



Full length article

Reliability of clinically feasible dual-task tests: Expanded timed get up and go test as a motor task on young healthy individuals



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ABSTRACT

Dual-Task testing has been reported to have a higher sensitivity to deficits associated with concussion; however, the feasibility as a clinical or field test is questionable due to the requirements of laboratory-based equipment. With an overarching goal of exploration of clinically feasible Dual-Task testing options, the specific aims of this study were 1) to evaluate the reliability of Dual-Task testing methods using the Expanded Timed Get-Up-and-Go (ETGUG) paired with Backward Digit Recall (BDR), Serial Seven (SS), and Auditory Pure Switch Task (APST), and 2) to determine the effects of Dual-Task testing on motor and cognitive performance in healthy college-aged individuals. Fifty-four healthy young adults completed two separate testing sessions, which consisted of Single-Task tests in a randomized order followed by 3 pairs of Dual-Task tests in a randomized order. Test-retest reliability for ETGUG time to completion was excellent for all Single- and Dual-Task conditions (ICC 0.89–0.92); however, ETGUG_{BDR} and ETGUG_{SS} were associated with learning effects ($p = 0.002$ and 0.007 , respectively). Test-retest reliability for Response Rate of the cognitive tasks was lower than those of motor task and all outcomes were associated with learning effects. The completion time of the ETGUG_{APST} pair indicated excellent reliability with no learning effect. Performance level declined in all tasks under Dual-Task conditions compared to Single-Task; however, motor tasks showed larger deficits indicating the prioritization of the cognitive task compared to the motor task.

1. Introduction

Executive functioning allows higher-order cognitive behavior such as planning, monitoring, and executing a sequence of goal-oriented complex actions and is often affected by concussions [1]. Dual-Task testing is one method of assessing executive function, specifically assessing “divided attention” (attention necessary to multi-task) and is commonly used in older adults to predict fall risk [2]. Decreased executive function has been associated with altered gait performance in older adults when a cognitive task is performed simultaneously [3]. Dual-Task testing has also been reported to detect continued neurocognitive and functional deficits in a concussed athlete, even after standard concussion assessment scores returned to normal [4–9]. Assessment of executive function, specifically divided attention, may provide further insight regarding readiness for returning to play as sports participation involves simultaneous motor and neurocognitive function [10]. It has been suggested that Dual-Task testing has the potential to be a more sensitive and practical concussion assessment tool [11]. The National Athletic Trainers’ Association position

statement on concussions endorses the use of different types of screening tools that separately evaluate postural stability, neurocognitive function and self-reported symptoms, which has been shown to be sensitive, reliable, and feasible in a clinical setting [12]. Despite the growing evidence supporting the efficacy of Dual-Task testing for concussion assessment, testing protocols reported in previous studies typically require advanced laboratory equipment to measure exclusive outcomes such as center of mass and ellipse area during gait and balance activities [4–9,11,13–16] and are therefore impractical in clinical settings.

The Timed-Up-and-Go Test is an established clinical test used to assess gait and postural control [17]. Gait speed during the Timed-Up-and-Go test has been shown to decrease significantly in an elderly population when combined with a cognitive task [17]. Slower gait speed during Dual-Task tests using level-walking has also been reported in concussed individuals [4,7,9,16]. These studies suggest that changes in gait performance instigated by a concurrent cognitive task, referred to as Dual Task Cost (DTC), is measurable using gait speed. The Expanded-Timed-Get-Up-and-Go test (ETGUG) is a modification of the

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Timed-Up-and-Go test and is considered a more appropriate clinical assessment for physically active individuals [18]. The increase in walking distance from six to twenty meters provides an extended period of time for cognitive task performance when utilizing Dual-Task testing. The only equipment necessary to implement the ETGUG is a chair, timer, and 10-m walkway, which makes this test more feasible in a clinical setting compared to a laboratory-based gait assessment that requires motion analysis systems.

The ideal cognitive tasks to be paired with ETGUG should be easily administrable by a single examiner in a clinical setting. The selected cognitive tasks should not utilize the same input or output used for the motor task, which would cause structural interference. For example, reading a sign and catching a baseball both require visual input, which limits the ability of the Dual-Task test to assess divided attention [19]. Controlling for structural interference allows any deficiencies in Dual-Task performance, when compared to Single-Task performance, to be attributed to the overload of the participant's attention capacity. The Serial Sevens (SS) test and the Auditory Pure Switch Task (APST) test have previously been used in Dual-Task research and the Backward Digit Recall (BDR) test is commonly used in on-field concussion assessment [4,6,13]. These tasks do not create structural interference when paired with the ETGUG and are number-based in order to minimize the influence of the participants' English ability on the outcome measures as compared to word-based tasks. These are also auditory-based tests that a clinician could implement without having additional equipment, as opposed to visual-based test that requires a computer or projector.

Previous Dual-Task concussion research has predominantly focused on tasks requiring extensive equipment such as three-dimensional motion analysis system, Sensory Organization Test and computerized neurocognitive tests [4–9,11,13–16]. Therefore, the goal of this study was to identify a combination of motor and cognitive tasks that produced a reliable and clinically feasible Dual-Task test in healthy young adults that, once established, may prove valuable through future investigations in assessing deficits in concussed patients in clinical settings. Therefore, the specific aims of this study were 1) to evaluate the reliability of the Dual-Task testing methods using ETGUG paired with SS, APST, and BDR, and 2) to determine the effects of Dual-Task testing on motor and cognitive performance in healthy college-aged individuals.

2. Methods

2.1. Participants

A total of 54 participants (33 females, 21 males) were recruited from the university. (Table 1) Exclusionary criteria included: a history of diagnosed concussions, lower extremity injury within the last 3 months, diagnosed learning disability, previous exposure to SS, BDR, APST, or ETGUG, or any physical condition that could affect the outcomes of the test. Of the 54 participants, two males were unable to complete the testing sessions due to injury. All participants completed an informed consent form approved by the university's Human Studies Program Institutional Review Board.

Table 1
Participant demographics.

	Male (n = 21)	Female (n = 33)	Overall (n = 54)
Age (y/o)	20.90 ± 1.6	21.00 ± 1.7	20.98 ± 1.67
Height (m)	1.75 ± 0.10	1.65 ± 0.08	1.69 ± 0.10
Body Mass (kg)	75.87 ± 17.33	62.71 ± 14.45	67.83 ± 16.77

2.2. Dual-Task conditions

2.2.1. Motor task

Expanded Timed Get-Up-and-Go (ETGUG) was used as the motor task. Participants were instructed to be fully seated with their back against the back of an armless chair (seat height ~46 cm), stand once they heard a verbal cue, walk around a cone placed 10-m from the chair, and sit back down in the fully seated position. The measured outcome was the total time to complete the course. [18] The same examiner recorded the time to completion, started at the verbal cue and stopped when the participant had returned to fully seated position, using a digital hand-held stopwatch.

2.2.2. Cognitive task

Three different auditory-based cognitive tasks were paired with ETGUG: SS, APST, and BDR. Participants were given instructions, including an example, prior to each task. All cognitive tests were administered for 20 s during the Single-Task session to standardize the testing duration for all cognitive tasks. This duration was determined based on the pilot testing to estimate the approximate time required to complete the ETGUG. The measured outcomes for the cognitive tasks were Percent Accuracy and Response Rate. Percent Accuracy was defined as the ratio of correct answers to the total number of responses. Response Rate was defined as the ratio of total number of responses to completion time (either 20 s for the Single-Task sessions or ETGUG time to completion for the Dual-Task sessions).

- Serial Sevens (SS)

Participants were given a random number between 80 and 100 and instructed to recite subsequent numbers resulting from subtracting seven for each response throughout the test. Each subtraction was considered a response; when participants failed to perform a correct subtraction, an error was scored [20].

- Auditory Pure Switch Task (APST)

Participants were instructed to discriminate out loud between even and odd numbers as the examiner called them out. The number set was comprised of random digits between one and eight [6,13]. Each number was given to participants immediately following the previous response.

- Backward Digit Recall (BDR)

Participants were asked to repeat sets of numbers given by the examiner in reverse order. The numbers included in this task were one through nine. Each set of numbers was randomly selected with the following restrictions: no digits were present more than once in any set of numbers, immediate ascending or descending pairs were eliminated (e.g., 5–6 or 6–5), no double multiple jumps were included (e.g., 2–4–6 or 3–6–9), and no consecutive sequences began or ended with the same digit [21]. A baseline BDR trial was performed in accordance to the BDR procedure to determine the length of number sets used during Single-Task and Dual-Task trials. The baseline trials started from three digits and increased by one digit if the digits were repeated correctly until participants failed to respond correctly. The last set of numbers each participant repeated correctly was utilized as their number of digits used for Single-Task and Dual-Task trials [22]. Each set was counted as one response and considered correct only if the participant repeated all numbers correctly.

2.2.3. Dual-Task

The motor task was combined with a cognitive task to create three distinct Dual-Task conditions: ETGUG_{BDR}, ETGUG_{SS}, and ETGUG_{APST}. The measured outcomes of each component of the Dual-Task conditions were same as those measured in the Single-Task condition. To illustrate

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