The Dual-Task Condition:

An Evidence-Based Guide to Assessment and Intervention for Attention-Related Fall Risk in Older Adults

Megan Christiansen, SPT
Dietra Buxton, PT, DPT
Division of Physical Therapy, UNC-Chapel Hill

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F.A.Q.

What is a dual-task (DT) assessment?

It is an assessment tool that measures the patient's ability to perform more than one task at a time. DT assessments typically combine a motor task, such as walking, and a cognitive task, such as counting. Patients are considered to have a "dual-task cost" if their performance on the motor task or cognitive task declines when the tasks are performed together under dual-task conditions versus when they are performed in isolation under single-task conditions.

What are the benefits of using dual-task assessments to evaluate patients?

DT assessments have been advocated for predicting falls risk in older adults and people with neurologic impairments, such as stroke (Beauchet, 2009; Hyndman, 2006). When used for this purpose, the goal is often to determine whether attentional resources are exceeded, and thus postural instability increases, when patients attempt to multi-task in everyday life contexts, such as walking and talking, or standing and dressing (Bensoussan, 2007).

What is the best way to use DT assessments in the clinic?

DT assessments identify some, but not all, fallers (Zijlstra, 2008). They may be most useful for identifying older adults who are at risk of falls because they are unable to divide and allocate attention to postural control when performing more than one task (Zijlstra, 2008). But, other assessments are needed to identify older adults who fall for other reasons, such as poor balance or mobility.

Take-home message: *Use a battery of outcome measures, including DT assessments, to best predict falls risk* (Verghese, 2002; Zijlstra, 2008).

Combining an assessment tool that takes cognitive factors into account with more traditional mobility measures may improve sensitivity for predicting falls (Verghese, 2002). Plus, it allows therapists to determine which interventions will be most effective for reducing the risk of falls. For example, patients who perform poorly on DT assessments may benefit most from DT interventions and/or referrals for cognitive rehabilitation and pharmacological treatments (Verghese, 2002).

Why is DT intervention useful?

Functional specificity: Dual-tasks are common in daily life, and older adults with DT deficits may be at greatest risk of falls when performing ADLs that require them to maintain their balance while performing a secondary cognitive or motor task such as walking and remembering a phone number (Silsupadol, 2006). Although balance training under single-task conditions improves motor performance under single-task conditions, the improvements in balance control may not generalize to dual-task performance. On the other hand, studies of older adults have demonstrated that DT balance training improves gait performance under both single- and dual-task conditions (Silsupadol, 2006; Silsupadol, 2009a; Silsupadol, 2009b; Hiyamizu, 2012). One theory that has been proposed to explain this finding is the Task Integration Hypothesis, which suggests that dual-task practice facilitates development of task-coordination skills; the ability to efficiently integrate and coordinate two tasks may be essential for improving dual-task performance (Silsupadol, 2009a; Silsupadol, 2009b).

A. Defining Terminology

- Dual-Task Cost (DTC): Describes a deficit in motor or cognitive task performance which occurs when tasks are performed together (under dual-task conditions) but not when each is performed alone (under single-task conditions).

  In some situations, performing certain tasks together (under dual-task conditions) seems to enhance performance more so than performing each alone (under single-task conditions). In such cases, there is a dual-task BENEFIT. For example, it is thought that combining rhythmic cognitive and motor tasks (such as “counting backwards” + “walking”) may be able to improve rhythmic performance of both tasks (faster counting speed/accuracy + greater gait regularity). (Beauchet, 2007)

  Calculate motor or cognitive DTC (or Benefit) with the following:

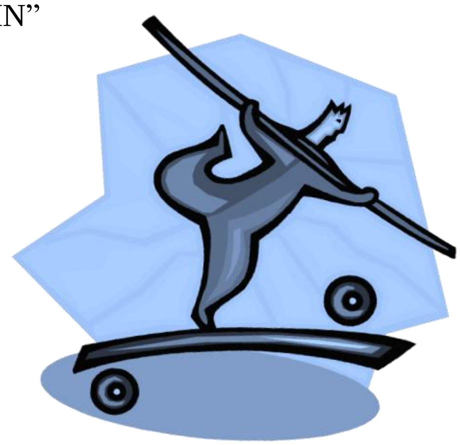
$$\frac{\text{Single-task performance} - \text{Dual-task performance}}{\text{Single-task performance}} \times 100 = \%\ \text{DTC or Benefit}$$

- Negative Predictive Value (NPV): The likelihood that an individual who tests “negative” truly does not have the condition (a “true negative”)

- Positive Predictive Value (PPV): The likelihood that an individual who tests “positive” truly has the condition (a “true positive”)

- Sensitivity: Ability to rule a condition out → think “SnOUT”

- Specificity: Ability to rule a condition in → think “SpIN”



B. Dual-Task Assessments

Stops Walking While Talking (Long & Short)

Literature

1. Lundin-Olsson L, Nyberg L, Gustafson Y (1997). 'Stops walking when talking' as a predictor of falls in elderly people. Lancet, 349(9052): 617.
2. de Hoon EW, Allum JH, Carpenter MG, Salis C, Bloem BR, Conzelmann M, Bischoff HA (2003). Quantitative assessment of the stops walking while talking test in the elderly. Arch Phys Med Rehabil, 84(6): 838-42.

Population(s)

Frail institutionalized older adults (mean age 80), some with dementia, depression, or post-stroke[1]; Frail institutionalized older adults (ages 79-93)[2]

Procedure

- Long: Patient engages in conversation while walking 100m-200m. Examiner visually identifies if the patient comes to a complete stop at any time during the test. Content of conversation is not specified. Procedure is not timed.[1]
- Short: Patient completes two 8m walks accompanied by examiner. No conversation during first 8m. 2m into the second 8m walk, examiner asks patient a simple question (what is your age?). Examiner visually identifies if the patient comes to a complete stop at any time during either walk. Each of the two walks may be timed for comparison.[2]
- Use of assistive device allowed for both versions, but no other human assistance[1,2]

Psychometrics

- Long[1]
  - Specificity: 95% for ruling in fall risk
  - Sensitivity: 48% for ruling out fall risk
  - PPV: 83% correct identification of individuals with high fall risk
  - NPV: 76% correct identification of individuals without high fall risk
- Short[2]
  - Not established

Interpretation

- Patients who stopped walking are more likely to demonstrate fall risk factors
  - Unsafe gait patterns[1]
  - Slower gait speed[1,2]
  - Increased dependence in ADLs[1]
  - Reduced trunk control[2]
- No cut-off scores or other normative data have been established for either version[1,2]
- NOTE: Sudden question posed during Short Version mimics unexpected DT situations in life which are associated with falling

Walking While Talking (WWT)

Literature

1. Verghese J, Buschke H, Viola L, Katz M, Hall C, Kuslansky G, Lipton R (2002). Validity of divided attention tasks in predicting falls in older individuals: a preliminary study. J Am Geriatr Soc, 50(9): 1572-6.
2. Brandler TC, Oh-Park M, Wang C, Holtzer R, Verghese J (2012). Walking while talking: investigation of alternate forms. Gait and Posture, 35(1): 164-166.

Population(s)

Community-dwelling older adults (ages 65-98) without dementia[1]; Community-dwelling older adults (mean age 79) without dementia or depression[2]

Procedure

- Patient should begin walking ~ 1 m behind the start line to allow for gait acceleration prior to the start of timing
- Verghese Original: Patient walks 6.1 m, turns, and walks back. Procedure is timed.[1]
    - WWT-Simple: walk while reciting the alphabet out loud
    - WWT-Complex: walk while reciting alternate letters of the alphabet out loud
- Brandler Alternate: Patient walks 6.1 m, turns, and walks back. Procedure is timed.[2]
    - 1 trial under single-task conditions (walking only)
    - 2 trials under dual-task conditions (patient is instructed to pay equal attention to both walking and talking tasks). Patient recites every other letter of the alphabet starting from a different initial letter for each trial (start from "a" then from "b" OR start from "m" then from "n"). Results of 2 DT trials are averaged, then used with ST trial to calculate DTC.
- Use of assistive device not clarified

Psychometrics

- Verghese Original[1]
    - WWT-Simple
        - Specificity: 89% for ruling in fall risk
        - Sensitivity: 46% for ruling out fall risk
        - PPV: 55% correct identification of individuals with high fall risk
    - WWT-Complex
        - Specificity: 96% for ruling in fall risk
        - Sensitivity: 39% for ruling out fall risk
        - PPV: 71% correct identification of individuals with high fall risk
- Brandler Alternate[2]
    - Not established

Interpretation[1]

- WWT-Simple > 20 seconds indicates fall risk
- WWT-Complex > 33 seconds indicates fall risk
- No cut-off scores or other normative data have been established for the Brandler Alternate[2]

Faster Counting While Walking

Literature

1. Beauchet O, Dubost V, Allali G, Gonthier R, Hermann FR, Kressig RW (2007). 'Faster counting while walking' as a predictor of falls in older adults. Age and Ageing, 36(4): 418-23.
2. Beauchet O, Allali G, Poujol L, Barthelemy JC, Roche F, Annweiler C (2010). Decrease in gait variability while counting backward: a marker of "magnet effect"? J Neural Transm; 117(10):1171-6.

Population(s)

Older adults (ages 75-100) living independently in senior housing facilities[1]

Procedure[1]

- Patient counts backwards from 50 under 2 conditions. Each trial is timed.
  - Walking: Patient covers 10 m at comfortable speed. Examiner tracks how many numbers are spoken out loud in the time taken to walk 10 m
  - Seated: Examiner tracks how many numbers are spoken out loud in the same time taken to walk 10m (from above)
- Counting performance is compared between Seated and Walking trials
- Use of assistive device not clarified

Psychometrics[1]

- Sensitivity: 87% for ruling out fall risk
- Specificity: 90% for ruling in fall risk
- PPV: 85% correct identification of individuals with high fall risk
- NPV: 90% correct identification of individuals without high fall risk

Interpretation

- Better counting performance (more numbers spoken) during Walking vs. Seated condition indicates high fall risk in older adults[1]
- NOTE: The majority of individuals who undergo this assessment are expected to display a decline in performance under dual-task conditions. Improvements in gait and counting performance under DT conditions have been observed <u>only</u> among individuals who display severe gait variability under ST conditions. These patients have very high gait instability which in turn puts them at great risk for falling.[2]

  It is believed that counting backward produces a metronome-like effect for individuals with irregular gait patterns, therefore helping to decrease variability. Because counting backward and walking are both rhythmic tasks, parallel processing may be stronger compared to processing of each task alone. As a result, both tasks improve when they are performed together. This kind of dual-task benefit is attributed to the "magnet effect" -- the tendency for biological oscillators to attract one another.[2] This phenomenon may indicate a strategy for prioritization of "optimal energy cost, attention demand, and gait control" initiated to maintain gait safety in those with severe gait instability.[1]

Timed Up and Go: TUG (Manual) & TUG (Cognitive)

Literature

1. Shumway-Cook A, Brauer S, Woollacott M (2000). Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. Phys Ther, 80(9): 896-903.
2. Hofheinz M, Schusterschitz C. (2010). "Dual task interference in estimating the risk of falls and measuring change: a comparative, psychometric study of four measurements." Clin Rehabil 24(9): 831-842.

Population(s)

Community-dwelling older adults with and without history of falls (ages 65-95)[1]; healthy community-dwelling older adults (ages 60-87)[2]

Procedure[1]

- Patient stands up from chair, walks 3 m "as quickly and safely as possible" before turning, walking back, and sitting down. Procedure is timed.
  - TUG (Cognitive): complete test while counting backward by threes from a randomly selected number between 20 and 100
  - TUG (Manual): complete the test while carrying a full cup of water
- Timing begins when the individual's pelvis lifts up from the chair and ends when the pelvis reaches the chair
- Use of assistive device is allowed, but no other human assistance

Psychometrics[1]

- TUG (Manual)
  - Sensitivity: 86.7% for ruling out fall risk
  - Specificity: 93.3% for ruling in fall risk
  - PPV: 90% correct identification of individuals with high fall risk
- TUG (Cognitive)
  - Sensitivity: 80% for ruling out fall risk
  - Specificity: 93.3% for ruling in fall risk
  - PPV: 87% correct identification of individuals with high fall risk

Interpretation

- TUG (Cognitive) in ≥ 15 seconds indicates fall risk[1]
- TUG (Manual) in ≥ 14.5 seconds indicates fall risk[1]
- Mean time to complete[2]
  - TUG (Cognitive) = 9.8 seconds
  - TUG (Manual) = 11.6 seconds
- Times for TUG (cognitive and manual) = no significant difference between men and women (P>0.05). Increasing age correlated with more time taken to complete either test.[2]
- TUG , TUG (Manual), and TUG (Cognitive) appear to be comparable in ability to detect fall risk[1]

Walking and Remembering Test (WART)

Literature

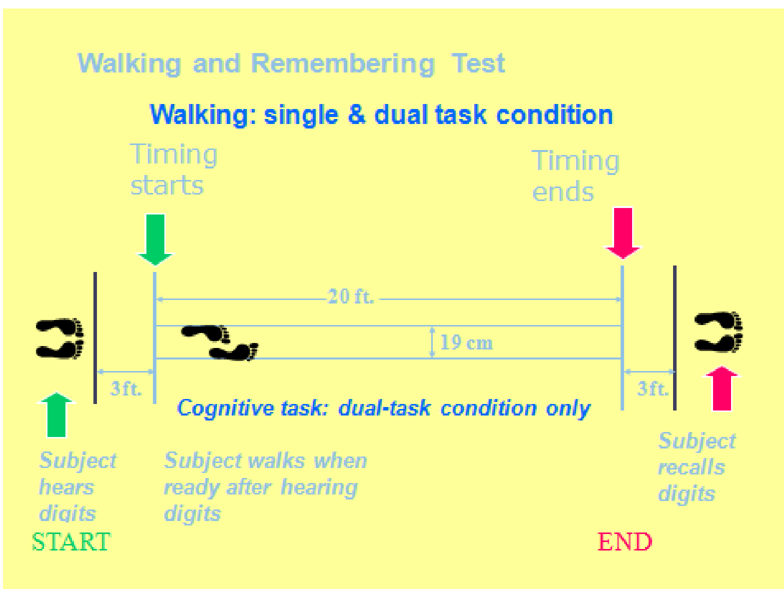
1. McCulloch KL, Mercer VS, Giuliani CA, Marshall S (2009). Development of a clinical measure of dual-task performance in walking: Reliability and preliminary validity of the Walking and Remembering Test. J Ger Phys Ther 32, 2-9.
2. Alzheimer's Disease Neuroimaging Initiative. Cognitive Testing: Digit Span Forward. PDF. http://adni.loni.ucla.edu/wp-content/uploads/2010/09/BLCogTestingWorksheet.pdf. Accessed March 3, 2013

Population(s)

Community-dwelling older adults (ages 65-86) without dementia[1]

Procedure (see diagram below)[1]

- Patient completes four testing components/steps:
  - Step 1- Single-task walking on a narrow path (19 cm wide, 6.1 m long): 1 trial at "comfortable speed," then 3 trials at "fastest comfortable speed." Procedure is timed, and number of steps off path is recorded.
  - Step 2- Single-task seated forward digit span (WAIS-R protocol): Examiner verbalizes a random sequence of 2 to 9 numbers for patient who must immediately repeat the sequence back in same order. Two number sequences of each length (i.e. 4-8 and 3-9, then 3-2-6 and 5-0-3…) are tested until the patient fails to repeat a set of two sequences correctly (highest number of correctly recited digits will be used for cognitive part of dual-task component).[2]
  - Step 3- Single-task seated while remembering digit span: Examiner verbalizes a random sequence of numbers (length determined by WAIS-R protocol). Patient pauses (time needed to walk 6.1 m path at "comfortable speed" in Step 1), then repeats the sequence out loud.
  - Step 4- Dual-task walking while remembering digit span: 4 trials completed (same protocol as Step 1). Examiner verbalizes a random sequence of numbers (length determined in Step 2). After hearing number sequence, patient walks narrow 6.1 m path, then repeats the sequence out loud upon reaching the end. Procedure is timed. Number of steps off path and digit span accuracy is recorded.
- DTC is calculated for cognitive and motor tasks



Graphic contributed by Karen McCulloch, PT, PhD, NCS

Psychometrics

- Sensitivity and Specificity not established

Interpretation[1]

- Measures presence of cognitive and motor DTCs while eliminating need for talking while walking
- Ability of WART to identify fall risk in older adults has not yet been studied
- Current protocol may be too time consuming for clinic; components of procedure may be used to test memory DT
- NOTE: Narrow path may make procedure too difficult for some patients; Can be performed on normal path

C. Ideas for Dual-Task Intervention

Primary Motor Task	**Secondary Cognitive Task**	**Secondary Motor Task**
* Stand with narrow base of support (eyes open or closed)	* Auditory discrimination (i.e. identify noises)	* Holding a ball with 1 or 2 hands
* Semi-tandem stance (eyes open or closed)	* Name things/words (i.e. types of fruit, or animals, movie stars, book titles, "things beginning with" or "rhyming with")	* Bouncing a ball with 1 or 2 hands
* Single-leg stance (i.e. draw a letter with one foot)	* Counting backward or forward by 2s or 3s	* Hold a ball in 1 hand and bounce a ball with the other hand
* Standing with external perturbations	* Reciting the ABCs (i.e. alternating letters) or multiplication tables	* Kick a ball
* Walking with a narrow BOS (i.e. walking between two lines of tape)	* Reciting something well-known (i.e. "Row Your Boat," nursery rhymes, poems, the Pledge of Allegiance)	* Hold a ball in 1 hand and kick a ball with foot
* Side-stepping or backward stepping	* Visual spatial tasks (i.e. give directions from house to grocery store, describe a favorite room in the house or other location)	* Bounce a ball in 1 and kick a ball with foot
* Side-stepping or backward stepping with a narrow BOS while avoiding obstacles	* Remembering something (i.e. phone number, grocery list, random number or word sequence)	* Reciprocally bounce 1 ball with both hands
* Standing on a soft or unstable surface	* Spelling words or spelling them backwards	* Carry a full cup of water
* Climbing up and down stairs	* Describing a vacation/weekend or vacation/weekend plans	* Balance a ball or a cup of water on a saucer, plate or Frisbee
* Marching with high steps	* Visual discrimination tasks (i.e. reading words written in different colors and then saying the color out loud rather than the written word – more difficult: color names written in another color, i.e. "blue" written with a red marker)	* Performing rapid alternating hand movements or arm circles
		* Lifting small free weights

How should the Motor Task be selected and progressed?

When selecting the motor task, the therapist should consider the patient's baseline functional status and the type and extent of mobility-related impairments. Motor tasks should become progressively more challenging over time. Gentile's taxonomy has been proposed as a tool for guiding activity advancement (Silsupadol, 2006). Under this framework, activities progress in the following order: (1.) body stability tasks, (2.) body stability + object manipulation, (3.) body transport tasks, and (4.) body transport + object manipulation (Gentile, 2000; Silsupadol, 2006). Altering the size of the movements (i.e. bigger/smaller steps or upper body motions), base of support, or the speed at which a task is performed can also influence level of difficulty (Trombetti, 2011).

How should the Cognitive Task be selected and progressed?

Again, it is important to consider the patient's baseline cognitive status when selecting a secondary cognitive task. Patients who are presented with dual motor and cognitive activities in a physical therapy clinic may initially be surprised by requests to perform a mental task by a healthcare provider who traditionally focuses on physical function. It may be helpful to explain some of the potential advantages of DT training, such as improvements in the patient's ability to multi-task during everyday life situations, improved balance and mobility, and decreased risk of falls (Silsupadol, 2006; Silsupadol, 2009; Yang, 2007).

It may also be useful to vary the type of cognitive task throughout the training period, as gait changes observed during DT performance differ depending on the type of cognitive task (Beauchet, 2005). For example, a combination of arithmetic, verbal fluency, auditory discrimination, and visuo-spatial tasks will enhance variety and allow the patient to practice coordinating and integrating motor tasks with different cognitive functions.

If cognitive performance is being evaluated and measured, it is important to ensure that the task is difficult enough to elicit DT cognitive costs (Verghese, 2007; Schwenk, 2010). The level of task difficulty necessary for eliciting DT cognitive costs will likely vary from patient to patient.

Some variations of the same task may be more challenging to perform than others, for example, reciting every other letter of the alphabet starting from "m" or "n" rather than the more typical "a" or "b" (Brandler, 2012), or counting by 3's from a number that is not a multiple of 3. Performing familiar cognitive tasks such as spelling, reciting a poem, or counting may be simple if performed normally, and more complicated if performed backward. Likewise, singing a well-known song is an easier task than vocalizing only every other or every third word out loud. Attentional demand is typically higher for novel tasks than for familiar ones, so varying task combinations often or changing parameters within one task (i.e. beginning a sequence on a different letter/number, or asking the patient to name objects of different colors) can help prevent dual-task cost from being masked by a practice effect.

Are there other ways to modify the level of difficulty in dual-task intervention?

Manipulating aspects of the environment can change the difficulty of a dual-task activity. Consider varying the surface on which the patient is performing, for example, standing or marching on foam while performing rapid alternating hand movements or naming kinds vegetables (Silsupadol, 2009a; Plummer-D'Amato, 2012). Performing tasks within a noisy, crowded and/or dynamic setting is also more attentionally demanding than completing tasks in a quiet, controlled environment.