

Tae Kwon Do: An Effective Exercise for Improving Balance and Walking Ability in Older Adults

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Background. Age-related declines in balance and walking ability are major risk factors for falls. Older adults reduce the dynamic components of walking in an effort to achieve a more stable walking pattern. Tae Kwon Do is an exercise that trains dynamic components of balance and walking that diminish with age.

Methods. Twenty participants from a Tae Kwon Do exercise class (average age 72.7 years) and 20 nonexercising controls (average age 73.8 years) participated. Balance and walking ability for all participants were pretested and posttested using the following measures: single-leg stance (SLS), Multidirectional Reach Test (MDRT), Timed Up-and-Go (TUG), walking velocity, cadence, gait stability ratio (GSR), and sit-and-reach (S&R). Analysis of variance for a mixed design was used to assess differences at the 0.05 level of significance.

Results. For nonexercising controls, no differences were found between pretest and posttest measures. Tae Kwon Do participants showed significant improvements on the MDRT when reaching backward, right, and left. TUG, walking velocity, GSR, and S&R also showed significant improvement in this exercising group.

Conclusions. Tae Kwon Do exercise was effective for improving balance and walking ability in community-dwelling older adults. These improvements were attributed to Tae Kwon Do movements that emphasize dynamic movement components typically deficient in the older adult walking pattern. Improving balance and walking ability through Tae Kwon Do exercise may serve to restore function that has declined with age and preserve mobility for older adults.

AGE-RELATED declines in balance and walking ability are major risk factors for falls in the older adult population (1). One third of older adults living in the community will experience a fall each year (2,3), and more than half of these falls will occur during walking (4,5). Not surprisingly, adaptations in the older adult walking pattern decrease dynamic components and stabilize walking. These adaptations represent an effort to minimize the requirements of dynamic balance, or the ability to remain balanced while the body is moving (6,7). Walking pattern changes include decreased motion at the hips, knees, and ankles that diminishes swing phase, resulting in a shorter step length and decreased walking velocity (8–11). Thus, older adults spend a greater portion of the walking cycle in double-limb support, creating a less dynamic walking pattern. This less dynamic walking pattern means, however, that their walk is much less effective at forward progression. Less effective forward movement can hamper daily activities for older adults and place them at risk for injury. One such example is community ambulation, during which decreased walking velocity can lead to traffic-related pedestrian injuries (12,13). Therefore, exercise interventions designed for improving or preventing deterioration of balance and walking ability should include tasks that focus on the balance requirements of *dynamic* activities.

Health benefits of exercise in older adults are numerous and well documented (14–18). Improvements in physical abilities such as strength (18), flexibility (17), aerobic

capacity (16), balance (14), and walking (15) have helped to lower fall risk and decrease severity of injury. Psychological benefits of exercise include improved cognition (19), positive affect (20), and self-esteem (21). Collectively, these improvements contribute to a better quality of life for older adults.

Tai Chi is a martial art form used for improving balance and walking ability in older adults, but has achieved varying results (22). Studies examining balance and walking ability as outcomes of Tai Chi have shown improvements (23–26), no change (23,27), or reductions in these measures (25,28). The 10 movement patterns of Tai Chi typically used in training older adults (25,27,28) are slow, controlled movements where performers gradually shift between standing postures while upper extremities execute prescribed movements (24,26,27). These movements, however, may not be sufficient for training those dynamic components deficient in the older adult walking pattern (8–11). Therefore, an exercise program that trains these dynamic components may be more suitable for preventing deterioration and improving dynamic balance and walking ability in the older adult population.

Tae Kwon Do is a martial art that combines kicking, blocking, and striking techniques, which require participants to actively shift their weight between the lower extremities while the upper extremities are moving. This type of movement necessitates stabilizing the body for efficient movement of the extremities to maintain balance during

Table 1. Health Status

Condition	TKD Group N (%)	Control Group N (%)
Hearing loss	10 (50)	7 (35)
Arthritis	14 (70)	16 (80)
Fractures	6 (30)	4 (20)
Osteoporosis	7 (35)	4 (20)
Diabetes	3 (15)	2 (10)
High blood pressure	12 (60)	8 (40)
Stroke	2 (10)	1 (5)
Parkinson's disease	1 (5)	0 (0)
Fear of falling	7 (35)	8 (40)
Falls in past 6 months		
0	18 (90)	17 (85)
1	1 (5)	3 (15)
2	1 (5)	0 (0)
No. of medications		
0	3 (15)	3 (15)
1–4	15 (75)	9 (45)
> 4	2 (10)	8 (40)
Perceived health status		
Fair	0 (0)	2 (10)
Good	16 (80)	12 (60)
Excellent	4 (20)	6 (30)

Notes: Total $n = 20$ for each group.

TKD = Tae Kwon Do.

these dynamic activities. These activities also include moving between long, wide stances that require older adults to spend more time in single-limb support as they lengthen their stride to achieve the desired stance.

Research on the efficacy of Tae Kwon Do in the older adult population is limited. One study documented balance improvement using single-leg stance (SLS) time. This measure increased by 16 seconds in a group of older adults after 17 Tae Kwon Do training sessions (29). Because SLS time is associated with walking ability (30), these results suggest that a short course of Tae Kwon Do training may be effective for improving balance and walking in older adults. The purpose of this study then, was to investigate the efficacy of Tae Kwon Do for improving balance and walking ability in older adults.

METHODS

Participants

Community-dwelling older adult volunteers were recruited as a sample of convenience from a Tae Kwon Do class offered to the community through the University of Texas Medical Branch (UTMB), Senior Services Office. Twenty participants agreed to have balance measures taken before and after attendance in the Tae Kwon Do class. These older adults included 17 women and 3 men aged 72.7 ± 6.1 years (range 60–83 years). All exercise participants selected for this study were newly enrolled in the class and had not undertaken Tae Kwon Do exercise in the past. A control group of 20 community-dwelling older adult volunteers who did not participate in Tae Kwon Do class were assessed along with the exercise participants. These nonexercising

participants were recruited from the UTMB Volunteer Registry and community groups at local churches. The control group consisted of 13 women and 7 men aged 73.8 ± 7.0 years (range 59–88 years). Informed consent was obtained from all participants prior to testing.

Potential participants were asked to fill out a health status questionnaire prior to the beginning of the testing procedures. This questionnaire has been used previously with success to assess health status in the older adult population (31,32). This information is summarized in Table 1. Older adults reported whether they had a history of pathologies listed in Table 1 within their lifetime. Fear of falling was assessed by the one-question fear of falling measure: “Do you fear that you will fall?” Perceived health status was self-assessed as excellent, good, fair, or poor.

All participants were free from severe pathologies that would preclude exercise. Potential participants reporting uncontrolled high blood pressure, uncontrolled diabetes, congestive heart failure, disabling rheumatoid arthritis, debilitating osteoporosis, or a fracture at the time of the study would not be included. Of those persons who were selected, two control group participants reported occasional use of an assistive device, but did not use it during the testing procedures. Of three participants reporting a stroke, one had speech affected and two had mild transient ischemic attacks. The participant reporting Parkinson's disease indicated that this was a recent diagnosis and that her symptoms were mild. The Charlson Comorbidity Index (CCI) provides a summary score for the health status information in Table 1. CCI measures the 1-year risk of mortality attributable to comorbidity, with scores ranging from 0–37; 0 indicates a low risk (33,34). The CCI for Tae Kwon Do exercise participants and nonexercising controls was the same ($CCI = 0.35 \pm 0.57$).

Because participants were nonrandomized volunteers and some reported mild neurological disorders, a chi-square test of homogeneity was used to confirm similarity of health status between the Tae Kwon Do and control groups. Participant samples were homogeneous with respect to the proportion of observations in each health status category reported in Table 1 [$\chi^2 (17) = 13.8, p = 0.68$]. Therefore, participant groups were considered to have equivalent health status (35).

Procedures

Prior to the first Tae Kwon Do class, all participants were pretested using the measures described below. These measures were chosen because they were clinically relevant and had demonstrated success in the older adult population (8,17,18,30,32,36,37). These same measures were used to posttest all participants at the conclusion of the Tae Kwon Do classes. Each participant proceeded through the tests in a random order for each testing session. Testers were blinded as to the group assignment of each participant.

SLS.—The length of time a participant stood on one leg was recorded using a stopwatch. Timing began when the participant lifted the foot from the floor and ended when the foot made contact with the floor. This static balance test

correlates with dynamic measures of walking (30) and is a predictor of falls in older adults (38).

Multidirectional Reach Test.—For this test, participants stood next to a meter stick aligned at the level of their acromion process. For each reach, participants positioned their arm parallel to the meter stick. An initial reading was recorded. They were then instructed to reach as far as they were able in the forward, backward, right, and left directions. A second reading was recorded for their final position and a difference score calculated. This test of balance measures limits of stability in four directions (32).

Timed Up-and-Go.—A stopwatch was used to time participants as they stood up from a chair, walked 3 meters, turned around, walked back, and sat down. This test of functional mobility (36) that includes walking was used to assess walking ability.

Walking velocity.—Participants walked back and forth along a 10-meter pathway until they stabilized at their comfortable walking pace. At the center of the 10-meter pathway, a 5-meter distance was marked. Participants were timed as they walked through this 5-meter distance, and walking velocity was calculated in meters per second. Walking velocity has been linked to balance measures in older adults (8,37) and is associated with fall risk (39).

Cadence.—As participants walked through the 5-meter distance described above for walking velocity, footfalls were counted. Based on this number of steps and the time it took to walk through the 5-meter distance, cadence was calculated in steps per second.

Gait stability ratio.—Gait stability ratio (GSR) was calculated by dividing cadence by velocity to achieve the number of steps per meter. Greater values of GSR indicate that older adults have decreased the dynamic phases of the walking cycle and are spending a greater portion of the cycle in double-limb support. Hence, GSR is an indicator of walking stability and is inversely related to balance (8). Therefore, as GSR increases, gait becomes increasingly less dynamic and is associated with poorer balance.

Sit-and-reach.—Participants sat on a therapeutic treatment table with their back against the wall and the soles of their feet placed against the sit-and-reach (S&R) box (Acuflex I; Novel Products, Inc., Rockton, IL). Participants placed their hands on the ruler mounted on the S&R box, and an initial reading was taken. Participants then leaned forward pushing a slide as far as possible. A second reading was taken, and a difference score was calculated. S&R is a valid measure of hamstring flexibility (40) and is linked to physical function in older adults (17,18).

These measures reflect characteristics of Tae Kwon Do exercise that would contribute to balance and walking improvements. For example, transitioning between long, wide stances can cause older adults to become more skilled at balancing on one limb and would be reflected in SLS times. Movements of the upper extremities from a stable

stance would contribute to improved Multidirectional Reach Test (MDRT) distances. Long, wide stances can also encourage increased step length and would show improvements in measures of walking. Kicking motions stretch the hamstring muscles and would improve S&R distances.

Tae Kwon Do classes met for 1 hour, twice per week for 11 weeks. Of the total 22 classes, participants attended an average of 15.4 ± 4.0 classes with an average adherence rate of 70.6%. The Tae Kwon Do classes followed a standardized curriculum for older adults (Phoenix & Dragon Martial Arts, Seabrook, TX). Classes began with a short warm-up during which participants walked around the perimeter of the room for approximately 5 minutes. Gentle stretching for the torso and upper and lower extremities followed. Tae Kwon Do exercise then began with a series of blocking, striking, and kicking movements performed while standing in place. Next, combinations using a block or strike with a kick were performed as participants stepped forward with each movement. Participants then practiced Tae Kwon Do forms, or sequences of choreographed movements. Tae Kwon Do forms include direction changes in which participants must turn before executing a block, strike, or kick. Classes concluded with practice of simple self-defense techniques of releasing from an aggressor's grasp.

Nonexercising controls were asked to maintain their current lifestyle. To maintain interest and involvement, nonexercising controls were phoned every 7–10 days by a research assistant. They were asked to report any lifestyle changes such as an extended illness, injury, or participation in a structured exercise program. No participants reported any of these lifestyle changes during the 11-week study. At the conclusion of the study, they were encouraged to join the next session of Tae Kwon Do classes.

Analyses

Analysis of variance (ANOVA) for a mixed design was used to assess the efficacy of Tae Kwon Do for improving balance and walking ability in older adults. A mixed design incorporates two independent variables (exercise and time) one of which is repeated across all participants (time) and the other forms independent groups (exercise) (41). The independent variable of exercise had two levels: Tae Kwon Do participants and nonexercising controls. The independent variable of time had two levels: pretest and posttest. Therefore, dependent measures were compared using an ANOVA for repeated measures to examine the effects of time within each exercise group. ANOVA for independent factors was used to examine the similarity between participant groups prior to exercise. Dependent measures were SLS, MDRT, Timed Up-and-Go (TUG), walking velocity, cadence, GSR, and S&R. Statistical analyses were assessed at the 0.05 level of significance.

RESULTS

Results of pretest and posttest measures for the Tae Kwon Do and nonexercising participants are shown in Table 2. The groups were similar at pretest on all measures except TUG and cadence values. Because health status was similar between participant groups, these differences may reflect the

Table 2. Means \pm Standard Deviations for Balance and Walking Measures

Testing Session	MDRT Front (cm)	MDRT Back (cm)	MDRT Right (cm)	MDRT Left (cm)	SLS (s)	TUG (s)	Walking Velocity (m/s)	Cadence (Steps/s)	GSR (Steps/m)	Sit-and-Reach (cm)
Pretest TKD	23.4 \pm 7.8	20.7 \pm 5.6	15.0 \pm 4.8	14.3 \pm 5.6	17.0 \pm 19.4	9.5 \pm 1.7	0.9 \pm 0.2	2.1 \pm 0.2	2.4 \pm 0.5	18.9 \pm 7.9
Posttest TKD	27.0 \pm 8.5	24.1 \pm 4.9*	19.2 \pm 6.2*	18.8 \pm 8.8*	27.2 \pm 39.4	8.6 \pm 2.1*	1.1 \pm 0.3*	2.2 \pm 0.4	2.0 \pm 0.4*	21.0 \pm 7.0*
Pretest Control	23.8 \pm 3.3	21.5 \pm 4.8	14.8 \pm 4.3	13.7 \pm 4.8	22.8 \pm 35.3	11.3 \pm 2.7*	0.9 \pm 0.2	2.0 \pm 0.2*	2.4 \pm 0.7	20.9 \pm 8.3
Posttest Control	23.1 \pm 7.0	21.8 \pm 6.4	14.9 \pm 4.6	15.3 \pm 5.1	21.5 \pm 39.1	10.9 \pm 2.9	0.9 \pm 0.2	2.0 \pm 0.2	2.4 \pm 0.5	19.8 \pm 8.1

Notes: *Different from pretest scores of TKD group ($p < .05$).

TKD = Tae Kwon Do; MDRT = Multidirectional Reach Test; SLS = single-leg stance; TUG = Timed Up-and-Go; GSR = gait stability ratio.

inability to randomly assign participants to the Tae Kwon Do or control groups.

Comparison of pretest to posttest scores for nonexercising participants demonstrated no significant differences (Table 2). In other words, the control group showed no changes in balance and walking measures from pretest to posttest.

Results of pretest to posttest comparisons for the Tae Kwon Do exercisers are found in Table 2. Examination of balance measures (Table 2) demonstrated significant improvement for the MDRT in the backward, right, and left directions. Participants' reach increased by at least 4.0 cm for each of these directions. Although the forward reach improved 3.6 cm, this change was not statistically significant. Times for SLS increased on average by 10.2 seconds. Although encouraging, this result was not statistically significant.

Assessment of walking ability demonstrated significant improvements (Table 2). Tae Kwon Do exercisers completed the TUG in less time after their exercise sessions. Walking velocity improved by 0.2 m/s, whereas cadence remained similar to pretest values. GSR decreased by 0.4 steps/m, indicating a more dynamic walking pattern that more effectively moves the body forward. S&R increased by 2.1 cm, indicating better hamstring flexibility for Tae Kwon Do participants.

DISCUSSION

This study examined the effectiveness of Tae Kwon Do training for improving balance and walking ability in older adults. Balance improvement was most evident in MDRT distances. Tae Kwon Do participants reached farther during their posttest than during their pretest in the backward, right, and left directions (see Table 2). These results indicate improved balance in positions that moved their center of mass toward the limits of their base of support (31,32). This finding is especially remarkable for backward movement, as participants have a shorter distance to move in this direction before their center of mass becomes displaced outside of their base of support.

The increasing trends for MDRT (in the forward direction) and SLS may become significant with longer durations of training. MDRT distances in the forward direction may have less room for improvement as pretest values for participants in this study were greater than values in previous studies of community-dwelling older adults (31,32). For SLS, variability of SLS posttest scores for Tae Kwon Do exercisers was greater than variability of pretest

scores (see Table 2). This change in variability indicates that some participants improved more than others. Increased variability can explain the lack of significance observed for this measure. Furthermore, increased variability may indicate that more participants were needed to achieve a significant result. To examine this possibility, a poststudy power analysis was conducted for SLS. The effect size index for these data was 0.77. To achieve significance of SLS at 80% power ($\alpha_2 = 0.05$), 30 Tae Kwon Do exercisers would be needed.

Tae Kwon Do exercisers improved significantly in walking ability. Faster times on the TUG and increased walking velocity indicate that they moved more quickly and efficiently after Tae Kwon Do exercise. Similarity in pretest and posttest cadence values was not surprising, as cadence is a measure that typically does not change with age (8–10) and therefore may not be affected by exercise. Consequently, the 0.2 m/s increase in walking velocity can be attributed to increased step length. As the value for cadence was 2.2 steps/s, the change in step length would equate to an approximate 9-cm increase for these older adults. A longer step length is accomplished by increasing swing phase distance and may be facilitated by improved hamstring flexibility as evidenced by S&R results. These walking pattern changes are collectively reflected by the drop in GSR after Tae Kwon Do exercise (see Table 2). This dramatic change in GSR indicates that Tae Kwon Do exercising participants increased dynamic components of their walking pattern. Their walking pattern at posttest is more effective for producing forward movement.

These findings hold implications for older adults who ambulate in the community. Increased effectiveness of the walking pattern permits older adults to cross the street more quickly and efficiently. This is important because older adults have the highest rate of traffic-related pedestrian injuries (13). Furthermore, many of these injuries that result in death occur at intersections (12). Therefore, by improving walking ability, Tae Kwon Do may serve to reduce injuries and fatalities for community-ambulating older adults.

Improvements in balance and walking ability can be explained by the nature of movements practiced during Tae Kwon Do exercise. First, Tae Kwon Do uses long, wide stances in conjunction with upper extremity motion. These stances encourage longer step lengths. Second, moving between stances using combinations of kicks, blocks, and strikes causes older adults to spend more time in single-limb support while coordinating their arm movements. These

types of movements can lengthen the swing phase of walking. Third, Tae Kwon Do forms further challenge dynamic balance by incorporating directional changes of 90°, 180°, and 270° in conjunction with blocks, strikes, and kicks. Practicing these turns emphasizes orientation with respect to space, thus improving balance while the body is moving. As a consequence, many of the movements practiced in Tae Kwon Do amplify the dynamic components diminished in the older adult walking pattern (8–11).

Results of this study provide provocative evidence that Tae Kwon Do is a useful exercise alternative for improving balance and walking in older adults. However, limitations regarding generalizability of these results exist because volunteers were used as a sample of convenience. Participants who were enrolled in the Tae Kwon Do exercise class may be more motivated toward exercise than those who served as controls. Inequality of TUG and cadence values between exercise and control groups at the pretest may also differentiate these groups. Matching participant groups by age, gender, and pretest scores may help remove potential confounders. Furthermore, participants exhibiting mild pathologies may have had an impact on test scores. These sampling issues emphasize the need for a randomized controlled trial using an exercising control group to further substantiate these results.

Summary

This study demonstrated that Tae Kwon Do is an effective exercise for improving balance and walking ability in community-dwelling older adults. These improvements in balance and walking may serve to preserve mobility and restore function that has declined with age.

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