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The reliability of the quantitative timed up and go test (QTUG) measured over five consecutive days under single and dual-task conditions in community dwelling older adults

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ABSTRACT

The timed up and go (TUG) test is a commonly used assessment in older people with variations including the addition of a motor or cognitive dual-task, however in high functioning older adults it is more difficult to assess change. The quantified TUG (QTUG) uses inertial sensors to detect test and gait parameters during the test. If it is to be used in the longitudinal assessment of older adults, it is important that we know which parameters are reliable and under which conditions. This study aims to examine the relative reliability of the QTUG over five consecutive days under single, motor and cognitive dual-task conditions. Twelve community dwelling older adults (10 females, mean age 74.17 (3.88)) performed the QTUG under three conditions for five consecutive days. The relative reliability of each of the gait parameters was assessed using intra-class correlation coefficient (ICC 3,1) and standard error of measurement (SEM). Five of the measures demonstrated excellent reliability (ICC > 0.70) under all three conditions (time to complete test, walk time, number of gait cycles, number of steps and return from turn time). Measures of variability and turn derived parameters demonstrated weak reliability under all three conditions (ICC = 0.05–0.49). For the most reliable parameters under single-task conditions, the addition of a cognitive task resulted in a reduction in reliability suggesting caution when interpreting results under these conditions. Certain sensor derived parameters during the QTUG test may provide an additional resource in the longitudinal assessment of older people and earlier identification of falls risk.

1. Introduction

The Timed up and go test (TUG) [1] is a modified version of the “Get up and go” test [2] that involves observing and timing the participant while they rise from an armchair, walk three metres, turn, walk back and sit down. The TUG is frequently used as part of the longitudinal assessment of older people and it is recommended by the American and British Geriatrics Societies as a screening tool for identifying older people at risk of falls. A time of 13.5 s or above to complete the test is considered significant in those over 65 for discriminating fallers from non-fallers [3]. However a recent review by Schoene [4] found that in high functioning older adults, the test has a ceiling effect, making it difficult to identify risk and/or detect change in this cohort. In addition, the method of measurement (time taken to complete) does not stratify the test into its constituent components, making it unclear which aspects of the test provide its predictive power.

Gait analysis provides further valuable information and this also forms an important component of a clinician’s assessment protocol. However while we frequently rely on visual observation, this alone is insufficient to provide accurate quantitative information about specific gait parameters, in particular measures of gait variability. This variability in spatio-temporal gait parameters has been implicated by a number of studies as a contributing factor to falls in older people [5–8]. Advances in technology have allowed the breakdown of the gait cycle into spatial (measures of distance) and temporal (measures of time) parameters. While the gold standard has been laboratory-based kinematic assessment, the use of inertial sensors for quantitative

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gait analysis has been explored by a number of research groups [9–11]. Of particular interest to us is the use of sensors to quantify gait during the TUG. One such example of this technology is the Kinesis Quantified Timed Up and Go-Kinesis QTUG™ (QTUG). In this method, Greene [6] found that clinically useful parameters can be derived automatically from inertial sensors placed on each shank (shin) which transfer the data derived from the sensors to a handheld tablet computer for analysis (this method is described in detail below). This study found a mean test accuracy of 76.8% in retrospectively estimating falls risk in a cohort of 349 community-dwelling older people in Ireland using this technology compared to 60.6% for the standard TUG and 61.4% for the Berg Balance Scale (BBS), where fallers were those who self-reported a fall, defined as 'an unexpected loss of balance resulting in coming to rest on the floor, the ground or an object below knee level' in the previous five years.

A prospective study by the same author found that in a cohort of 226 older adults, the QTUG yielded a mean classification accuracy of 79.7% in prospectively identifying participants that fell in a two year follow up period, compared with 59.4% for the standard TUG and 64.3% for the BBS [12], so it appears that the QTUG has promising clinical utility for longitudinal assessment and falls prediction.

Walking however does not occur in isolation and successful completion of everyday tasks requires that we perform two or more tasks concurrently, ranging from walking and talking, to negotiating a busy road and in recent years, the use of this dual-task methodology has been used to assess the interplay between gait and cognition [13,14]. The dual-task paradigm requires that two tasks are performed simultaneously, in order to compare performance under single task conditions. Changes in performance while dual-tasking are interpreted as interference due to competing demands for the attentional resources required by both tasks, and depend on the ability to properly allocate attention between the two tasks [15]. There is evidence that the addition of a cognitive dual-task has an effect on spatio-temporal gait parameters, and a systematic review carried out by Al Yahya [16] found that this effect may be more pronounced in healthy older adults. In addition there is a growing body of research supporting the idea that those older people at risk of falls show increased gait variability under dual task conditions compared to non fallers [17–21] suggesting that the addition of a dual-task component to gait assessment may aid detection of falls risk and identify change at an earlier point, particularly in those not identified under single-task conditions.

If the dual-task QTUG is to be adopted as a method of longitudinal assessment of high functioning, community-dwelling older adults, it is important that we know which aspects of the test are reliable and if they are reliable under all conditions. The aim of this study is therefore to examine the relative reliability of the QTUG in measuring spatial, temporal and turn-derived test and gait parameters over five consecutive days under three different conditions; single-task, motor dual-task, and cognitive dual-task in community dwelling adults over the age of 65.

2. Methods

This observational study, which was granted ethical approval by the local health service executive (HSE) and university ethics boards, selected 12 community dwelling adults over the age of 65, with a mean age of 74.17 ± 3.88. All participants had been referred to a primary care physiotherapy department for assessment of balance and provided informed consent. Participants were living independently in the community and were free of any significant physical or psychological impairment that could affect gait or their ability to follow instructions and all were able to walk independently indoors. Prior to testing all participants completed the screening assessment for falls evaluation (SAFE) www.health.vic.gov.au/agedcare, a balance assessment consisting of the Berg balance scale [22] and the Activities of balance confidence scale [23]. All participants had a Berg balance score >45/56 indicating a low risk of falls. Table 1 outlines participant characteristics.

The single-task and motor and cognitive dual-task QTUG tests were carried out each day for five consecutive days. Testing was conducted in a standardised home environment consisting of a furnished and fully operational test apartment in which the participants stayed during the testing days. Tests were performed at the same time each day with identical set up and protocol. The three tests were carried out in the same sequence each day by the same tester; test conditions are detailed below. Data were acquired using Kinesis QTUG™, using the following method. Two SHIMMER kinematic sensors, each containing a triaxial accelerometer and an addon triaxial gyroscope sampling at 102.4 Hz, were attached to the anterior of each shank (shin) by means of elasticised bandages. The sensors were oriented to capture movement about the anatomical mediolateral axis, placed at roughly the mid-point of the shank, during the TUG. The data derived from the sensors was streamed wirelessly via Bluetooth to a handheld tablet computer for analysis. A total of 44 parameters were derived from the left and right shank angular velocity signals in each of the saggital, vertical and lateral sensor axes, using a previously described algorithm [12,24,25], and reported as temporal, spatial, angular-velocity and turn-derived parameters. A total of 21 of the reported parameters were selected for reliability analysis. Time to complete the test, walk time, and turn derived parameters were chosen due to their close relation to clinical observations performed during the standard TUG. The remaining parameters were chosen based on previous research which identified the most frequently reported gait parameters in the literature under single and dual-task conditions [16].

3. Test conditions

1. Single task (ST) – the participants were asked to stand up from a standard chair (46 cm seat height, 65 cm armrest height), walk three metres as quickly as they could to a mark on the floor, turn and return to the chair. No instructions were given about how to turn.
2. Motor task (MT) – the participants were asked to stand up, pick up a glass of water on a table to their left, walk three metres as quickly as they could to a mark on the floor and return to the chair.
3. Cognitive task (CT) – the participants were asked to stand up walk three metres as quickly as they could to a mark in the floor, turn and return to the chair while subtracting three loudly from a random three digit number. No instructions were given on which task to prioritise.

Power analysis showed that a minimum sample size of 11 was required when 5 observations were recorded, in order to establish

Table 1
Participant characteristics.

Characteristics	Participants
n (female/male)	12 (10/2)
Mean age (years)	74.17 ± 3.88
Mean SAFE falls risk assessment score	7 ± 4
Mean Berg Balance Score	52 ± 5
Mean Activities of Balance Confidence Score (%)	75.28 ± 19.80
Time to complete TUG single task (s)	9.62 ± 3.08
Time to complete TUG motor task (s)	10.78 ± 3.64
Time to complete TUG cognitive task (s)	11.81 ± 2.62