscles are associated with the hip. Thus, the main goal of this research is not preventing falls but instead to focus on whether strength training can improve one’s hip strategy for regaining balance, i.e. do improvements in strength in the muscles associated with the hip girdle improve static balance in older adult women?

Rationale

- Research is useful to the aging population
  - Population of seniors will double over the next 20 years and falls occur in one-third of the population over 65
- Area is worth studying for its impact on strategies for reducing frequency of fall related morbidity and mortality
- More commonly used strategy to regain balance in older population is the hip strategy
  - Muscles mainly activated in this movement are the quadriceps and abdominals.

Objectives

- To determine the effects of a short-term (12 weeks) progressive resistance exercise programme on lower body function of women aged 70 and older.
- To evaluate the relationship between progressive resistance exercise and timed static balance as measured by the Kinesthetic Ability Trainer (K.A.T.).
METHODOLOGY

Those subjects recruited for the study underwent preliminary testing one week prior to the start of the training programme. Subjects in the study were tested on three main primary outcomes:

1) Neuromuscular recruitment by the timed two-legged squat;

2) Lower Body Function by the timed chair stand; and

3) Static balance assessed by the Kinesthetic Ability Trainer (K.A.T.).

Training consisted of 12 weeks of a progressive resistance training programme outlined in Appendix B. Post Training testing was completed within 1 week of finishing the programme.

Participants

Forty-four women aged 70-86 (Table 1) who lived in the Greater Vancouver District participated in the study. All subjects included in the study were considered untrained as defined as participating in exercise less than 2 hours per week, and did not meet any of the exclusion criteria. Subjects were recruited through posters and advertisement in local newspapers. Interested respondents were first interviewed over the phone and then subject selection involved medical clearance to participate in the study. Exclusion criteria were: (i) Restricted limb or trunk movement; (ii) Medical contraindications to maximal muscle strength testing; (iii) Uncontrolled hypertension or diabetes; (iv) Symptomatic cardiorespiratory disease; (v) Severe renal or hepatic disease; (vi) Uncontrolled epilepsy; (vii) Progressive neurological disorder; (viii) Dementia over DSM level 3; (ix) Marked anaemia (with Hg less than 100 G/L); (x) Marked obesity with inability to exercise; (xi) Medication with B-Blockers, Warfarin or CNS stimulants; (xii) Already performing intense Cardiovascular exercise for more than 30 minutes, 3x/week. Subjects were
then placed into the control (C) group or the training (E) group depending on their preference. It should be noted that although subjects self selected their group, each subject volunteered for the study initially with the intent and motivation to exercise as recruitment posters expressed the need for volunteers to participate in a training study. Thus one could argue, that although randomization of subject allotment did not take place, the subjects in each group were characteristically homogeneous in their motivation and desire to exercise. Subjects in the training group (n_E = 22) were allotted to workouts consisting of 1 hour strengthening and stretching programmes 3 times per week. Participants in the control group (n_C=22) were asked to maintain their current lifestyle.

Table A. Group Characteristics

<table>
<thead>
<tr>
<th>Group Characteristics</th>
<th>Control Group (n = 22)</th>
<th>Exercise Group (n = 22)</th>
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<tbody>
<tr>
<td>Age (years)</td>
<td>75.9 (3.7)</td>
<td>76.1 (4.8)</td>
</tr>
<tr>
<td>PASE Questionnaire</td>
<td>127.1 (57.5)</td>
<td>108.8 (51.4)</td>
</tr>
<tr>
<td>Activity Score</td>
<td></td>
<td></td>
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</tbody>
</table>

Values shown are means (±SD)
Note. The differences between the control and exercise groups were not statistically significant for either the age or PASE scores.

Training Protocol

The training protocol was designed especially for this study and was comprised of exercises that were associated with the hip girdle and lower body. The training protocol commenced one week after preliminary testing and continued for twelve weeks. Training occurred three times per week for one hour including warm up (10 minutes), strengthening (35 minutes) and stretching (15 minutes). The ratio of subjects to trainer was usually 1:1 with a maximum 4:1. Muscles targeted in the programme include (i) Quadriceps, (ii) Hamstrings, (iii) Gluteus Medius, (iv) Tensor Fascia Latae, (v) Gastrocnemius, (vi) Rectus Abdominus, and (vii) Transversus

The training programme was divided into two parts. The first phase consisted of 4 weeks of familiarization, coordination and adaptation to exercise. The subjects performed 1 set of 20 repetitions for all exercises except the Timed Two-Legged Squat where a maximum length of time was encouraged. The second part of the training programme, commenced in the 5th week and continued until the end of the 12 weeks. This phase focused on muscular endurance and subjects performed 2 sets of 15 repetitions for all exercises except the Timed Two-Legged Squat. Resistance was increased individually according to progress logged. After 12 weeks of training, subjects underwent physical testing again on their Timed Two-Legged Squat, Timed Chair Stand and K.A.T. Balance performance. By the study's end, 4 women from the E group had dropped out of the study due to illness (n=1), and soreness (n=3). Whereas 2 women from the C group dropped out as they did not wish to participate further (n=2). Upon completion of the study 38 women had been divided into two groups: E group (n=18) and C group (n=20).

Facilities

Two facilities were used to conduct training in this study. The Executive BirdCoop at UBC was the primary location. The fitness centre at the Kerrisdale Community centre was also used during the study because of the willingness of the participants but the unavailability of the transit system in the Greater Vancouver District during the study to transport the participants to the Executive BirdCoop.
Equipment

The following equipment was used in this study for testing:

- Standard Armless Chair – 45 cm from ground
- Plumb line – 10 cm from the wall
- Goniometer
- Stopwatch
- K.A.T. Balance System

The K.A.T. 2000 Balance Platform (Breg Inc. Fallbrook, CA) offers a quantitative assessment for both static and dynamic balance. The K.A.T. consists of a stable base, a moveable platform located over an air bladder, a handrail and digital display of pressure. The display of the bladder is in pressure per square inch (psi) and is accurate at the 0.5% level from 0 to 7 psi. The support becomes more stable as air pressure within the bladder increases [12].

The following equipment was used in this study for training:

- Leg Press & Leg Curl
  - Keiser Equipment Systems, (Fresno CA)
  - Hoist Fitness Systems, (San Diego CA)
- Thera-band resistive elastic bands and tubing (Hygenic Co, Akron, OH)
  - Red – Easy
  - Purple - Medium
- Ankle Weights
  - Adjustable 5 and 10 pound ankle weights (All-Pro, Carpinteria, CA)
- Standard Armless Chair – 45 cm from the ground
  - Turnstile Chair
  - Stability Ball (Resist-A-Ball, Destin, FLA) 45-55 cm
Experimental Protocol

Subjects were asked to refrain from excessive exercise on the day of the test. Testing in both groups (E and C) was carried out at baseline and after 12 weeks. Testing was also carried out at 6 weeks for the training group. Baseline Testing included an informed consent form, the PASE questionnaire and three tests: The Timed Two-Legged Squat (TLS), the Timed Chair Stand (TCS) and the K.A.T. Balance System were used to measure balance as a function of time. Anonymity of the subject was maintained by using a subject number instead of the person’s name on the questionnaire and assessment sheets. A sample test sheet is located in Appendix B.

Preliminary Testing

Variables that were measured include:

1) Lower body function by the Timed Chair Stand;
2) Timed Static balance by the K.A.T. Balance System platform; &
3) Neuromuscular Recruitment by the Timed Two Legged Squat;
4) Physical Activity Level by the Physical Activity Scale for the Elderly (PASE) questionnaire. Sample questionnaire is located in Appendix B.

Week 6 – Mid-Training Testing

Due to extraneous circumstances only subjects in the E group underwent 6-week testing on the Timed 2 Legged Squat, Timed Chair Stand and Timed K.A.T. Balance measure.

Post Training Testing

Following the 12 weeks, subjects in both the C and E groups underwent post-training testing. Variables that were measured include:

1) Lower body function by the Timed Chair Stand;
2) Timed Static balance by the *K.A.T. Balance System platform*;

3) Neuromuscular Recruitment by the *Timed Two Legged Squat*;

4) Self-Reported Well-Being by a *Subjective Questionnaire*;

5) Physical Activity Level by the PASE questionnaire for the C group only.

**Test Protocols**

The Timed Chair Stand (TCS) measured lower extremity function as total time in seconds to rise five times from an armless chair positioned 45cm from the ground. Subjects were not to use their arms to support themselves to achieve a standing position. Research has shown the chair stand to be a reliable physical performance measure [13]. This protocol was repeated three times.

Crawford et al. [12] developed the K.A.T. Balance measure protocol. Each subject was given six trials: three conditions of platform stability (1.0, 2.5, 4.0 psi) and two visual conditions, eyes open and eyes closed. Because of a concern for safety for the older adults, the eyes open conditions were given before the eyes closed conditions. A random numbers table was used to select platform stability settings for the eyes open condition. The same order was used for the eyes closed condition. A completely randomized selection of test conditions was not used because of the concern for safety of the older adults.

To ensure consistency, one investigator set all platform stability settings. Also, prior to the first test condition, the psi value was set to 6.0 psi to replicate the stance on a hard surface. The subject stepped onto the platform in a comfortable position. The investigator outlined the subject’s feet with chalk to insure consistent foot placement throughout the six trials. To begin the test, the psi level was adjusted to the first randomly selected trial. A taped shield in front of the display blocked the subject’s view of the settings and a standard set of instructions was given before each trial. Those instructions were, “(i) Focus on a mark on the wall; (ii) Maintain a level
platform until you either grab the handrail, are told to stop or 30 seconds passes; (iii) Let go on the count of 3.” The subject then removed their hands from the handrail upon command and stood as quietly as possible and tried not to grab the handrail. The measure of balance was recorded as the length of time the subject maintained platform stability within ± 0.2 psi for a maximum of 30 seconds. Each trial was terminated if the subject: 1) grabbed the railing; 2) could not maintain the set platform stability within ± 0.2 psi; 3) completed the 30 second trial; or 4) opened eyes during the eyes closed conditions.

After each trial, the subject had the option of stepping off and the same procedure was used for the next two trials with the subject’s eyes open. After the three conditions were run with the subject’s eyes open, the eyes closed tests was performed in the same order as the eyes open conditions. Subjects were permitted to rest between trials.

The Timed Two-Legged Squat (TTLS) protocol had the subject perform a squat as low as possible without body deviation from a plumb line and maintaining biomechanically efficient alignment of their knees, nose and toes. To achieve this consistently, the subject had to maintain a starting position facing the wall. Their toes were 10 cm from the wall with their hands on their shoulders and arms abducted 90 degrees. The test started when the tester requested the subject squat as low as possible to the ground while keeping their heels on the floor, and maintaining their nose, knees and toes 10 cm from the wall. The subject could not touch the wall with any part of the body and their head had to remain parallel to the floor. The test was considered complete when the subject deviated from the squat position. Quantifiable measures in the test included knee angle and total time in seconds the squat was sustained from the tester’s request. This protocol was repeated three times.
PASE Questionnaire

Washburn et al. [14] devised the Physical Activity Scale for the Elderly (PASE) to measure activity levels of adults aged 65 and older. The PASE Questionnaire was utilized in this study as a marker to explain any differences between the training and control groups. As well, it was used to discern any test score discrepancies between pre and post testing in the control group. The questionnaire is simple, and consists of only 10 questions. The average time to fill out the questionnaire was between 5 and 10 minutes.

Self-Reported Well-Being

A self-response question, administered at the end of the programme, was designed to measure if the participants noted any change in their own well being since starting the programme. Assuming that each individual participant could successfully judge the state of their current well being, a single post-programme question regarding the changes in their lifestyle was asked. The question was as follows, “Since starting the programme, has your sense of well-being changed? And if so, how?” A sample test sheet is located in Appendix B.

Statistical Analysis

The Statistical package used to analyze all data was SPSS 10.0 for Windows. All data was considered continuous. A 2X2 mixed design with repeated measures (pre to post) and between subjects (exercise versus control) factors analysis of variance was conducted to test differences between the E and C groups in Timed Two-Legged Squat, Timed Chair Stand and Timed K.A.T. Balance measures. As well a one-way (3x1) repeated measures ANOVA was conducted to test differences between pre-, mid-, and post-testing within the training group for each test variable. A simple main-effects analysis (post-hoc for the interaction) was executed to look at group differences at pre and post training times. Intraclass correlations and Pearson Product Moment
correlations were used to conduct test-retest reliability between trials for the TLS and TCS and t-tests were used to analyze differences between PASE scores.

**Hypotheses**

1) The E group will exhibit a greater increased difference in Two-Legged Squat times than the C group as measured by the Timed Two-Legged Squat after 12 weeks.

2) The E group will exhibit a greater decreased difference in time for their Timed Chair Stand than the C group as measured by the Timed Chair Stand after 12 weeks.

3) The E group will exhibit a greater increased difference for their timed balance measures than the C group as measured by the K.A.T. Balance System after 12 weeks in the following trials:
   3.1 Eyes Open K.A.T. psi set to 1.0
   3.2 Eyes Open K.A.T. psi set to 2.5
   3.3 Eyes Open K.A.T. psi set to 4.0
   3.4 Eyes Closed K.A.T. psi set to 1.0
   3.5 Eyes Closed K.A.T. psi set to 2.5
   3.6 Eyes Closed K.A.T. psi set to 4.0

4) The E group will report more of a demonstrated improvement in well-being than the C group as answered by the post training subjective questionnaire.
RESULTS

The focus of this study was aimed at functional tests and thus no exact measures of strength were taken. Following are the results of the Timed Two-Legged Squat, Timed Chair Stand, KAT Balance Measure and Well-Being Question. However, to show there was an actual increase in lower body strength, Table 1 shows the average weight lifted after weeks 1, 6 and 12. Thus demonstrating indirectly an improvement in lower body strength.

Table 1. Average Weight used during Exercise After Weeks 1, 6, and 12.

<table>
<thead>
<tr>
<th>Exercise (lbs)</th>
<th>Week 1</th>
<th>Week 6</th>
<th>Week 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg Press(^a)</td>
<td>173.23 (19.03)</td>
<td>234.62 (41.36)</td>
<td>258.00 (49.08)</td>
</tr>
<tr>
<td>Hamstring Curl(^a)</td>
<td>35.69 (7.26)</td>
<td>43.85 (8.91)</td>
<td>47.00 (8.23)</td>
</tr>
<tr>
<td>Hip Flexion(^b)</td>
<td>6.32 (2.46)</td>
<td>9.01 (3.12)</td>
<td>10.63 (3.22)</td>
</tr>
<tr>
<td>Hip Abduction(^b)</td>
<td>5.15 (2.38)</td>
<td>8.07 (3.19)</td>
<td>9.99 (3.54)</td>
</tr>
<tr>
<td>Standing Calf Raise(^b)</td>
<td>5.76 (2.91)</td>
<td>9.01 (3.12)</td>
<td>10.63 (3.22)</td>
</tr>
<tr>
<td>Controlled Knee Raise(^b)</td>
<td>4.88 (2.76)</td>
<td>8.07 (3.19)</td>
<td>9.71 (3.32)</td>
</tr>
</tbody>
</table>

Values shown are means (±SD)
\(a\): Keiser Equipment Systems (Fresno, CA)
\(b\): All Pro Ankle Weights (Carpinteria, CA)

Note: Abdominal Curl data was omitted as it could not be quantified.
Timed Two - Legged Squat

Figure 1 demonstrates a significant difference between the Training (T) group (n=18) and the Control (C) group (n=20) after 12 weeks of training [Interaction test, F (1,36) = 20.22, p<0.001].

As a simple main-effects analysis (post-hoc for the interaction) a t-test was executed to look at group differences at pre and post training times (each t-test at 0.025 significance level).

At baseline measures, the t-test revealed no significant differences between mean TLS times for either group (p=0.808). The post training t-test revealed a significant difference in mean TLS times between the control and training group (p=0.025).
Table 2. Group Means for Average Timed Two Legged Squat

<table>
<thead>
<tr>
<th>GROUP</th>
<th>WEEK 0</th>
<th>WEEK 6</th>
<th>WEEK 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>61.10</td>
<td>NA</td>
<td>58.55</td>
</tr>
<tr>
<td>(n=20)</td>
<td>(30.62)</td>
<td>(24.14)</td>
<td></td>
</tr>
<tr>
<td>Training</td>
<td>58.49</td>
<td>82.77</td>
<td>84.88**</td>
</tr>
<tr>
<td>(n₀=19, n₁₂=18)</td>
<td>(36.16)</td>
<td>(42.85)</td>
<td>(41.06)</td>
</tr>
</tbody>
</table>

Values shown are means (±SD)

** Indicates significant difference compared pre to post (p < 0.001).

Figure 2. Training Group Timed Two-Legged Squat, 0, 6 & 12 Weeks

After reviewing Figure 1 and noting the significant difference (p<0.001) over 12 weeks of training it was revealed that the major change occurred within the first 6 weeks (Figure 2) when the 12 weeks were broken up into two periods: pre-mid (0-6 weeks) and mid-post (6-12 weeks). Only in the first 6 weeks of training was significance shown [t (18)=2.61, p=0.018]. No significant change was noted in the mid-post phase.

In addition, test-retest correlations were conducted to check the reliability of the test. Intraclass correlations as well as Pearson correlations were conducted for each testing period.
Results of the reliability analysis demonstrated significance at the p < 0.01 levels for each testing period and each trial. The results of the correlations for each testing period and trial are in Table 3.

Table 3. Timed Two-Legged Squat Reliability Analysis using Pearson and Intraclass Correlations.

<table>
<thead>
<tr>
<th>Testing Period (Weeks)</th>
<th>Trial 1-2</th>
<th>Trial 2-3</th>
<th>Trial 3-1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pearson (r)</td>
<td>ICC</td>
<td>Pearson (r)</td>
</tr>
<tr>
<td>0</td>
<td>.907</td>
<td>.904</td>
<td>.901</td>
</tr>
<tr>
<td>6</td>
<td>.893</td>
<td>.893</td>
<td>.912</td>
</tr>
<tr>
<td>12</td>
<td>.809</td>
<td>.808</td>
<td>.918</td>
</tr>
</tbody>
</table>

* All values demonstrate significance (p<0.01)

**Timed Chair Stand**

Between-group differences for average chair stand times (TCS) for baseline and post training testing are shown in Figure 3 and demonstrate a significant difference between groups over the 12-week period [Interaction test, F (1,36) = 28.61, p < 0.001].
Table 4. Group Means for Average Timed Chair Stand

<table>
<thead>
<tr>
<th>GROUP</th>
<th>WEEK 0</th>
<th>WEEK 6</th>
<th>WEEK 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>9.35</td>
<td>NA</td>
<td>9.28</td>
</tr>
<tr>
<td>(n=20)</td>
<td>(2.10)</td>
<td></td>
<td>(2.11)</td>
</tr>
<tr>
<td>Training</td>
<td>10.26</td>
<td>8.49*</td>
<td>7.63**</td>
</tr>
<tr>
<td>(n0=19, n12=18)</td>
<td>(2.86)</td>
<td>(1.97)</td>
<td>(1.81)</td>
</tr>
</tbody>
</table>

Values shown are means (±SD)
* Indicates significant difference compared pre to mid (p < 0.001)
** Indicates significant difference compared mid to post (p = 0.001).

A t-test was conducted to confirm group differences at baseline and post training. At baseline, the t-test revealed no differences among group means (p=0.263). However, post-training testing revealed significant differences among the group means (p=0.015). Table 3 reports the group means. Differences within the training group (n=18), over 0, 6 & 12 weeks are shown in Figure 4. The plot revealed significance in TCS means after 12 weeks of training,
between 0 and 6 weeks \( t(18) = 5.34, p < 0.001 \) and between 6 and 12 weeks \( t(17) = 4.21, p = 0.001 \).

*Indicates significant difference: \( p < 0.001 \). ** \( p = 0.001 \)

Figure 4. Training Group Timed Chair Stand 0, 6 & 12 Weeks

Table 5. Timed Chair Stand Reliability Analysis using Pearson and Intraclass Correlations.

<table>
<thead>
<tr>
<th>Testing Period</th>
<th>Trial 1-2</th>
<th></th>
<th></th>
<th>Trial 2-3</th>
<th></th>
<th></th>
<th>Trial 3-1</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pearson ( r )</td>
<td>ICC</td>
<td>Pearson ( r )</td>
<td>ICC</td>
<td>Pearson ( r )</td>
<td>ICC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Weeks)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>.861</td>
<td>.860</td>
<td>.953</td>
<td>.953</td>
<td>.896</td>
<td>.896</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>.938</td>
<td>.937</td>
<td>.957</td>
<td>.957</td>
<td>.883</td>
<td>.882</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>.951</td>
<td>.950</td>
<td>.952</td>
<td>.951</td>
<td>.939</td>
<td>.936</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* All values demonstrate significance \( P < 0.01 \)

To check the reliability of the TCS, test-retest correlations were conducted to see whether the results were consistent with the research by Ostchega et al. [13] who demonstrated an ICC of
p > 0.5. The intraclass and Pearson correlations conducted for each testing period resulted in significance at the p < 0.01 levels for each testing period and each trial (Table 5).

Timed K.A.T. Balance Measure

A within group analysis (n=18) was first conducted to see the effects of training over the three time periods: baseline, mid, and post training. A separate repeated measures ANOVA was utilized for each of the six conditions (i.e., dependent variables) (Table 6).

Table 6. K.A.T. Balance Conditions

<table>
<thead>
<tr>
<th>Eyes Open</th>
<th>Eyes Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. psi = 1.0,</td>
<td>D. psi = 1.0,</td>
</tr>
<tr>
<td>B. psi = 2.5,</td>
<td>E. psi = 2.5,</td>
</tr>
<tr>
<td>C. psi = 4.0,</td>
<td>F. psi = 4.0,</td>
</tr>
</tbody>
</table>

Note: psi refers to pounds per square inch.

The results on the K.A.T. Balance Measure (KBM) revealed no significance on conditions C, D and E. However, condition B shown in Figure 5 [One-way ANOVA with linear trend, F (1,17) = 6.65, p = 0.019], and condition F shown in Figure 6, [One-way ANOVA with linear trend, F (1,17) = 4.75, p = 0.044] both demonstrated significance. Table 7 shows the KBM means for these conditions. Noted also is the trend in condition A towards significance [One-way ANOVA with linear trend, F (1,17) = 4.10, p = 0.059].
Table 7. KBM Means for Conditions A – F within the training group only.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Week 0</th>
<th>Week 6</th>
<th>Week 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (n=18)</td>
<td>3.41 (2.89)</td>
<td>7.22 (9.21)</td>
<td>6.73 (7.29)</td>
</tr>
<tr>
<td>B (n=18)</td>
<td>19.49 (12.58)</td>
<td>25.69 (6.24)</td>
<td>25.74 (6.69)</td>
</tr>
<tr>
<td>C (n=18)</td>
<td>27.59 (6.85)</td>
<td>30.00 (0.00)</td>
<td>30.00 (0.00)</td>
</tr>
<tr>
<td>D (n=18)</td>
<td>1.75 (0.50)</td>
<td>1.49 (0.39)</td>
<td>1.69 (0.49)</td>
</tr>
<tr>
<td>E (n=18)</td>
<td>4.50 (3.95)</td>
<td>3.87 (3.80)</td>
<td>7.00 (8.05)</td>
</tr>
<tr>
<td>F (n=18)</td>
<td>13.02 (12.51)</td>
<td>15.06 (12.23)</td>
<td>19.32 (11.20)</td>
</tr>
</tbody>
</table>

Values are means (± SD)
* Significantly different compared with week 0 (p=0.023).
** Significantly different compared with week 6 (p=0.044).
* Indicates significance between groups compared from pre to post (p=0.026).

*Indicates significant difference from pre to mid (p =0.023).

Figure 5. Training Group K.A.T. Balance Time Condition B, at 0, 6 & 12 Weeks
*Indicates significant difference from mid to post (p =0.044).

Figure 6. Training Group K.A.T. Balance Time Condition F at 0, 6 & 12 Weeks

However, differences were noted in the previous plots and thus 6-week plots were analysed. In condition B, only KBM means for the training group between 0 and 6 weeks ($T_0 = 19.49 \pm 12.58$, $T_6 = 25.69 \pm 6.24$) were significant [$t (18) = 2.48, p = 0.023$]. As for condition F, KBM means for the training group ($T_6 = 15.06 \pm 12.23$, $T_{12} = 19.32 \pm 11.20$) revealed significance only between weeks 6 and 12 [$t (17) = 2.17, p=0.044$].

Group differences were then analysed and of the six conditions tested, only condition F (Eyes closed, psi = 4.0) demonstrated significance, [Interaction test, $F (1,36) = 5.422, p=0.026$]. Figure 7 shows the interaction.
*Indicates significant difference (p =0.026).

Figure 7. Control & Training Groups K.A.T. Balance Time Condition F, 0 & 12 Weeks

The simple main-effects t-test was carried out to confirm group differences at baseline and post training times. The t-test of KBM' means for condition F ($C_0=15.58 \pm 12.57, T_0 = 13.02 \pm 12.51$) revealed, no significant differences between groups at baseline testing. However, at post training testing, significant improvements were seen in the training group ($C_{12}=12.08 \pm 10.32, T_{12}=19.32 \pm 11.20, [t (36) = 2.07, p=0.045]$). For group responses to the K.A.T. Balance conditions refer to Table 8.
<table>
<thead>
<tr>
<th>K.A.T. Balance Condition</th>
<th>Group Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Eyes Open, psi = 1.0</td>
<td>No significant differences were seen between groups. However, both groups saw minor improvement – possibly due to improvements in coordination.</td>
</tr>
<tr>
<td>B. Eyes Open, psi = 2.5</td>
<td>No significant differences were seen between groups. However, a significant difference was seen within the T group over the pre-mid phase and maintained over mid-post phase – improvements possibly due to neural adaptation and coordination.</td>
</tr>
<tr>
<td>C. Eyes Open, psi = 4.0</td>
<td>No significant differences were seen between groups. Condition not challenging enough. Training group improved as a whole but both groups reached upper limit of 30 seconds on test.</td>
</tr>
<tr>
<td>D. Eyes Closed, psi = 1.0</td>
<td>No significant differences were seen between groups. Very challenging condition. Both groups saw average minor decreases over the 12 weeks.</td>
</tr>
<tr>
<td>E. Eyes Closed, psi = 2.5</td>
<td>No significant differences were seen between groups. Challenging condition. Both groups saw average minor improvements but no significant changes.</td>
</tr>
<tr>
<td>F. Eyes Closed, psi = 4.0 *</td>
<td>Significant differences were seen between groups. Also, T group saw significant improvement over mid-post phase – possibly due to improved control over Somatosensory processes.</td>
</tr>
</tbody>
</table>

* Indicates significant improvements (P<0.05).
Self-Reported Well Being

All 39 women who finished the programme answered the question. What resulted were a multitude of positive responses. The patterns that emerged from these responses produced the following categories (Table 9). The number beside the category refers to the amount of times each response was mentioned.

Table 9. Categorical Responses to Self Reported Well Being Question

<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>18</td>
</tr>
<tr>
<td>Will Continue to Exercise</td>
<td>4</td>
</tr>
<tr>
<td>Feel Better/Healthier</td>
<td>7</td>
</tr>
<tr>
<td>Balance Improved</td>
<td>4</td>
</tr>
<tr>
<td>Don’t ache as much</td>
<td>6</td>
</tr>
<tr>
<td>Feel stronger</td>
<td>4</td>
</tr>
<tr>
<td>Easier to climb stairs</td>
<td>6</td>
</tr>
<tr>
<td>More Energy</td>
<td>4</td>
</tr>
<tr>
<td>Satisfaction of doing exercise</td>
<td>5</td>
</tr>
<tr>
<td>Standing steadier</td>
<td>3</td>
</tr>
<tr>
<td>Easier to get up and down</td>
<td>5</td>
</tr>
<tr>
<td>More Alert</td>
<td>3</td>
</tr>
<tr>
<td>Easier to walk</td>
<td>5</td>
</tr>
<tr>
<td>Easier to get out of bathtub</td>
<td>2</td>
</tr>
<tr>
<td>Exercise can be fun</td>
<td>5</td>
</tr>
<tr>
<td>More Flexible</td>
<td>2</td>
</tr>
</tbody>
</table>

All eighteen responses of “No”, came from subjects in the control group. Two subjects in the control group responded yes to the question. Their response as to why their well being had improved over the 12 weeks is because they had decided to undertake an exercise programme. However their PASE questionnaire was analysed, and there was not a significant difference between pre and post reported activity. All other responses resulted from the training group.

Responses to the question were not limited to only those categories mentioned above. The following are anecdotal excerpts (Table 10) taken from the question, “Since starting the programme, has your sense of well-being changed? And if so, how?” These excerpts were chosen as they reflect the general attitude of the participants within the training group.
Table 10. Anecdotal Excerpts to Self-Reported Well-Being Question

“I’m Happier”
“My hips don’t creak when I get out of bed.”
“When I walk – I feel my stomach muscles taut.”
“My laugh muscles got a good workout.”
“I feel lighter on my feet.”
“I have more pep.”
“I ran for the bus.”
“I enjoyed the unique atmosphere of the classes.”
“Knowing that 3 times a week I have to get up and down appropriately, makes me feel that life is wonderful and that at 86 I am still a living and participating part of the human race.”

PASE Questionnaire

Statistical analysis of the PASE scores revealed no significant differences between the activity levels of the control group at pre and post intervals. The questionnaire was used solely as a measuring tool to distinguish any changes the control group may have seen over the 12 weeks.
DISCUSSION

This study showed that static squat times, lower body function, static balance at a platform stability level of 4.0 and well-being improved with a progressive resistance training programme over a course of 12 weeks in women aged 70-86. Although changes were seen over the course of 12 weeks, the majority of change occurred during the first 6 weeks, most likely due to neuromuscular coordination and adaptations [18]. It should be noted that to maintain as well as improve on the changes seen, it is imperative that each subject continue with an exercise programme. Still to induce strength changes from weeks 6-12 or longer one must subscribe to a periodized exercise programme and maintain an intensity whereby the last two repetitions of each set are consistently difficult to perform.

Timed Two-Legged Squat

Patla et al. [15] showed that as one ages one tends to rely more on upper leg and trunk strength to balance, therefore it follows one should train those muscles to improve balance. Previous research on muscular strength and recruitment has mostly used tests of 1RM (Repetition Maximum) [16], strain gauges [17], or isokinetic strength measuring devices [18]. However, none of these tests are considered functional in nature even though they are quite valid and reliable measures of strength. One focus of this study was to utilise functional tests to measure strength and improve independence.

Current literature to date has not used the Timed Two-Legged Squat (TLS) test as a measure of neuromuscular recruitment. However, the TLS was used because it was a non-invasive, easy to administer test and was able to measure muscular recruitment as a function of time from a squat position. The test measured total number of seconds to hold a standing squat while maintaining biomechanical alignment of one's nose, knees and toes 10 cm from the wall.
The test could also be completed standing flush against the wall. For the purpose of this study though, the distance of 10 cm from the wall was chosen so as not to put the subjects in an awkward position against the wall. However, during the course of the study it was noted, that although the stance is a reliable measure (ICC > 0.8) of muscular recruitment, it is not suitable for women aged 70-86 as it is “Unlady like”. Although the stance was practiced by a considerably younger age population before commencing the study, the idea of an “Unlady like” stance never factored into any discussions prior to setting the protocol and was already utilised by the tester and subjects before the stance’s etiquette was called to question.

Analysis of the TLS demonstrated a significant difference between the control and training groups (Table 2) after post (12 weeks) testing. Upon closer analysis of the T group into two time periods (0-6, 6-12 weeks), it was noted that significance was only found during the pre-mid (0-6 weeks) phase of exercise. This would indicate that neuromuscular changes and adaptations did occur but only during the first 6 weeks of training, which is consistent with current research [19].

Although the test can be utilized for any age group, subjects who have flexibility concerns with their lower lumbar or weight bearing concerns because of problematic knees may tend to have difficulty completing the test because of its nature. That is, the test requires continued maintenance of a closed kinetic chain squat that may irritate or aggravate certain conditions. Limitations of the test include not knowing exactly if each subject performed maximally while maintaining their alignment. Placing the subject flush against the wall could alleviate the problem of making sure each subject was lined up properly with the plumb-line. The test could also be improved with the use of a digital goniometer. As well, it is unknown how well these tests differentiate between neuromuscular recruitment and strength gains. Further research is warranted to assess any possible correlations.
However, the simplicity of the test and the fact it can be executed with a stopwatch, goniometer and a wall makes it very accessible and easy to administer. As well, the exercise can be used as a safe introduction and progression into an exercise programme containing concentric and eccentric squats. Future research could utilize this test as a safe isometric, noninvasive measure of neuromuscular adaptation and recruitment.

Timed Chair Stand

Judge et al. [10] concluded in their study with older adults that control of postural muscles was of prime importance rather than muscle force development to improve single stance balance time. Buchner et al. [20] in their review study reported they did not find exercise studies that focused on functional status outcomes other than balance and gait. Ostchega et al. [13] conducted a study using data from the NHANES III survey (National Health and Nutrition Examination survey 1988-1994) and used the timed chair stand (TCS) as one of their physical performance exams. They found the TCS test (ICC > 0.5) to be a reliable measure of functional ability and may also demonstrate any functional limitations. The mean time (SEM) values in seconds recorded from their study for women aged 70-79 are 14.19 (.29) and for women aged 80 and older 16.58 (.30). In a study on sarcopenia, Vandervoot et al. [21] reported functional impairments associated with decreased power capacity is of current interests especially with older adults because daily living activities involve dynamic movements generated by muscle power. They also concluded that muscle dynamics change during aging and that puts considerably more stress on the legs creating muscular fatigue.

Consistent with other studies of functional measures, this study utilised the timed chair stand as a functional measure of lower body strength and power because it was easy to administer, score and had high test-retest reliability (ICC>0.860, r=0.861).
Analysis after 12 weeks of training between the control and training groups demonstrated a significant difference (p<0.001). Upon further analysis of the training group’s response from pre-mid and mid-post, statistical significance was shown in both time periods (Table 4). The strength of the pre-mid analysis followed the research supporting neural adaptation in the first 4-8 weeks. Moreover, the improvements after 12 weeks are indicative of strength improvements in the musculature of the lower body [19], thus demonstrating that strength, power, and lower body function can be improved in women aged 70-86 in 12 weeks of training (Table 1).

It was noted that in working with healthy older adults, not every subject attained the same degree of improvements possibly due to ceiling effects of the lower limits of the test. A possible explanation for the low values seen in the study could be due to the small sample size of healthy women. This study’s sample was considerably smaller (n=44) than the sample utilized in the NHANES III survey (n=2760). Thus the higher mean values seen in the NHANES survey are more representative of the population as a whole. Also of interest is that Ostchega et al. [13] found in their study that Chair Stand Times were lower in Non-Hispanic Whites than in Non-Hispanic Blacks or Mexican Americans. Thus another possibility of the low values seen could be due to the majority of Caucasian ethnicity of the participants in this study. However, the timed chair stand has no upper limits and thus is useful in healthy and frail older adults. Benefits of the test are that it is safe, effective, reliable, and easy to score and administer test.

K.A.T. Balance Measure

Although poor balance is definitely a risk factor for falls, being unable to regain lost balance is an even greater risk. To date, many researchers have investigated ways of improving balance and preventing falls. The goal of this research was to see the effects of progressive resistance training on balance maintenance. The reasoning is that if it is possible to improve strategies to regain balance, then it is possible to decrease the risk factor associated with falls in
older adults. The method in this study used to measure timed balance was the Kinesthetic Ability Trainer (K.A.T.). The K.A.T. was utilised for many reasons. The main reason was its straightforwardness as a tilting stability platform with LCD display afforded simplicity to score and use. As well, Crawford et al. [12] had established norms with which to compare our results. In her study, Crawford demonstrated values of 20.6 ± 11.4 seconds for a psi level of 2.5 with eyes open, and 10.3 ± 10.6 seconds for a psi level of 4.0 with eyes closed. These normative values established by Crawford are consistent with the initial values seen at Week 0 (Table 7) for conditions B and F; which in this study are the two balance conditions that demonstrated within group significance (Table 7). However, the improvements in condition B were seen from weeks 0-6, which would imply that the improvement in time was due to either neuromuscular coordination [18] or possible learning effects. The analysis also demonstrated that the only between group difference noted was condition F. This is quite important as condition F lacked visual input; logic implies then only one of two inputs could have improved. Although no aspect of the resistance training focused solely on vestibular functioning, it is possible that it could have led to improvements in maintaining balance. The more plausible reason on the other hand, is that the progressive resistance training programme improved the somatosensory input as well as any related processes. Thus subjects in the training group only exhibited improved time to balance. Why then was there only a significant increase between groups in condition F? For the eyes closed conditions, possible explanations may include that the platform stability for conditions D and E may have been too difficult to see any significant changes. For the eyes open conditions, condition C was considered easy by the subjects and aptly demonstrated ceiling effects. As for conditions A, it was subject to minor improvements in mean balance times, and thus changes to both groups may be attributed to the visual input or learning effects on the test. Future considerations for measuring balance using the KAT include establishing normative data at other
psi levels such as 1.5, 2.0 or 3.0 that are appropriately difficult yet manageable unlike conditions D, A and E to see possible improvements in balance times.

Limitations of the Kinesthetic Ability Trainer include possible experimenter bias as the main investigator did all the test measurements as well as all the training. As well, the K.A.T. has not been used extensively in research and thus may still require additional reliability and validity trials to control for extrinsic or intrinsic variables such as weather and mood that may affect balance in older adult women. Lastly, the control group was not tested at six weeks due to extraneous restraints on the subjects.

**Self Reported Well-being**

Health and well-being has garnered more attention in the last few years. Research has shown that self reported quality of life has improved after undertaking a training programme [22]. A question that keeps surfacing is how well are people living in their older age? With this in mind, this study utilised a subjective questionnaire to assess self-reported well-being. The questionnaire was quantified categorically by recording the number of times a response was written down (Table 8) as well as the general feeling and attitude of the participants within the training group. The categorical responses indicated improved health, less aching and improved function for example in the ability to climb stairs. The strength of the questionnaire lay in each subject’s ability to recall any apparent changes in the 12 weeks of training. As the question was open ended, there was not a limit on the answer expressed or the length of the answer. Therefore it allowed each subject the opportunity to express what they felt was most important to them over the 12 weeks of training. Although recall ability could also be a limit to the questionnaire, no subject seemed to have this problem.
Implications of well-being data for further research is the need to identify which components of the programme, that is which type, duration, intensity are most influential in improving well-being.

Also of concern, are possible confounding variables for well-being such as the use of healthy older adults and not frail older adults. Also outside influential life events may have had an impact on the balance and well-being outcomes. As well, improvements in mood may have been the result of the increased social interaction with other subjects or the trainer. Nevertheless, the healthy adults in the control group did not respond in the same manner to the questionnaire as the training group. Therefore, it's feasible to conclude that 12 weeks of training can have a significant impact on well-being.

Summary

The results of this study conclude that the Timed Chair Stand and the Timed Two-Legged Squat are both reliable measures of lower body strength and muscular recruitment respectively. As well, the study demonstrated that the possible gains in muscular recruitment and lower body strength in 12 weeks may improve balance time in certain conditions and has a profound positive effect on well-being in women aged 70-86. Using an approach of personal attention and conditioning the muscles associated with the hip girdle and lower body, it is possible to see significant improvements in function in older adult women aged 70-86.

Limitations

Limitations of this study possibly include experimenter bias, as training and testing was carried out by the investigator; a small sample size could have had an impact on power within the balance conditions and testing was only carried out at six weeks on the training group. Many volunteers were used in testing procedures and could have contributed to lower measurement
reliability. As well, only healthy older adults were used in this study and were not randomized because circumstances did not allow for it.

**Future Considerations**

Taking into account the limitations of the study, future research could focus on more functional testing as well as testing other aspects of balance such as dynamic balance. A follow-up study could be conducted to study fall incidence as well as conduct the same study with men or a different population like the frail elderly for instance. Other methods for improving balance could look at training studies that remove visual stimuli as well as look at the effects of training in a prone versus vertical position. However, these future studies should maintain a focus of improving function and well-being in older adults.
REFERENCES


APPENDIX A

REVIEW OF LITERATURE

EXERCISE AND OLDER ADULTS

INTRODUCTION

The primary goal of older adults is to maintain a healthy, independent lifestyle. Falling by older adults is a serious issue with possible consequences of injury, disability and challenge to independence. The idea for this paper was conceived when it was noted that decreased lower extremity strength and impaired balance are important risk factors for the loss of physical function and the occurrence of falls. As well, the area is worth studying to look at the effect of improving lower extremity force measures on static and dynamic balance [10].

Balance

Balance is essential for coordination of motor responses, eye movements and postural adjustments. For one to balance, maintenance of the vertical position of the body’s centre of gravity (COG) over the base of support is required [9]. The main joints that are involved in balance are the ankle, knee and hip. The ankle, thigh and lower trunk muscles control these joints. A disruption in the sense of balance can lead to vertigo, nausea and disorganized balance reactions. One may have impaired balance for 2 reasons: (1) The position of COG relative to the base of support is not accurately sensed, or (2) the automatic movements required to bring the COG to a balanced position are not timely or effectively coordinated. Balance is coordinated by three different systems, vestibular, visual and somatosensory. Balance depends on the integration of these systems, visual and spatial perception, effective muscle tone and strength and joint flexibility [9, 23].
**Vestibular Input**

The role of the vestibular system is to measure gravitational, linear and angular accelerations of the head in relation to inertial space. The organs involved in this process occur in the vestibule of the inner ear and are called the semicircular canals. When the head rotates, there is a force exerted by the inertia of fluid in the semicircular ducts, which act against the cupula. This action displaces the sensory hairs on the receptor cells and alters the number of nerve fibres that are innervated. This system can respond to angular accelerations or decelerations as low as \(0.1^\circ/\text{sec}^2\) [23]. The semicircular ducts are orthogonal to each other and this is important because it allows one to track and have precise control of the head and eye position in 3-dimensional space. The vestibular system acts as a whole to keep the body balanced and to keep the eyes fixed on a point even when moving [9, 23].

**Visual Input**

The second system involved in balance is vision. Vision measures the orientation of the eyes and head in relation to surrounding objects. The role of vision is most important when other sensory input such as vestibular or proprioception is impaired. Vision influences and corrects the COG alignment when attempting to balance and thus postural sway is greater with eyes closed than open [9, 23].

**Somatosensory Input**

The third system used by the body to achieve balance is proprioception. Proprioception or somatosensory inputs are derived from contact forces and motions between the feet and the support surface. Proprioception is the sense that tells where in space the parts of the body are and where they are in relation to themselves. To do this, the muscles and joint proprioceptors must constantly transmit information on position back to the brain [9, 23].
The biomechanics of balance involves the coordination of ankle, knee, neck and hip joints. Motions in the body are not determined simply by muscles acting directly on joints but also from indirect forces from the leg and trunk muscles that act on neighbouring joints through inertial interaction forces among body segments. The body integrates these systems and consequently makes postural adjustments by using anticipatory and feedback mechanisms [9, 23].

**Anticipatory Mechanism**

The body utilizes a feedforward mechanism to predict disturbances. By recognizing trends in afferent input, the body generates postural adjustments with a pre-programmed response to maintain stability before voluntary movements occur. These individual responses are shaped by experience and result in the smoothness of the response in stabilizing the hip [9, 23].

**Feedback Mechanism**

The feedback mechanism is started with any change in the body’s centre of gravity. Most feedback mechanisms have a characteristic distal to proximal sequence. This process is very fast and refined continuously by practise and is learned like a skilled voluntary movement [9, 23].

**Fall Prevention Strategies**

Postural adjustments involve coordination and activation of the muscles surrounding the ankle, knee and hip joints. The motions are not determined solely by muscles acting directly on these joints but from muscles on neighbouring joints through inertial forces between body segments. A person uses one or a combination of three strategies when their balance is disturbed [9, 23]
i) The person can take a step or a stumbling reaction. This movement is only effective when the centre of gravity (COG) is displaced outside of the limit of stability perimeter.

ii) The ankle strategy shifts the COG while keeping the feet stable by rotating the body. The body can be approximated as a rigid mass moving around the ankle joints. At the same time, contractions of the thigh and lower trunk muscles are required to resist destabilization of the proximal joints due to indirect effects.

iii) The hip strategy is more commonly used and is employed when the COG shifts in the opposite direction to the hip because of the inertia of the trunk. This movement generates a shear reaction force against the support surface. The hip strategy requires destabilization of the lower limb and knee and is thus resisted by coordination and activation of the ankle, knee and hip joints. The quadriceps and abdominals are then activated to flex the hip and move the COG backward and thus the knee and ankles remain stable.

The effectiveness and appropriate use of these strategies depend on 3 conditions:

(1) The configuration of the base of support.

(2) The COG alignment in relation to the limit of stability.

(3) The speed of the postural movement or adjustment.

In an elderly population, the third condition is quite important and can be a major risk factor for falling because as one ages, one reduces sensation and speeds of general movement, which impacts the time to regain balance. It should be noted that new strategies can be trained but require practice to become familiar with the pattern. Thus it is up to the individual to take on a training regimen to train or retrain strategies in the maintenance of balance [9, 23].
Influences of Aging

Aging has both a direct and indirect influence on strength, functional independence, body composition, balance and quality of life. With aging come decrements in muscle mass, force production per cross sectional area of muscle, and isokinetic joint moment force in several lower extremity muscles [10]. Age related loss in skeletal muscle mass is referred to as ‘sarcopenia’ [7, 8] and can be considered a disorder of aging. This is usually a result of reduced physical activity or leading a sedentary lifestyle by aging adults. Between the ages of 20-70 years, the average person loses about 20% of the body’s muscle mass [7]. There are many consequences to sarcopenia that occur because of deconditioning, physical inactivity or chronic disease. Decreased strength, power, endurance, flexibility, and restricted range of movement as well as decreased ability to perform activities of daily living occur with aging [24]. These changes can be partially attributed to age related changes in muscle length and connective tissue, which contributes to further reductions of tensile strength in ligaments, greater rigidity in the muscles and peripheral support structures surrounding lower limb joints [25].

Research has also shown that functional independence and functional fitness can decrease significantly with age and are thus important risk factor for falls and fall related injuries [24]. Functional fitness is defined, as “the level of fitness necessary for a person to take care of personal, household, social or daily living needs as to maintain a residence at home”. Functional fitness may decline as a result of reduced sensation and vestibular dysfunction [23]. Skelton and Dinan [25] described that with age the balance system and unconscious processes might not integrate as well or as quickly. This was found from an increase in body sway that was related to poor tactile sensitivity and poor joint sense on a firm surface. Patla [15] showed that aging reduced reflex speeds and contributed to poor coordination, losses of flexibility and strength and as a result people relied more on upper leg and trunk strength to balance. Reduced power
capacity is also a result of reduced speed of movement and this results in a slower gait, thus creating excessive muscle fatigue [21].

Also shown to deteriorate with aging are the spinal stretch reflexes used in proprioception. These impairments in the various pathological conditions such as vision, vestibular function, hearing and muscle and joint proprioception lead to disturbed or altered postural control. The altered postural control leads to an increased prevalence of postural sway within the elderly population. Sway has been shown to be higher in elderly women than men in a 2:1 ratio [[23].

In 1993, Judge et al [10] showed that increased postural sway increased the risk of falls. These differences in sway with age are stressed in single leg stance testing. Studies now show that fall prevalence increases with aging [2, 26]. Increased fall rate prevalence is associated with mobility impairment, dizziness [27], and complex interactions of intrinsic and extrinsic risk factors [25, 28]. Intrinsic risk factors are considered to be age, sex, health and behaviour related whereas extrinsic factors are related to the environment and surroundings [28]. Intrinsic risk factors may lead to insufficient muscle strength and flexibility in tasks such as lifting one’s body mass from a chair or toilet seat or dressing or climbing into a bath [11]. Hip and knee extensor strength is needed to stand from a sitting position and hip and knee flexors must maintain flexibility in order not to limit posture or walking ability [24].

However, the rate of decline in muscle mass and overall function seen in older adults can be reduced by regular physical activity. Research has shown that after age 60, muscle mass and strength, decrease by about 1% per year due to the loss of muscle fibers [5]. Also, low levels of physical activity have been associated with increases in mortality rated from cardiovascular disease. Evidence shows that exercise will improve the three most important causative factors: balance, muscular strength and osteoporosis [5]. Skelton & Dinan [25] showed that most intrinsic physical risk factors such as balance and gait deficiency could change with exercise. Shephard [11] reports that hip fractures might be avoided if an older patient’s bone density is
maintained by regular weight bearing exercise or if balance had been sustained from regular vertiginous challenges to the cerebellum.

In summary, there are many changes associated with aging. These changes such as sarcopenia, decreased balance, mobility and functional independence can lead to increased postural sway. Increase postural sway along with said age related changes have been shown to be risk factors for increased prevalence of falls and fall related injuries. Research has shown that safe, approved physical activity in any form undertaken at any age can have positive side effects on aging with older adults [4, 6, 8, 10, 11, 16, 24, 28-30].

Implications of Exercise Programme with an Elderly Population

The effects of an exercise programme undertaken at any age are beneficial to health. Research has shown that starting a strength training protocol at any age can lead to increases or maintenance of muscle strength, endurance, flexibility and improved functional performance [4, 6, 8, 10, 11, 16, 24, 28-30].

Increased physical activity in older adults has been shown to both protect and increase rate of falls. This is because those who remain active could maintain their balance, reflexes, flexibility, and regain their imbalances. On the other hand, partaking in frequent physical activity increases opportunities for falls [29]. Despite this, the benefits of a safe, progressive exercise programme far outweigh the chance of falling. There are two important advantages to exercise regimens. First, since falls are a common occurrence in the elderly, an intervention programme is probably more cost effective when compared to other public health measures [17]. Second, exercise is beneficial to participants in that it may decrease the fear of falling and may improve physical function by increasing strength and other important health areas like cardiovascular health and sleep [28]. Shephard [11] looked at exercise and its impact on absolute life expectancy and functional status. He concluded that an early history of exercise will
probably not predict longevity and that the health benefits of exercise can’t be stored but must be continued to maintain a healthy lifestyle [5, 31]. Another study showed that physical activity is associated with an increase in average lifespan and that it is better to have been inactive at college and active in old age than to have participated in exercise at college and become sedentary in old age [31].

Cross sectional studies show that those who engage in regular physical activity their whole lives show higher levels of functioning and a slower rate of decline than their sedentary counterparts [5, 32]. This is because resistance training can possibly prevent sarcopenia and its associated abnormalities [8] and thus regular exercise helps to avoid premature deaths of middle and early old age [11]. Also, regular exercise elevates the mood of most people and therefore it is possible that exercise not only increases average lifespan but also increase quality adjusted life expectancy [16] which allows for maintenance of personal independence in later years [11].

Exercise is able to maintain personal independence and may actually improve [16] in older adults by increasing muscular strength and endurance [8]. In addition, older adults are capable of significantly improving lower extremity strength with resistance training [10] and consequently muscle power [25] as well. Muscle power is important because to prevent a trip one must be able to get the stabilizing leg out fast enough to prevent or reduce the severity of the fall [25]. There is a general trend now that exercise programmes for older adults should focus on the maintenance of functional abilities and general well being rather than specific adaptations for physical fitness [33]. Sherrington et al [30] demonstrated that a one-month home programme of weight bearing exercises designed to improve hip extensor strength significantly improved lower limb strength and walking velocity in a post hip fracture population. In a study by Brill et al [24], a strength training programme using free weights improved the functional performance of subjects as measured by a 6-metre walk, chair stand, stair climb and balance tests. Still, there are limitations to these studies. First of all, subjects are not blinded to treatment and thus may exert
themselves upon retesting. Secondly, experimenter bias may play a role as well as the simplicity of the tests, i.e. the lack of precision used in these studies [24, 30].

Gardner, Robertson and Campbell [28] report that exercise can be carried out not only in older people with moderate disability and cognitive functioning but also in frail institutionalized older people [28]. Although, some studies have found improvements in gait and balance [3, 24, 30], there are no national guidelines giving detailed specific advice on exercises for falls prevention and exercise regimens in old age [25, 28]. Gardner et al do outline that the exercise programme prescribed should be regular and sustainable to be effective but should also have the resources to restart and reassess, as many older adults are prone to illness, accident and social change [28]. Skelton & Dinan recommend that occupational therapists and physiotherapists prescribe exercise programmes that:

i. train muscles around the ankle, knee, and hip joints;
ii. increase flexibility of the trunk and lower limbs;
iii. include balance training; and
iv. educate proper falling and getting up from the floor [25].

The exercise programme prescribed should consist of a proper warm up and cool down with stretching. Post exercise stretching is important, as it is more effective at increasing flexibility than stretching before exercise [26]. In addition, exercising in groups is a great way to promote adherence and compliance to the programme [25, 26].

When starting a training protocol with an older population one should consider the recommendations from Bracewell et al [34] in that a successful programme should:

1. Use easily adjustable equipment with small weight increments while keeping the body upright.
2. Use personable trainers – Social atmosphere is critical for compliance.
3. Be close to a major bus route.

4. Provide guidance.

5. Educate – so the individual will become more independent.


Thus when prescribing a strength training protocol one must remember the principles of training set out by the ACSM [1]:

1. Principle of Specificity
   - Only muscles trained will exhibit hypertrophy

2. Principle of Overload
   - The training stimulus must exceed normal loading
   - The stimulus must be increased progressively

3. Principle of Reversibility
   - Any positive effect will be maintained only as long as exercise is continued

4. Principle of Initial Values
   - Most benefit is seen in those with lowest initial values

5. Principle of Diminishing Returns
   - There exists a biological/genetic ceiling that determines the extent of improvement

In summary, strength training and exercise in general have many beneficial effects on an older adult population. General findings reveal that individuals who undertake resistance-training exercises increase their energy requirements, decrease body fat mass and increase metabolically active tissue [35]. As well, exercise can increase levels of confidence, which may lead to higher levels of activity and prolong and maintain conditioning. Exercise prescription for the elderly should follow guidelines set out by the ACSM with a couple of differences in mind. Exercise should be of lower intensity, increased duration, slower progression and low-impact with
emphasis on functional capacity [33]. However, it is unknown which exact type, duration and intensity of exercise has the greatest effect [1, 25, 28].

**Influence of Exercise on Balance**

Balance is an intricate and complex process. In the past, studies have used many different interventions in the hopes of improving balance. The list of interventions includes training and measuring of strength, endurance, flexibility, balance, computerized balance training, Tai Chi, functional performance tests and walking [28].

In 1993, Judge et al [10] performed a study to assess balance using single stance time as a measure of balance. No significant results were found, however it was proposed that increase in single stance time could be due to i) tolerance of instability, ii) increased resistance to fatigue of the gluteus medius or iii) improved balance. Judge et al also noted that control of postural muscles rather than muscle force development may be the critical factor in single stance time.

Another study that focused on balance hypothesized that an aerobic exercise programme (endurance training) that involved substantial body movements would show the greatest improvements in balance as measured by static and dynamic tests. Their hypothesis was based on the theory that moving the body’s centre of mass at varying speeds and in varying direction as well as stressing the ability to maintain balance over a fixed based of support would contribute to the greatest increases in balance [36]. They noted that endurance training does not train balance but ascertained that endurance training could train balance using the principle of specificity. That is, specific exercises could improve certain specific balance tasks. Still, they concluded that it is difficult to train balance with any type of training in adults with mild deficits and therefore they were not able to find any significant results due to the lack of power to detect small effects.
Engels et al [37] also used ankle weights for an 8-week strength-training programme. The measure of balance used was the single leg stance and functional reach, but no significant results were found from the study.

Brill et al [24] conducted a strength-training programme of the upper and lower body using dumbbells and ankle weights to see the effects on physical function of older adults. The lower body strength programme consisted of squats, knee raises, leg curls, toe raises and leg kicks to the side. The results of the intervention showed significant results in the balance component of testing. However, a weakness of the study was the test used to measure balance. Although inexpensive and quite reasonable, the method Brill and her colleagues used has not been validated in any study.

In a study of balance and the elderly, Wolfson et al [38] used 4 groups: a control, balance, strength, and strength and balance group. The balance group consisted of balance training divided into platform and non-platform exercises three times per week. The strength training group met three times per week and performed lower body resistance training which consisted of prone lying hip extension and knee flexion, side lying hip abduction and resistive exercise machines for leg extension. Outcome measures in the study included loss of balance (LOB), functional base of support (FBOS), and single stance time (SST) tests. Results of the study showed that balance training showed significant improvements and had the greatest effect for all three tests. The strength-training group only showed significant improvements in the single stance time test. Thus Wolfson and her colleagues concluded it is possible to realize short-term gains in strength and balance with a high intensity supervised training programme.

A study designed by Messier et al [39] looked at the effect of a long term, 18-month, exercise programme on older adults. The study design tested balance under single and double leg stance with two groups, an aerobic walking and a strength-training group. Results from the
study showed significant improvements in static balance within the strength-training group but failed to list the exercises used for the training programme.

Campbell & Robertson [3] designed a home based exercise in women aged 80 and older to decrease falls and increase muscular strength and balance. The moderate intensity exercises used ankle weights for hip extension, abduction and knee movements. Other exercises included range of movement exercises and knee squats. The results of the study demonstrated that after 6-months, balance and functional performance measured by the timed chair stand improved in the exercise group.

Lord et al. [17] designed a 12-month exercise programme to improve balance strength and falls in older women. The design of their study included 1 hour exercise sessions twice a week. The classes included a warm-up period, conditioning, stretching and cool down period. The conditioning period contained aerobic exercises, as well as strengthening, flexibility and balance exercises. The leg movements in the conditioning period were designed to condition and improve the range of motion and muscles associated with the hip, knee and ankle joints. Lord et al concluded that exercise plays an important role in improving stability.

In a shorter study consisting of 9 weeks, Grahn Kronhed et al.[40] showed that a multidimensional exercise programme significantly improved balance performance in older adults. Their rationale for the improved performance was better use of afferent impulses and not increases in strength because of the short-term training time. However, one limitation of the study was the ceiling effects of the clinical tests used to measure balance.

Another short-term study designed by Carter et al. [41] tested a twice weekly 10-week exercise programme on osteoporotic women aged 65-75. The protocol mainly consisted of exercises designed to improve posture, balance, and coordination. The researchers found that the programme did not significantly improve outcome measures of static balance, dynamic balance, or knee extension strength. They concluded that a 10 week training programme might be too
short to elicit a substantial change in the fall risk factors of osteoporotic women. They also noted that one limitation to the study was the use of mainly healthy and fit women, which limits the generalisability of the study.

A study designed by Shumway-Cook et al [42] measured the effects of exercise on selected factors. The researchers found that a multidimensional exercise regime can significantly improve balance, mobility and fall risk in older adults. Their reasoning was that stability emerged from a complex interaction of the sensorimotor and neural systems. The 8-12 week programme demonstrated that balance could be improved assessed by the Berg Balance Scale and Balance Self-Perceptions Test in healthy older adults aged 65 and older. The study used a quasi-experimental design and was considered an acceptable alternative to an experimental design, as randomization was not possible. This was duly noted as a limitation in the study.

An interesting study looking at the possible gains in strength from balance training in comparison to strength training demonstrated that balance training alone contributed to increases in strength and improvements in balance measured by one leg stance and a tilting stabilometer. However, it was shown that improvements of balance on the stabilometer were only seen in the balance training group and not the strength-training group. Still the researchers concluded that the gain in strength was probably a result of improved intramuscular and intermuscular coordination. As well, more economical activation of agonistic muscles may have achieved greater stabilization of the extremities and thus contributed to overall improved balance [18].

It can be concluded from these studies that endurance and strength training, while showing significant improvements in single-stance time, have a variable resulting impact on balance. This is possibly due to exercises that are not stress specific enough to improve balance. Therefore it should be noted that programmes ought to include components of some balance training in order to see improvements [38]. One thing all studies did agree upon was that continual exercise is
required in that long-term exercise may improve balance impairments. Recommendations for future studies and future programmes on balance training include:

(1) Multidimensional Exercise Programme [40],

(2) Better pelvic control of body weight could improve balance over a narrowed base [38],

(3) Moderate Tai Chi or other forms of balance training as it can have favourable effects on decreasing the occurrence of falls [43].

(4) Walking is useful in fall prevention and appears to have the greatest and most persistent effect on fall risk factors [36].

*In summary,* when developing a training programme to improve balance, one must remember to include certain exercises that directly stress balance and balance related muscles, specifically those muscles associated with the hip girdle and lower limbs. It is important to remember that musculoskeletal dysfunction has an adverse effect on balance and thus every programme should encompass some strength training. It has been recommended by Gardner et al [28] that there is a need to identify which components of exercise are most effective in lowering falls and therefore more studies are needed to determine the most effective type, duration and intensity of exercises to improve balance.
Influences of Exercise on Well-Being

To improve function and maintain adherence to exercise in older adults, a major emphasis of any training programme should be social interaction and enjoyment. It's been noted that an exercise intervention may offer an effective health promotion strategy with potential of decreasing costs of health care as well as improving quality of life [17]. A study conducted by Hassmen et al.[44] demonstrated that individuals aged 25-64 who exercised at least two to three times a week experienced less negative affect and significantly more positive affect. As well, the researchers concluded that there are a number of positive consequences that stem from regular physical activity and that there is a consistent association between physical activity and enhanced well being.

Another study conducted by Damush and Damush, [22] looked at the effects of strength training on strength and health related quality of life in older adult women in 8 weeks of training. The study used two questionnaires to create quality of life scores. Their main findings concluded that strength gains in healthy older adult women could be seen with inexpensive equipment in a short time period. As well, the study concluded that the social atmosphere may have had an effect on the quality of life outcomes and that regularly attending a scheduled peer grouped activity outside of the home may improve the functioning of older adult women by possibly developing a sense of belonging, a social network and having something meaningful to do.

In summary, a moderate intensity exercise programme is an effective and safe way to stave off age-related decrements in health and increase strength and muscle mass in older women. Increases in strength have been shown to decrease the risk of falls and have many positive side effects. More importantly, although the primary goal of resistance training is to increase strength and thus independence, self-confidence and coordination, training also improves health, quality of life and general well-being [35].
Study Procedures:

Subjects are required to fill out a questionnaire before commencing the study. The questionnaire consists of 8 questions measuring physical activity levels and will take approximately 10 minutes to complete. The study consists of 12 weeks of training with testing occurring 1 week before and after training. The testing that will take place is comprised of a lower body strength test that is referred to as a Timed Two-Legged Squat and a Timed Chair Stand and a Balance Board called the K.A.T.

- The Timed Two-Legged Squat measures the time the subject is able to maintain a squat as low as possible.
- The Timed Chair Stand measures the time it takes for a subject to rise from an armless chair five times.
- The K.A.T. Balance System is a balance board with an inflatable air pressured bladder that can be manipulated to simulate different ground situations. There will be 6 different situations. Three of them will be completed with eyes open and three of them will be completed with eyes closed.

The training that will take place consists of 6 exercises that focus on muscles associated with the hip girdle.

The exercises consist of:

1. Timed Two Legged Squats,
2. Keiser Leg Press,
3. Standing hip abduction,
4. Standing Calf Raises
5. Controlled Knee raises, and
6. Isometric abdominal exercises.

The equipment that will be used includes ankle weights, Resistive Bands and the Keiser Leg Press strength trainer machine.

All training will occur 3 times per week for 1 hour per day at the UBC Tennis Centre with volunteers and co-investigator present and supervising each session. For consistency, all testing will occur at UBC by the co-investigator. Subjects will be responsible for their own methods of transportation to UBC.

The total time commitment required of a subject will be approximately 40 hours.
Exclusions:

Participants are required to undergo a physical examination with their physician and receive medical clearance before participating to ensure they are healthy and able to participate. If any potential subject meets any exclusion criteria they will be excluded from the study.

(1) Restricted limb or trunk movement
(2) Medical contraindications to maximal muscle strength testing
(3) Uncontrolled hypertension or diabetes
(4) Symptomatic cardiorespiratory disease
(5) Severe renal or hepatic disease
(6) Uncontrolled epilepsy
(7) Progressive neurological disorder
(8) Dementia over DSM level 3
(9) Marked anaemia (with mm Hg less than 100 G/L)
(10) Marked obesity with inability to exercise
(11) Medication with B-Blockers, Warfarin or CNS stimulants
(12) Already performing intense Cardiovascular exercise for more than 30 minutes, 3x/week

Risks:

There are inherent potential risks associated with any increase in physical activity. Some of these risks include light-headedness, and localized muscle fatigue. There is also the possibility of discomfort with localized leg muscle fatigue and delayed muscle soreness and increased risk of a fall. You are obligated to immediately inform the appraiser of any excessive pain, discomfort, fatigue, or any other symptoms that you may suffer during and immediately after the test.

It should be noted that taking part in this study could be beneficial for overall functional independence.

Confidentiality:

Any information resulting from this research study will be kept strictly confidential. All documents will be identified by code number and kept in a locked filing cabinet. Only the principal and co-investigators will have access to this information. Participants will not be identified by name in any reports of the completed study.
The Effects of a Neuromuscular Training Programme on Balance in Older Adults

How it Works:

In this workout, you will be focusing on the muscles of the lower body including the quads (front of the leg), hamstrings (back of the leg), glutes (butt), and calves. Perform each exercise for 12 to 16 repetitions with enough weight that you can ONLY complete the desired number of repetitions. If you're a beginner, start with one set and add a set after two weeks or so. If you're an intermediate exerciser, do two sets of each exercise with 30-45 seconds of rest in between sets. If you're advanced, do three sets of each exercise, with 30-45 seconds of rest. Rest at least 48 hours between your exercise sessions to allow your muscles to recover. **Make sure you warm up for at least 5 to 10 minutes before starting your weight training workout and see your doctor before beginning any exercise program.

Exercises

2 legged timed squat: Starting position - Standing with your feet shoulder width apart, toes pointing slightly outward. Hands are on your hips and your back is straight.

Bend your knees and lower your body (SQUAT). Make sure your knees are directly over your ankles, heels glued to the floor so you can wiggle your toes, and please do keep your back straight. Line up your nose with your toes and your knees. It’s like sitting down in a chair. Hold this position (the proper alignment) for as long as you can. Repeat.

Leg Press: This exercise works mainly your Quadriceps. You can use a machine or do more squats to do this exercise. Sit in the machine and adjust the weight accordingly. Put your feel on the platform in front of you and push through your heels to extend your legs. Return your legs to the starting position slowly.

Hamstring Curl: This exercise works your Hamstrings. You can use a machine or ankle weight to do this exercise. Pull your heels toward your butt to contract your hamstrings, and then slowly return to the starting position.

Standing Hip Flexion: This exercise works your Hip Flexor muscles. Stand upright behind a chair or some other object, which you can use as support to help you keep your balance. Rest your arms lightly on the back of the chair. Slowly raise one knee until it is parallel with the floor and then slowly lower it back to the starting position.
**Calf Raises:** This exercise mainly works your Gastrocnemius. Lift onto the very tips of your toes and slowly lower. (tip: stand on the floor or on a step and balance with a chair or the wall.)

**Standing Hip Abduction:** Stand upright behind a chair or some other object, which you can use as support to help you keep your balance. Rest your arms lightly on the back of the chair. Raise one leg out to the side as far as it will go while keeping both your feet pointed in the same direction. Return your leg slowly to the starting position.

**Controlled Knee Raises:** Sit down in a chair but do not lean back, although do sit up straight. This exercise is designed to work on your Transverses abdominus. To do this exercise correctly you must suck in your belly button to your back and at the same time raise one knee. As you release your leg down to the ground, you must suck in your belly button again. This exercise is known to be called, "Suck it in, suck it in!" as this is the most important aspect of the exercise.

**Isometric Abdominal Exercise:** Along with the Transverses abdominus, the Rectus abdominus is also very important. To work this muscle, lie on the floor with knees bent. Put your hands on your legs and slowly slide your hands up to your knees. When you’ve reached your knees, hold for as long as you can and then release slowly.
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Balance Training Study

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<th>Keiser Leg Press</th>
<th>Seated Leg Curl</th>
<th>Standing Hip Flexion</th>
<th>Standing Hip Abduction</th>
<th>Standing Calf Raises</th>
<th>Controlled Knee Raises</th>
<th>Isometric Abdominal Exercises</th>
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### Balance Training Study

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<td>Isometric Abdominal Exercises</td>
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Balance Training Study - Stretching Instructions

1. Quadricep Stretch,

Stand facing an object you can use for balance, such as a wall – or do this with a teammate. Place your left hand on the object, and put your weight on your left leg. Bend your right leg up at the knee, and reach behind you with your right hand and grab your right ankle. Gently pull your heel towards your bottom; you will feel a stretch in the front of your right leg. Hold this position for 30 seconds. Now, shift your weight to your right leg, balance yourself with your right hand, and gently pull your left leg up behind you with your left hand. Again, hold for 30 seconds. This will complete one cycle. Repeat this cycle two times.

2. Hamstring Stretch,

Place your left foot on a secure table or object. Gently lean your upper body forward. Keep your knees straight and maintain a curve in your lower back. Hold for 30 seconds, then relax. Now place your right foot up and lean forward. Hold for 30 seconds, then relax. This will complete one cycle. Repeat this cycle two times.

3. Calf Stretch,

Stand facing a wall, with your right foot in front of your left. Lean forward with your hands on the wall. Bend the right (front) leg, leaving the left leg straight; be sure to keep both heels flat on the ground. Continue until you feel a gentle stretch. Hold for 30 seconds. Then stand up, put your left foot in front of your right, lean forward and stretch your right leg – be sure to keep both heels flat on the ground. Hold for 30 seconds, then stand up. This will complete one cycle. Repeat this cycle two times.

4. Hip Flexor Stretch,

Kneel or stand with your weight evenly distributed on your right knee or foot and your left foot. Gently shift your weight forward, stretching your right leg behind you. Hold this position for 30 seconds. Return to the starting position and repeat with your left knee or foot and your right foot on the ground. Again, gently stretch forward, this time stretching your left leg behind you. Hold for 30 seconds. Repeat the cycle two times. Be very smooth in your movement – no bouncing!
5. **Groin Stretch, Knees Bent,**

Sit down on the ground and bring the soles of your feet together in front of you. Grasp your feet and gently pull yourself forward to stretch your groin and your back. Do not bounce. Hold this position for 30 seconds, then let go of your feet and stretch your legs out. This will complete one cycle. Repeat this cycle two times.

6. **Sitting Stretch, Chair,**

Sit on the edge of a chair, feet apart. Place your hands on your knees, and gently bend forward as far as possible. Slide your hands down to the ankles to increase the intensity of the stretch. Return to the starting position. Hold this position for 30 seconds. This will complete one cycle. Repeat this cycle two times.

**Tips**

*Breathe Slowly Don't Bounce:*

Flexibility training exercise should be static, performed without movement. Each position should be held for a minimum of 30 seconds or more for best results. The position should be one of comfortable mild muscle tension. Never bounce when stretching as this actually can cause the opposite of relaxation of the muscle. This may result in injury. Therefore bouncing ballistic stretching is counter productive and should be avoided.

*Pain? No Gain:*

While stretching you should feel tension as the muscles are gently pulled but there should be no pain. If you notice that the muscle being stretched is shaking uncontrollably then you have stretched too far. Gradually increase your range and don’t go too far too fast.

*Hold for 30 seconds:*

As mentioned previously hold each stretch for a minimum of 30 seconds. The stretch routine before or after exercise should correspond with the major muscles to be worked. A 7-10 minute stretching session, a small commitment that will result in a great physical benefit.
To get into a lying position:

Stand next to a very sturdy chair that won’t tip over (put the chair against the wall for support if you need to). Put your hands on the seat of the chair. Lower yourself down on one knee. Bring the other knee down. Put your left hand on the floor and lean on it as you bring your left hip to the floor. Your weight is now on your left hip. Straighten your legs out. Lie on your left side. Roll onto your back. Note: You don’t have to use your left side, you can use your right if you prefer.

To get up from a lying position:

Roll onto your left side. Use your right hand, placed on the floor at about the level of your ribs, to push your shoulders off the floor. Your weight is on your left hip. Roll forward, onto your knees, leaning on your hands for support. Lean your hands on the seat of the chair you used to lie down. Lift one of your knees so that one leg is bent, foot flat on the floor. Leaning your hands on the seat of the chair for support, rise from this position. Note: You don’t have to use your left side, you can use your right if you prefer.
### Testing Sheet

Name ___________________________ Date __________________

Age ____________________________

Phone Number ____________________ Code __________________

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**Timed 2 legged squat**

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**Timed Chair Stand**

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**Timed Balance Exercise**

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Since starting the programme, has your sense of well-being changed? If so, how?