

## **A Review of the Current Evidence for Dual-Task Training Among Older Adults at Risk for Falling**

### **Introduction**

Approximately 13.3% of the United States population is age 65 or older.<sup>1</sup> As members of the Baby Boomer generation begin to join this group, the number of geriatric falls is simultaneously increasing. Annually, one third of community-dwelling older adults who are 65 and older experience a fall, and half of these individuals will fall repeatedly.<sup>2-6</sup> Since risk increases with age, half of individuals over age 80 are also expected to suffer a fall each year.<sup>3</sup> Falls represent the leading cause of both fatal and non-fatal injury among older adults, inducing lacerations, head trauma, and fractures of the spine, hip, forearm, leg, ankle, pelvis, upper arm and hand.<sup>2,6</sup> Such injuries can result in prolonged hospitalization, as well as decreased mobility, function, and independence which in turn increase the elderly individual's risk of future falls.<sup>2,4,6</sup> In 2010, fall-related healthcare expenses consumed an estimated \$30 billion, and the yearly total is projected to continue rising with an increasingly older population.<sup>2</sup>

A variety of factors contribute to heightened risk of falling later in life. Intrinsic causes include declines in sensory abilities, strength, flexibility, and balance which reduce overall physical function. Extrinsic items are those influenced by the environment, for example, the presence of a curb, slippery floor, or flight of stairs.<sup>4</sup> In addition to the physical factors, many researchers now consider attentional ability to play a significant role in geriatric fall risk, particularly when attention must be divided between two simultaneous actions.<sup>4,7,8</sup> This form of multi-tasking, known as a dual-task condition, most often involves concurrent performance of a motor and cognitive task (i.e. walking and talking). As the aging process continues for an older adult, basic functions including balance and postural control, ability to navigate obstacles, and gait become increasingly difficult under dual-task conditions.<sup>4-6,8,9</sup> The onset of cognitive impairment such as dementia further decreases elderly motor performance under dual-task conditions, especially when cognitive demand is high.<sup>10</sup> Declining dual-task performance is not only predictive of heightened fall risk, but also of deficits in cognitive and physical function which can limit community participation.<sup>4, 8-11</sup>

Exercise interventions such as balance training, strengthening, and Tai Chi are known to improve key (particularly intrinsic) components of fall risk, and are beneficial for older adults with histories of falling.<sup>4,5,6</sup> In the past, traditional balance and gait training interventions have focused on practice under a single-task condition (one task at a time). However, with growing emphasis on the role of attention in geriatric fall risk, an increasing number of sources now advocate the use of dual-task performance training in fall prevention programs.<sup>4,5,9,10</sup>

Although dual-task performance training is gaining popularity as a means for addressing balance deficits and fall risk, it is a relatively new intervention concept in the geriatric population, and single-task performance training continues to enjoy widespread use in the clinic. The purpose of this literature review is to evaluate the effectiveness of dual-task training as an intervention, and to determine if dual-task training is more effective than single-task training for improving overall balance in older adults (age 65 and over) who are identified as at risk for falling. It is hoped that the findings collected to answer this PICO question will help clinicians to identify more efficient means of intervention for addressing the growing issue of falls among older adults.

### **Summary of Studies**

All of the studies included in this review are randomized control trials, a strong design choice which helps to reduce the influence of confounding variables. The studies are organized below based on the nature of comparison between experimental and control groups. A wide variety of outcome measures and intervention techniques are represented.

#### *Dual-Task Training vs. Single-Task Training*

A primary aim of this literature review is to compare the effectiveness of dual-task training (D-T), and single-task training (S-T) as methods for attenuating fall risk and improving balance performance. Four of the included studies specifically investigate this comparison. The first, by Plummer-D'Amato et al, involved 20 healthy community-dwelling older adults (average age 76-77) who received 45 minutes of intervention once weekly for four weeks, and also attended two weekly low-intensity exercise classes. Both the D-T and S-T group rotated between three stations concerning balance, gait, and agility, and all exercises progressed in difficulty over the course of the intervention. The study's primary outcome measure, time required to complete an

obstacle course under single and dual task conditions, demonstrated a ceiling effect in both groups that rendered it insufficient for detecting intervention effect. Both S-T and D-T intervention resulted in improved TUG time and gait speed, but no significant differences were noted between groups.<sup>8</sup> Hiyamizu et al completed a similar two-group comparison consisting of 43 healthy community-dwelling older adults (average age 71-72) who participated in strength, balance and gait training (D-T group completed cognitive tasks only during balance training) for 60 minutes twice weekly over 12 weeks. Both D-T and S-T intervention produced similar improvement for the Chair Stand Test, Functional Reach Test, TUG, and Trail Making (cognitive) Test. However, the D-T group demonstrated greater performance improvement under dual-task conditions for Stroop Task answering rate, and standing postural control.<sup>4</sup>

Two studies by Silsupadol et al contained 3 experimental groups: one single-task training, and two varieties of dual-task training. Previous studies suggest that instructional set may influence the success of dual-task training, and that variable priority instructions (shifting attention between two tasks) result in faster learning and superior performance compared with fixed priority instructions (giving equal amounts of attention to both tasks at once). Both Silsupadol studies included 23 community-dwelling older adults with proven balance impairment, and intervention was provided to all three groups for 45 minutes, three times weekly for four weeks.<sup>9,11</sup> Participants in the first Silsupadol study (average age 74.8) rotated between 4 stations (body stability, and body transport, both alone and combined with hand manipulation) for intervention according to training group.<sup>9</sup> As in the Plummer-D'Amato study, all exercises progressed in difficulty over the course of the intervention.<sup>8,9</sup> All 3 intervention groups demonstrated improved Berg Balance Score and gait speed under single-task conditions. Under dual-task conditions, the two D-T groups demonstrated greater increases in gait speed than did the S-T group, with members of the variable priority group showing more improvement than those in the fixed priority group. In addition, only the variable priority group demonstrated increased gait speed after 2 weeks of training, and maintained improvements at 12 weeks post-intervention.<sup>9</sup> For the second Silsupadol study, intervention consisted of balance tasks, during which both D-T groups completed simultaneous cognitive tasks. Under single-task conditions, all groups displayed decreased angle of inclination between center of mass and ankle joint during gait, and both D-T groups demonstrated increased counting speed and performance (while

sitting) while the S-T group showed no improvement. The S-T group also demonstrated no improvement during the seated auditory Stroop task while both D-T groups increased response speed. During a practiced dual-task condition (narrow walking + backward counting by 3s) all groups once again demonstrated decreased angle of inclination as well as decreased number of missteps. However, the variable priority D-T group showed the most improvement of all for balance and cognitive performance under dual-task conditions. Though all groups showed improvement on familiar tasks (those practiced in training), dual-task processing skills (acquired during practice of one task) did not appear to transfer for improved performance of new, unpracticed tasks.<sup>11</sup>

The Plummer-D'Amato, Hiyamizu, and Silsupadol studies demonstrate that both dual-task and single-task training are capable of improving factors associated with fall risk including balance control, and gait speed (less than or equal to 1.0 m/s is associated with falling). This is particularly true under single-task conditions, where dual-task training consistently produces results that are never less than comparable to those produced by single-task training.<sup>4,8,9,11</sup> Though the Plummer-D'Amato study concludes that dual- and single- task training produce similar levels of improvement in balance and gait, performance under dual-task conditions is not adequately assessed due to failure of the primary outcome measure.<sup>8</sup> The three remaining studies all identify areas in which performance after dual-task training is superior to that following the single-task training.<sup>4,9,11</sup> In fact, only dual-task training demonstrates the potential to boost cognitive performance via higher Stroop answering rate<sup>4,11</sup> and improved counting performance.<sup>4</sup> Comparison of the Silsupadol studies appears to confirm variable priority information set as superior to both single-task and fixed priority dual-task training<sup>9,11</sup>. Corroboration by studies from additional authors is now needed to rule out bias and possible confounding variables. Overall, dual-task training appears to carry some advantages over single-task training. However, due to poor representation of statistical power,<sup>4,11</sup> small sample sizes<sup>8,9,11</sup> including the Plummer-D'Amato pilot study,<sup>8</sup> and poor support for two primary outcome measures (Plummer-D'Amato's obstacle course<sup>8</sup>, and Silsupadol's angle of inclination<sup>11</sup>) further research is indicated to strengthen the evidence base.

### *Dual-Task Training vs. Dual-Task Training*

Two of the studies chosen for this review compare two different applications of dual-task training to each other. In a study by Trombetti et al, 134 community-dwelling older adults (average age 75.5) at high risk of falling completed a 60 minute music-based intervention once a week for 6 months. All participants received the same treatment: a Jaques-Dalcroze eurhythmics program (movement to piano music as a multi-task exercise) with progressive difficulty over the course of intervention. Half of the study participants received the 6 month treatment initially then rested for a second 6 months, while the other half rested first, then started the program after a delay of 6 months. Under dual-task conditions, the initial group demonstrated improvements in gait (increased stride length, decreased stride length variability), improved balance (greater single-leg stance, Tinetti, and TUG test scores), and fewer falls during the first 6 months compared to the delayed group. Overall, the incidence of falls, and number of subjects with multiple falls decreased in the later 6 months (when all participants had or were receiving intervention) compared with the first 6 months, and initial group displayed retention of training effects 6 months after the end of intervention.<sup>5</sup>

A pilot study conducted by Uemura et al also observed the effect of two different dual-task training programs. 18 healthy community dwelling older adults, divided into two groups, took part in 35 minute interventions once weekly for 24 weeks. One group was trained using a “dual switch exercise (DSE)” which consisted of 3 motor tasks - weight shifting, repeated starting/stopping during walking, and reversing direction without turning the body - all of which were practiced with simultaneously with cognitive tasks. The second group practiced cognitive tasks in combination with “steady state walking” (forward, backward, and laterally) on a straight path. Difficulty of the exercises in both groups was progressed through the course of the intervention. Both groups improved steady state walk time as a result of dual-task training, but members of the DSE group demonstrated improved gait initiation (faster reaction time and improved backward displacement of the center of pressure), while the other group did not.<sup>6</sup>

While adequate statistical power is present in the Trombetti study, the Uemura pilot study is less statistically sound.<sup>5,6</sup> However, Uemura’s work suggests the possibility that some forms of dual-

task training may be more effective than others.<sup>6</sup> This concept is also demonstrated in the two Silsupadol studies which suggest the superiority of dual-task training with variable priority information set vs. fixed priority information set.<sup>9,11</sup> Despite the lack of comparison to single-task training, both of the above studies clearly demonstrate the ability of dual-task training to improve factors associated with fall risk.<sup>5,6</sup> The Trombetti study is particularly intriguing as a novel and fun approach to dual-task training that appears to inspire high compliance among elderly participants, and lifestyle changes that extended beyond completion of the program. Evidence of training effect retention and decreased incidence of falls at the 6 months follow-up suggest that Jaques-Dalcroze eurhythmics could represent a valuable discovery for use in fall prevention.<sup>5</sup> Both the Uemura and Trombetti studies identify aspects of dual-task training which merit further investigation.

#### *Dual-Task Training vs. No Intervention*

Li et al's study of dual-task training is very different from the other sources in this literature review. To begin with, the comparison compares performance following dual-task training to performance by individuals who receive no intervention of any kind. In addition, the dual-task training itself is computer-based with no specific motor task.<sup>7</sup> Silsupadol's study of dual-task processing skills failed to produce evidence of training-related transfer to novel motor tasks under dual-task conditions, a result which is replicated in other studies.<sup>7,11</sup> However, research in the field of cognitive aging suggests that broader transfer of dual-task training effects is possible when process-nonspecific abilities (such as executive control process) are emphasized over process-specific abilities. Li theorized that dual-task training without a motor component might result in better training effect generalization. 20 healthy community-dwelling older adults (70 years and older) were recruited to take part in the study. The control group did not receive intervention, while the treatment group completed 5 60-minute sessions of computer-based dual-task training which utilized blocks of visual discrimination tasks. Dual-task performance increased over the 5 sessions, evident as a drop in mean reaction time. Upon completion of the intervention, members of the treatment group demonstrated improved single-limb balance and better alignment during double-limb stance when compared with untreated controls. The results imply that cognitive dual-task training of executive control skills produced a training transfer effect which generalized to novel motor tasks (balance). Though, the Li study is small, and

carries no statistical power justification, the concepts it presents could hold vital implications for the future of dual-task training.<sup>7</sup>

### *Dual-Task Training vs. Other Intervention*

Cognitive impairment constitutes exclusion criteria in the majority of studies included in this review. However, Schwenk et al specifically examines the effects of dual-task training on elderly individuals with mild to moderate dementia, a population known for its high risk of falling. 61 older adults who fit the criteria (average age 81.9) were allocated to two groups for 12 weeks of intervention. The dual-task treatment group participated in 120 minutes of intervention twice weekly, which encompassed an hour of resistance training, functional balance training, and individual as well as group dual-task training. Exercise difficulty progressed over the course of intervention. Members of the control group met together for 60 minutes of non-specific low-intensity exercises twice weekly. Dual-task training incorporated either a simple dual-task (counting forward by 2's) or a complex dual-task (counting backward by 3's). The study found that participants were not challenged enough under the simple dual-task, and that members of the dual-task training group demonstrated significant improvements in gait speed and stride length only with practice of the more complex dual-task. Members of the control group did not demonstrate gait improvement under either dual-task condition. It was therefore concluded that individuals with cognitive impairment may improve attention-related performance (such as walking) under challenging dual-task conditions by means of specific dual-task training. Schwenk's study is the first to demonstrate that dual-task training may be used effectively to improve motor performance in elderly individuals who are cognitively impaired.<sup>10</sup>

### **Limitations of the Current Evidence**

The studies contained in this literature review demonstrate several recurring limitations. Sample sizes are generally small, with the Plummer-D'Amato and Uemura studies specifically labeled as pilots.<sup>6,8</sup> Only the Hiyamizu, Trombetti, and Schwenk studies contain more than 23 participants.<sup>4,5,10</sup> The literature review as a whole contains very low statistical power. Of the eight studies, Hiyamizu, Li, and Uemura fail to provide justification for statistical power,<sup>4,6,7</sup> Plummer-D-Amato provides justification but does not retain enough participants in each group,<sup>8</sup> and the Schwenk and (one) Silsupadol studies provide partial justification for statistical power

but with too little detail to determine if statistical power is upheld.<sup>10,11</sup> Only one Silsupadol study and the Trombetti study demonstrate acceptable statistical power, resulting in questionable reliability in the vast majority of the evidence.<sup>5,9</sup> Across all current studies, over 75% of participants are female.<sup>4-11</sup> As a result, it is harder to generalize conclusions to both genders. Trombetti's study in particular predicts that music therapy might be more appealing (and therefore more effective) among elderly women, but with only 4% male participation, the conclusion remains little more than speculation.<sup>5</sup> To improve knowledge of the lasting effects of dual-task training, significantly more follow-up is warranted. Only one Silsupadol study, and the Trombetti study attempt any investigation of long-term training effect retention.<sup>5,9</sup> In general, many of the studies included in this review are among the first of their kind, resulting in very little repetition of methods, and specific focus.

### **Factors that Limit Application of the Evidence to Clinical Practice**

The current base of evidence available for dual-task training in older adults is relatively small, and includes a high number of pioneer studies which lack corroboration and adequate statistical power. Elderly women compose the vast majority of study participants,<sup>4-11</sup> and recruitment methods may unwittingly select volunteers who are more health conscious, fit, and/or motivated than the average older adult.<sup>4,6-8</sup> As a result, the conclusions may not generalize readily to clinical practice. Very few studies include follow-up to evaluate retention of dual-task training effects, so little is known about the long-term value of the intervention as it relates to fall prevention.<sup>5,9</sup> Only half of the reviewed studies concern participants known to be at heightened fall risk.<sup>5,9-11</sup> Results derived from studies of healthy older adults may apply less congruently to the elderly with balance impairments seen in the clinic. Finally, though one study exists to support use of dual-task balance training in older adults with mild to moderate dementia, more evidence is required before a strong generalization may be formed.<sup>10</sup> The success of dual-task intervention in older adults with severe cognitive impairment remains unknown.

### **Recommendations for Improving the Evidence Base**

The reliability, generalization, and clinical relevance of the current evidence require strengthening through future studies with adequate sample sizes, statistical power, and efficient follow-up. At present, there are few studies with statistically reliable results which compare

single-task training to dual-task training in the elderly population. There is even less corroboration available for studies concerning individuals with cognitive impairment, the potential merits of non-motor dual-task training, the underlying mechanisms of dual-task training, and the superiority of various approaches to dual-tasking compared with others. The underlying mechanisms of dual-task training, and training transfer to novel tasks remain poorly-understood, and represent a significant gap in the literature. Improved understanding of these areas could help to optimize application of dual-task training in the clinic. Specific populations currently under-addressed by the available dual-task training evidence include elderly men, individuals with severe cognitive impairment, older adults with dependence on assistive devices, and elderly persons who are age 80 and above.

## **Conclusions**

The growing issue of geriatric falls in the United States must be answered by selection and development of more efficient fall prevention interventions. Dual-task training demonstrates promise as a technique for addressing the attentional component of motor control. All studies included in this literature review show dual-task training to be at least as effective as the more traditional single-task training.<sup>4-11</sup> The technique has been successfully used among individuals with cognitive impairment,<sup>10</sup> and may allow for transfer of skills to novel tasks<sup>7</sup>. The few studies which include follow-up suggest that improvements acquired through dual-task training can be at least partially retained.<sup>5,9</sup> Some forms of dual-task training may be better than others, and factors such as complexity of cognitive task, or instruction set may further define intervention success.<sup>6,9-11</sup> Though the effectiveness of dual-task training is confirmed, its superiority to single-task training as a means of fall risk reduction remains largely unconfirmed due mainly to poor statistical power. Further research is needed to expand the available evidence with larger investigations based on the current pilot studies, reduction of common limitations, and greater overlap of corroborating conclusions to aid in creation of relevant clinical guidelines.

## Sources

1. U.S. Department of Commerce. State & County QuickFacts. <http://quickfacts.census.gov/qfd/states/00000.html>. United States Census Bureau. Accessed November 9, 2012.
2. Centers for Disease Control and Prevention. Falls Among Older Adults: An Overview. <http://www.cdc.gov/homeandrecreationalafety/falls/adultfalls.html>. Page Revised September 20, 2012. Accessed November 9, 2012.
3. National Council on Aging. Center for Healthy Aging. <http://www.ncoa.org/improve-health/center-for-healthy-aging/falls-prevention/>. Accessed November 9, 2012.
4. Hiyamizu M, Morioka S, Shomoto K, Shimada T. Effects of dual task balance training on dual task performance in elderly people: a randomized controlled trial. *Clin Rehabil*. 2012 Jan;26(1):58-67.
5. Trombetti A, Hars M, Herrmann FR, Kressig RW, Ferrari S, Rizzoli R. Effect of music-based multitask training on gait, balance, and fall risk in elderly people: a randomized controlled trial. *Arch Intern Med*. 2011 Mar 28;171(6):525-33.
6. Uemura K, Yamada M, Nagai K, Tateuchi H, Mori S, Tanaka B, Ichihashi N. Effects of dual-task switch exercise on gait and gait initiation performance in older adults: preliminary results of a randomized controlled trial. *Arch Gerontol Geriatr*. 2012 Mar-Apr;54(2):e167-71.
7. Li KZ, Roudaia E, Lussier M, Bherer L, Leroux A, McKinley PA. Benefits of cognitive dual-task training on balance performance in healthy older adults. *J Gerontol A Biol Sci Med Sci*. 2010 Dec;65(12):1344-52.
8. Plummer-D'Amato P, Cohen Z, Dae NA, Lawson SE, Lizotte MR, Padilla A. Effects of once weekly dual-task training in older adults: A pilot randomized controlled trial. *Geriatr Gerontol Int*. 2012 Oct;12(4):622-9.
9. Silsupadol P, Shumway-Cook A, Lugade V, van Donkelaar P, Chou LS, Mayr U, Woollacott MH. Effects of single-task versus dual-task training on balance performance in older adults: a double-blind, randomized controlled trial. *Arch Phys Med Rehabil*. 2009 Mar;90(3):381-7.
10. Schwenk M, Zieschang T, Oster P, Hauer K. Dual-task performances can be improved in patients with dementia: a randomized controlled trial. *Neurology*. 2010 Jun 15;74(24):1961-8.
11. Silsupadol P, Lugade V, Shumway-Cook A, van Donkelaar P, Chou LS, Mayr U, Woollacott MH. Training-related changes in dual-task walking performance of elderly persons with balance impairment: a double-blind, randomized controlled trial. *Gait Posture*. 2009 Jun;29(4):634-9.