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# A Comparison of Hip versus Ankle Exercises in Elders and the Influence on Balance and Gait

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## ABSTRACT

**Purpose**: Reductions in hip and ankle strength and range of motion (ROM) in elderly subjects have been associated with decreased functional mobility and risk of falls. The purpose of this research was to determine if short duration hip or ankle interventions designed to increase ROM and strength could improve ROM and strength of those joints, as well as improve balance and gait outcomes. **Methods**: Well elderly volunteers recruited from retirement communities and a senior citizen center were randomly assigned to a hip or ankle intervention group. Both groups performed a home exercise program (HEP) of stretching 5 days a week and strengthening 3 times a week for 8 weeks. The HEP was focused on the hip or ankle joint depending on group assignment. **Results**: Thirty-five subjects completed the exercise program. Neither group demonstrated statistically significant change from pretest to post-test in hip or ankle ROM or strength, or in balance or gait measures. **Conclusions**: The 8-week HEP was insufficient, perhaps in duration intensity, to effect change in impairments or functional limitations in a group of well elderly subjects. Physical therapists should be aware of limitations when giving unsupervised targeted exercises for a short duration.

**Key Words:** balance, gait, exercise, aging

## INTRODUCTION

Reductions in range of motion (ROM),[1,2] strength,[3,4] balance, and gait parameters[5] among elders are of concern to both elders and health care providers because such declines may be related to other negative outcomes. Several studies have shown that older adults with slower gait velocities are more likely to be homebound, use an assistive device, or experience falls as compared to nonfallers.[6-8] Balance, as measured by one-legged stance times and the timed 'Up & Go' (TUG), was impaired in elders who fell in the past year compared to elders without a history of falls.[9,10] Strength and ROM limitations in elders also have been shown to be related to functional limitations and to a history of falls.

Ferrucci et al found that elderly subjects who were unable to maintain side-by-side and tandem stance for more than 10 seconds had decreased hip flexor muscle strength when compared to subjects who stood for more than 10 seconds.[11] Decreased performance in one-legged and tandem stance times also were associated with weak hip extensor muscles in elders ($r = .28$-$.41$).[12] Elderly subjects with a history of falls demonstrated weaker hip extensors,[3] ankle dorsiflexors,[3,4,9] and ankle plantarflexors[4,9] when compared to those who have not fallen.

The relation between reduced ROM, strength, and functional impairments in elderly subjects raises the question whether improvements in these impairments might result in functional gains. Greater lower extremity strength and hip flexion-extension ROM have been found to be associated significantly with faster gait velocity in elders.[11,13-19] Intervention studies have demonstrated that older adults can improve strength with exercise.[14,20-25] Elastic bands such as Thera-Band® Resistive Bands, a convenient means to apply resistance for strengthening, have been used effectively in strengthening the lower extremity muscles of older adults.[23,26,27] Exercise programs that involve lower extremity muscle strengthening in the elderly have been shown to have a positive effect on balance[28-30] and gait velocity.[31-33] Increases in ankle dorsiflexion ROM have been linked to improved balance after 4 weeks of daily stretching performed twice a day by elders.[34]

A variety of exercise strategies are reported to influence ROM, strength, balance, and gait in the elderly. However, none of the studies report the effects of an HEP that targets just one lower extremity joint, such as increasing ROM and strength of only the hip joint and hip muscles, or increasing ROM and strength of only the ankle joint and ankle muscles. A targeted program that consists of relatively few exercises may increase compliance among elders. If a simple and safe HEP of relatively short duration can produce changes in impairment or functional outcome measures in a group of well elders, the program may facilitate both compliance and improve long-term effectiveness. Therefore, the purpose of this study was to determine if an 8-week HEP focusing on the hip joints alone or the ankle joints alone would improve ROM, strength, balance, and gait in well elders.

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## METHODS

This study used a randomized pretest/post-test design. Pretest measurements were followed by randomization, then a training session to teach each of the 2 intervention groups their exercises, and by phone calls and home visits as necessary to review exercises and progress the program. Post-test measurement was taken at the end of the 8-week HEP.

### Subjects

Subjects were recruited through presentations given to retirement communities at monthly meetings, and at a senior center. Subjects who indicated interest were interviewed by telephone to determine if they met the inclusion criteria. Inclusion criteria were ascertained by subject self-report. Subjects were required to be: over 60 years old, able to ambulate 10 meters independently without a device, able to follow instructions for testing and the HEP, not currently receiving physical therapy, and available to participate for the 8-week study duration. Potential subjects were excluded from this study if they reported: (1) a diagnosis of stroke or Parkinson disease; (2) a history of vestibular problems, lower extremity amputation, known lumbar disk problems or vertebral compression fractures within the past year; (3) hip surgery within the past year; (4) visual impairment that affected their ability to read the exercise cards; or (5) inability to lie prone.

Qualified subjects were given a scheduled time for the pretest measurements in the community room at the retirement facility at which they resided or a room at the senior center. The subjects signed an informed consent approved by the institutional review boards of The Sage Colleges and Rocky Mountain University of Health Professions.

### Outcome Measurements

A physical therapist examiner (GM) who was blinded to subjects' group assignment performed all the pretest and post-test measurements. The examiner engaged in prestudy training with the assessment tools to maximize her reliability. Measures for all subjects included measurements of: passive hip extension and ankle dorsiflexion ROM bilaterally; isometric strength of bilateral hip extensor and flexor muscles, and of the dorsiflexor and plantarflexor muscles bilaterally; one-legged stance times; side-by-side and tandem stance times; the TUG; and gait velocity. A second series of trials for each measurement was completed within a 30-minute period at both pretest and at post-test. The testing order was the same for all subjects and for all sets of measurements. Repeated testing was done both to permit assessment of measurement reliability and to permit use of average values over 2 trials.

Pretest and post-test goniometric measurements for passive hip extension ROM of both hips were performed in the Thomas Test position as described by Kendall et al[35] (Figure 1). Passive ankle dorsiflexion ROM of both ankles was performed with a biplane goniometer with the knee extended using the procedure described by Petty et al[34] (Figure 2). A biplane goniometer (Preston) has a plastic base that the plantar surface of the foot rests on to prevent pronation, and one arm of a goniometer that lines up with the lateral malleolus and fibular head. A Nicholas hand-held dynamometer (Lafayette Instruments, IN) was used for strength assessment. Subjects performed an isometric contraction for 4 to 5 seconds using the protocol recommended by Bohannon.[36] Strength testing of the right and left hip flexor and extensor muscles was performed in supine with the hip and knee flexed to 90° (Figure 3).

**Figure 1. Technique for measuring hip extension range of motion.**

**Figure 2. Technique for measuring ankle dorsiflexion range of motion.**

Ankle dorsiflexor and plantarflexor muscle strength was tested with the subject in supine with the ankle in a neutral position and the knee extended (Figure 4). After a demonstration of the strength assessment procedure, the subject was given a practice trial followed by the data collection trial. If it appeared that the subject was compensating during the strength testing, the assessment was repeated. The examiner did not report any difficulties with stabilization or providing adequate resistance.

The TUG was performed by each subject as described by Podsiadlo and Richardson.[37] One-legged stance times, side-by-side stance with eyes open, and tandem stance times were obtained using the protocol by Bohannon et al for one-legged stance time.[38] Timing was stopped and the maximum value was assigned if the subject was able to hold the position more than 30 seconds in tandem and one-legged stance based on the protocol by Bohannon et al.[38] A ceiling of 3 minutes was chosen by the principal investigator for side-by-side stance time to determine if the subject had difficulty maintaining the position. A value of 180 seconds was assigned for subjects who reached the ceiling time. A Stride Analyzer (B&L Engineering, Calif) was used to determine gait velocity over a distance of 6

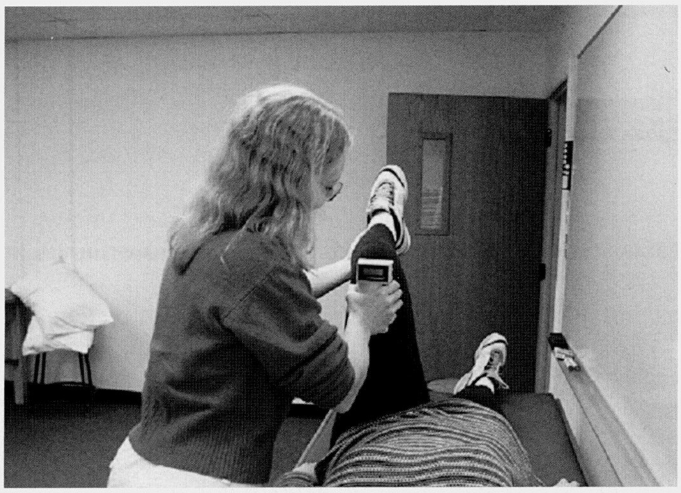

**Figure 3. Technique for measuring hip flexion strength.**

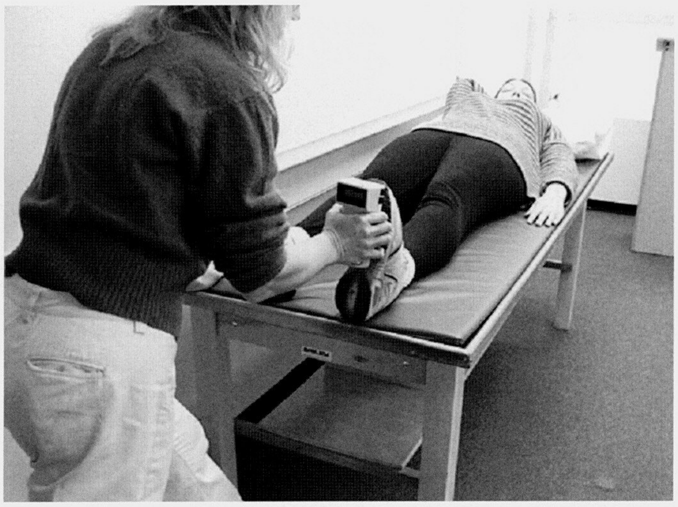

**Figure 4. Technique for measuring ankle plantarflexion strength.**

meters. The Stride Analyzer consists of footswitches that are placed in the subject's shoes and a recorder worn on a belt. The subjects were instructed to walk at their normal walking speed. The examining therapist (GM) manually turned on the recorder with a hand held trigger when the subject crossed the start and finish lines that marked the 6-meter walkway. Subjects began walking 2 meters before and ended 2 meters after the demarcated lines to capture true gait velocity over the 6-meter test area without acceleration or deceleration. The information on the recorder was then uploaded to a computer for analysis and output to the equipment software's spreadsheet in meters per minute.

### Intervention

After pretest measurement was taken, the principal investigator (LG) randomly assigned the subjects to a hip intervention or ankle intervention group by using a table of random numbers. The principal investigator taught the subjects individually how to perform the HEP at the subject's place of residence no later than 1 week after the pretest measures were obtained. The subjects in the hip group were taught exercises to stretch their hip joints into extension and strengthen their hip flexor and extensor muscles. The subjects in the ankle group were taught exercises to stretch their ankle joints into dorsiflexion and strengthen their ankle dorsiflexors and plantarflexor muscles. Both groups of subjects were instructed to perform the stretching exercises 5 days a week, for a total of 4 minutes. Both groups were instructed to perform the strengthening exercises 3 days a week using 3 sets of 15 repetitions each time. Subjects were given a handout of the Rating of Perceived Exertion Scale[39] to assist in determining perceived difficulty with the exercises. This rating scale is a Likert scale ranging from 0 (no exertion) to 20 (maximum exertion). An exercise log to be completed daily was also handed out to subjects to permit monitoring of compliance with the exercise program. Subjects were asked to check off how many of the required exercises they performed each day. Both groups were instructed to continue their exercise program for 8 weeks.

For the subjects in the hip group, stretching and strengthening exercises were performed on both hips; for subjects in the ankle group, stretching and strengthening exercises were performed on both ankles. Stretching into hip extension was done in the Thomas Test position with the leg passively extended off the bed. Stretching for ankle dorsiflexion was performed in standing with one forefoot at a time on a 2" tall block of wood with the knee straight. The subject's hands were placed on the back of a chair or countertop for balance. The subject held the assigned position for 60 seconds 4 times with a 10 second rest in between sets. The stretching protocol was based on a study by Feland et al.[40] Subjects were instructed to do their stretching exercises 5 days each week, Monday through Friday.

Strengthening exercises were prescribed depending upon the manual muscle test (MMT) grades obtained by the primary investigator (LG) during the training visit using standardized MMT protocols described by Hislop and Montgomery.[41] If hip flexor, hip extensor, ankle dorsiflexor, or ankle plantarflexor muscles were determined to be $\leq$ 3/5 strength on MMT for the ankle joint and < 3/5 for the hip joint, the following positions were used for strengthening. Hip flexion exercises were performed in supine, and hip extension exercises and ankle exercise were performed in sidelying. Ankle dorsiflexion exercises were performed in sitting without resistance, and ankle plantarflexion exercises were performed in sitting with resistance. If hip flexor or extensor strength was 3/5 on MMT, hip flexion exercises were performed in sitting and hip extension exercises in prone. If the strength of tested muscles was $\geq$ 4/5 on MMT, Thera-Band® Resistive Bands were used for resistance in the 3/5 prescribed positions. Each exercise (with or without resistance) consisted of 3 sets of 15 repetitions as recommended by the American College of Sports Medicine for elderly people.[42] A length of yellow, red, green, or blue Thera-Band® Resistive Band (in order of resistance) was selected for each subject based on a reported perceived exertion rating of no less than 11 (fairly light) and no greater than 15 (hard) after 3 sets of 15 repetitions at the time of exercise instruction. While a rating of perceived exertion scale is not ordinarily used to ascertain exercise tolerance in this way, it seemed to be a reasonable means of determining that a subject was getting adequate resistance during exercise without exceeding what are considered reasonable limits for cardiovascular safety.[39] Subjects were instructed to perform strengthening exercises using the same regimen of 3 sets of repetitions for 3 days per week on Monday, Wednesday, and Friday.

The principle investigator (LG) visited each subject after the first week of the exercise intervention to inquire how the subject was doing with the exercises and to answer any questions. Phone calls were made weekly thereafter. If the subject reported an 11 or less rating on the scale after completing 3 sets of 15 repetitions with their current color of resistive band, the principle investigator visited the subject and progressed the HEP by giving them a more resistive color of Thera-Band®. At the end of the 8-week intervention period the subjects were given an appointment time to return to the community room or senior center for the post-test measures. The examining physical therapist (GM) remained blinded to the subjects' group assignments. At that time, the primary investigator asked subjects how long it took them to do the exercises each day and if they felt that they benefited from them. Subjects were sent their own results 1 month after the post-test measures were completed.

## DATA ANALYSIS

Intrarater reliabilities for pretest measurements were assessed using the intraclass correlation coefficient (ICC 3,1).[43] Data from the right and left sides for bilateral measurements were collapsed for these calculations. A standard error of the measurement (SEM) was also calculated for each outcome measurement at pretest.[44] For all subsequent analyses, the mean value obtained for 2 repeated trials, and for right and left sides for bilateral measurements, were used in calculations. Nonparametric statistics were used because the data did not approximate a normal distribution.

Descriptive statistics for all variables were ascertained, including change scores from pretest to post-test. Wilcoxon Signed-Ranks Tests were used to determine if pretest to post-test changes within groups for strength and ROM were statistically significant. Mann Whitney-*U* tests were used to determine whether the pretest/post-test change scores for each outcome were statistically different between the hip and ankle groups. An alpha level of .05 was used for determining significance for all statistical analyses. Data were analyzed using SPSS(r) 10.0.[45]

## RESULTS

Of the 49 subjects participating in the preliminary screening, 33 were from the retirement communities and 16 were from the senior center. Four people were not eligible for the study based on the inclusion criteria; 10 started the study but did not continue. Of those 10 who did not complete the study, 6 were assigned to the hip intervention group and 4 to the ankle intervention group. Reasons for not continuing in the study included not wanting to exercise in hot weather, world events (9/11/01), noncompliance, and unrelated injuries during the data collection period. One subject hurt her back after doing one of the exercises incorrectly; an incident report was filed, and she withdrew from the study. Thirty-five subjects completed the study, 23 from the retirement communities and 12 from the senior center. There were 16 subjects in the hip intervention group, averaging (74.3 ±5.7) years of age; 15 (94%) were female. There were 19 subjects in the ankle intervention group, averaging (77.8 ±5.7) years of age, all of whom were female. Mann Whitney-*U* tests did not show significant differences in the mean age or in pretest measurements between the 2 groups.

Pretest ICC values ranged from .70 to .96. Pretest ICC and SEM values are shown in Table 1. Descriptive statistics for all strength and ROM variables for both groups are shown in Table 2; those for balance and gait measures are shown in Table 3. The pretest/post-test change scores exceeded measurement error (SEM) only for hip extensor strength in the hip group and for side-by-side stance time for the ankle group (Table 4). None of the differences between pretest and post-test measurements for either group reached statistical significance for any of the measurements based on the Wilcoxon Signed-Ranks tests. There were no statistically significant differences between groups on change scores for any of the measurements based on the Mann Whitney-*U* tests.

**Table 1. Pretest Measurement Reliability Statistics***

| Measurement | ICC | SEM |
|---|---|---|
| Hip flexor strength | .93 | .76 kg |
| Hip extensor strength | .93 | .67 kg |
| Ankle dorsiflexor strength | .90 | .83 kg |
| Ankle plantarflexor strength | .95 | .73 kg |
| Hip extension range of motion | .93 | 1.8° |
| Ankle dorsiflexion range of motion | .97 | 2.18° |
| Side-by-side stance | .97 | 7.8 sec |
| Tandem stance | .70 | 5.6 sec |
| One-legged stance | .87 | 2.3 sec |
| Timed "Up&Go" | .90 | 1.0 sec |
| Gait velocity | .96 | 2.75 m/min |

*Intraclass Correlation Coefficients (ICC) and Standard Error of Measurements (SEM)

Statistical analyses were repeated using only subjects who were at least 80% compliant with their exercises. Compliance was obtained by taking the number of repetitions performed by the subject divided by the total number of repetitions during the 8-week exercise period compiled from the exercise log. Eight of 16 subjects in the hip group and 11 of 19 subjects in the ankle group reached the criterion level of compliance (54% of the total sample). No statistically significant changes from pretest to post-test, or differences between groups were found for the 'compliant' subgroup of subjects.

A $X^2$ analysis was done to determine if the number of times that subjects were progressed using Thera-Band® Resistive Bands was associated with group assignment. Fourteen of 35 subjects were progressed to a higher resistance Thera-Band® between 1 and 4 times based on the Rating of Perceived Exertion criterion. Table 5 shows the number of individuals in each group that were progressed. Subjects doing ankle exercises were more likely to be progressed than subjects doing hip exercises ($X^2 = 5.55; p=.02$).

## DISCUSSION

Reliability values for the measurements conducted by the examiner in this study were strong. The lower reliabilities for tandem stance time (.70) and for one-legged stance time (.87) are likely to be attributable to relatively limited variability in those data because there is no reason to believe that timing these tasks is markedly different in difficulty than timing side-by-side stance or the TUG. In spite of the strong ICC values, the

**Table 2. Descriptive Data for Strength and Range of Motion Measurements**

| Measurement | Central Tendency and Variability | Hip Group Pretest | Hip Group Post-test | Ankle Group Pretest | Ankle Group Post-test |
|---|---|---|---|---|---|
| Hip flexor strength (kg) | Mean ± SD | 3.60 ± 1.61 | 3.64 ± 1.42 | 2.70 ± 2.31 | 3.07 ± 2.26 |
| | (Median Quartiles) | 3.48 (2.56,4.59) | 3.89 (2.68,4.51) | 1.85 (.73, 4.65) | 2.50 (1.3, 4.10) |
| Hip extensor strength (kg) | Mean ± SD | 2.63 ± 1.81 | 3.32 ± 2.28 | 2.34 ± 1.94 | 2.57 ± 2.07 |
| | (Median Quartiles) | 2.75 (1.38,3.66) | 2.94 (1.27,5.35) | 1.78 (.55, 3.55) | 1.85 (1.03, 4.30) |
| Ankle dorsiflexor strength (kg) | Mean ± SD | 3.49 ± 1.37 | 3.88 ± 1.88 | 2.81 ± 2.33 | 3.34 ± 1.82 |
| | (Median Quartiles) | 3.30 (2.88, 4.23) | 4.44 (2.17,5.34) | 2.55 (1.05, 4.65) | 3.60 (1.60, 4.85) |
| Ankle plantarflexor strength (kg) | Mean ± SD | 6.07 ± 2.45 | 6.32 ± 2.35 | 5.91 ± 3.00 | 5.93 ± 3.00 |
| | (Median Quartiles) | 6.14 (4.47,8.51) | 6.79 (4.38,8.69) | 6.15 (3.38, 7.88) | 5.40 (3.83, 7.63) |
| Hip extension ROM (degrees) | Mean ± SD | 1.9 ± 4.0 | 2.7 ± 2.3 | 3.3 ± 2.7 | 2.9 ± 2.8 |
| | (Median Quartiles) | 2.4 (-2.0,4.7) | 2.7 (1.3,4.4) | 3.0 (2.0, 5.5) | 3.0 (1.2, 4.5) |
| Ankle dorsiflexion ROM (degrees) | Mean ± SD | 1.57 ± 4.2 | 2.1 ± 5.4 | -.7 ± 4.5 | .9 ± 4.9 |
| | (Median Quartiles) | 2.2 (-2.4,4.4) | 2.9 (-1.5,5.2) | -1.5 (-3.5, 3.5) | 1.2 (-1.5, 3.2) |

n=16 for hip group; n=19 for ankle group

**Table 3. Descriptive Data for Balance and Gait Measurements**

| Measurement | Central Tendency and Variability | Hip Group Pretest | Hip Group Post-test | Ankle Group Pretest | Ankle Group Post-test |
|---|---|---|---|---|---|
| Side-by-side stance time (sec.) | Mean ± SD | 180.0 ± .0 | 180.0 ± .0 | 151.0 ± 58.3 | 174.8 ± 22.7 |
| | (Median Quartiles) | 180.0 (180.0, 180.0) | 180.0 (180.0, 180.0) | 180.0 (180.0, 180.0) | 180.0 (180.0, 180.0) |
| Tandem stance time (sec.) | Mean ± SD | 11.7 ± 9.3 | 13.1 ± 10.4 | 13.2 ± 11.1 | 14.5 ± 12.0 |
| | (Median Quartiles) | 10.9 (3.3, 20.7) | 8.7 (5.0, 23.9) | 10.3 (1.8, 23.5) | 12.0 (2.3, 30.0) |
| One-legged stance time (sec.) | Mean ± SD | 5.8 ± 7.4 | 5.5 ± 7.1 | 5.3 ± 5.3 | 6.7 ± 6.6 |
| | (Median Quartiles) | 2.79 (1.91, 6.82) | 3.30 (1.40, 6.66) | 2.90 (1.64, 7.98) | 2.74 (1.75, 12.45) |
| Timed up and go (sec.) | Mean ± SD | 11.0 ± 3.2 | 10.3 ± 3.1 | 10.9 ± 3.4 | 10.0 ± 2.0 |
| | (Median Quartiles) | 10.2 (9.6,11.9) | 10.0 (8.3, 10.8) | 9.7 (8.5, 12.2) | 10.1 (8.4, 10.8) |
| Gait velocity (m/min.) | Mean ± SD | 60.6 ± 14.0 | 62.10 ± 12.00 | 63.7 ± 13.8 | 62.9 ± 10.8 |
| | (Median Quartiles) | 64.7 (53.6, 70.4) | 63.0 (56.9, 71.5) | 60.8 (53.4, 74.3) | 64.5 (55.8, 72.3) |

hip group n=16; ankle group n=19

**Table 4. Standard Error of Measurements (SEM) and Pretest to Post-test Change Scores**

| Measurement | SEM | Change Score: Hip Group | Change Score: Ankle Group |
|---|---|---|---|
| Hip flexor strength (kg) | .76 | .04 ± 1.49 | .37 ± 1.61 |
| Hip extensor strength (kg) | .67 | .70 ± 1.31 | .24 ± 1.58 |
| Ankle dorsiflexor strength (kg) | .83 | .39 ± 2.01 | .58 ± 1.75 |
| Ankle plantarflexor strength (kg) | .73 | .25 ± 1.66 | .02 ± 2.97 |
| Hip extension range of motion (°) | 1.8 | .8 ± 4.2 | -.5 ± 3.2 |
| Ankle dorsiflexion range of motion (°) | 2.1 | .6 ± 5.1 | 1.6 ± 4.2 |
| Side-by-side stance time (sec) | 7.8 | .0 | 23.8 ± 51.2 |
| Tandem stance time (sec) | 5.6 | 1.4 ± 5.6 | 1.3 ± 8.0 |
| One-legged stance time (sec) | 2.3 | -.3 ± 3.6 | 1.3 ± 4.4 |
| Timed "Up&Go" (sec) | 1.0 | -.7 ± 1.1 | -.9 ± 2.4 |
| Gait velocity (m/min) | 2.7 | 1.6 ± 6.4 | -.7 ± 8.0 |

**Table 5. Number of Subjects Progressed[1] with Thera-Band® Resistive Band**

| | Progressed x1 | Progressed x2 | Progressed x3 | Progressed x4 |
|---|---|---|---|---|
| Hip Group | 2 | 0 | 0 | 1 |
| Ankle Group | 8 | 2 | 1 | 0 |

[1]Progression to next thickness of Thera-Band® Resistive Band based on Rating of Perceived Exertion
$X^2 = 5.55; p=.02$

SEM values (based on the ICC and standard deviation of a measurement) are relatively large. The magnitude of the SEM values would appear to be related to the substantial variability among subjects in most of the measurements. The pretest to post-test change in hip extensor strength exceeded the SEM for that measurement in the hip group, but only by .03 kg. The pretest to post-test change in side-to-side stance time exceeded the SEM for that measurement in the ankle group, but those data were markedly skewed. While the mean change in that group was 23.8 seconds, the median change was 0 seconds. None of the changes in any of the outcome measures for either group reached statistical significance. The statistical findings and the group change scores compared to the SEMs both lead to the conclusion that neither group as a whole showed improvement with the interventions.

The findings in this study are similar to those found in several other studies. Buchner et al found no improvement in balance and gait outcomes in their study of 105 community dwelling older adults age 68 to 85 who performed strengthening and endurance home exercises 3 times a week for 1 hour over 24 to 26 weeks.[21] Rubenstein et al found no improvements in hip or ankle strength, or in balance when 59 men over 74 years old performed a 90-minute group exercise 3 times a week for 12 weeks.[46] McMurdo and Johnstone did not have any statistically significant outcomes for 86 subjects that had a mean age of 82 years who performed strengthening exercises, mobility exercises, or health education for 6 months at home.[47]

Krebs et al[23] and Chandler et al[22] found that a HEP improved lower extremity strength and gait velocity among community dwelling older subjects with functional impairments. Subjects in this study were well elders without obvious functional impairments. Compared to data from other studies, subjects in this study demonstrated similar one-legged and side-by-side stance times for older adults,[38] and similar TUG times and gait velocity for nonfallers.[8,10,13] The 8-week intervention in this study may have had a greater effect if the subjects had limitations in balance and gait measures at pretest.

While subjects in this study did not show evidence of functional impairment, they had weaker hip flexor, ankle plantarflexor, and ankle dorsiflexor strength[48] and weaker hip extensor strength[33] compared to elderly subjects in other studies. They also had decreased hip extension[49] and ankle dorsiflexion[50] ROM at pretest compared to subjects in other studies. These apparent initial deficits might indicate that the interventions were not of sufficient rigor or duration to effect change because there appears to have been opportunity for improvement given initial values. The use of the Perceived Exertion Rating scale to progress the exercise program may not have been an effective way to direct the strengthening progression, or a Perceived Exertion Rating of 11 or less may be an insufficiently rigorous criterion for progression. Even though the duration, frequency, and intensity of the exercise programs were developed using evidence from the literature, the stretching and strengthening exercises were chosen to isolate hip exercises from ankle exercises. This limited the available exercise options because exercises that act on multiple joints had to be excluded (both the ankle dorsiflexors and the hip flexors are lengthened in the runner's stretch that was used in another study[34]). Attempting to prevent contamination of exercises between groups may have resulted in a less than optimal exercise program. There was also a potential bias in the sample because 12 subjects recruited from the senior center (34.3% of the sample) were participating in an aerobics class at the time of recruitment. These subjects may have been less likely to respond to this moderate intensity exercise program, given their current activity level.

Subjects in this study who were at least 80% compliant with their program did not demonstrate changes different than the group as a whole. King et al found that elderly subjects who adhered to 66% to 80% of their exercise program had favorable results.[51] While using a cut-off below 80% may have led to different results in this study, inspection of the data does not support this as a factor in determining effectiveness of the intervention. Only 54% of the subjects were at least 80% compliant. However, this appears to be fairly typical for community dwelling elderly.[52-54] This degree of compliance should be taken into account when recommending exercise programs for well elders, especially considering both the relatively brief commitment required each day and the fact that 34.3% of the participants were already participating in a group exercise program.

The mean or median change scores for the functional outcomes in this study did not for the most part exceed measurement error. When questioned by the primary investigator at the end of the study, however, more than half of the subjects in each group (65% in the ankle group, 56% in the hip group) reported that they found the exercises to be beneficial. Fourteen (40%) of the subjects were progressed at least once using the Thera-Band® Resistive Bands, suggesting an increased tolerance for exercise for some of the subjects

In this study, there was substantial intersubject variability in most measurements and evident skew in some of the data (see Tables 2 and 3). If the variability in impairment and functional outcome measurements observed in this study are typical of well elders, this has implications for future studies of similar outcomes for this population. When a great deal of variability among study subjects in a measurement can be anticipated, it will be more difficult to demonstrate statistically significant differences over time or between groups. This is particularly true in a study where small changes are expected, and would indicate a need for large numbers of subjects per group.

## CONCLUSION

Two groups of well elderly subjects performed hip or ankle exercises over an 8-week period to determine if they would improve in selected measures of strength, ROM, balance, or gait. The intervention appeared to be insufficient either in duration or in intensity to effect change in this sample. An important outcome of this study was documentation of a large intersubject variability that should be taken into consideration in future research on similar measurements in this population.

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