JAMDA 17 (2016) 864.e9–864.e15

JAMDA

journal homepage: www.jamda.com

Original Study

Transition Between the Timed up and Go Turn to Sit Subtasks: Is Timing Everything?

Aner Weiss ME [a], Anat Mirelman PhD [a,b], Nir Giladi MD [a,b,c], Lisa L. Barnes PhD [d,e,f], David A. Bennett MD [d,e], Aron S. Buchman MD [d,e], Jeffrey M. Hausdorff PhD [a,b,*]

[a] Center for the Study of Movement, Cognition, and Mobility, Neurological Institute, Tel Aviv Sourasky Medical Center, Tel Aviv, Israel
[b] Department of Physical Therapy, Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel
[c] Department of Neurology, Sackler Faculty of Medicine, and Sagol School of Neuroscience, Tel Aviv University, Tel Aviv, Israel
[d] Rush Alzheimer's Disease Center, Rush University Medical Center, Chicago, IL
[e] Department of Neurological Sciences, Rush University Medical Center, Chicago, IL
[f] Department of Behavioral Sciences, Rush University Medical Center, Chicago, IL

Keywords:
Aging
disability
cognition
inertial sensors
accelerometers
turn-to-sit
Timed Up and Go

A B S T R A C T

Objective: The Timed Up and Go (TUG), one of the most widely used tests of mobility, has been validated and associated with adverse outcomes in the community, acute care, and nursing home setting. It is composed of several distinct subtasks; however, the temporal relationship when transitioning between subtasks has not been well-studied. We tested the hypothesis that longer transition durations between the final turn to the sitting subtasks are associated with worse motor and cognitive performance in older adults.
Methods: A total of 1055 participants (80.33 ± 7.57 years, 76.96% female) performed the TUG while wearing a 3-dimensional inertial sensor on their lower back. We employed a series of linear regressions to examine the association of the duration between the turn and sitting subtasks with clinical characteristics including motor and cognitive functions.
Results: Participants employed 2 different strategies when they transitioned from turning to sitting. (1) Distinct transition strategy: 816 participants (77.34%) first completed the turn before starting to sit. The average duration between these distinct subtasks (D-interval) was 715 ± 980 ms. (2) Overlapping transition strategy: 239 participants (22.65%) started to sit before completing the turn. The average overlap duration between these tasks (O-interval) was 237 ± 269 ms. Participants who employed the distinct transition strategy were slightly younger than those who employed the overlapping transition strategy ($P \leq .013$). Higher D-intervals and O-intervals were associated with worse TUG performance ($P \leq .02$), with poorer motor and cognitive function, [ie, worse parkinsonian gait ($P \leq .001$), lower level of perceptual speed ($P \leq .03$), and with worse mobility disability ($P \leq .001$)]. A longer D-interval was associated with worse gait speed and bradykinesia ($P \leq .001$), whereas a longer O-interval was associated with increased rigidity ($P = .004$).
Conclusions: Older adults apparently employ 2 different strategies when transitioning from turning to sitting. The instrumented TUG can characterize additional gait and balance aspects that cannot be derived from traditional TUG assessments. These new measures offer novel targets for intervention to decrease the burden of late-life gait impairment.

The Timed Up and Go (TUG) is a widely used measure of mobility in older adults. Since its introduction in 1991, it has been cited more than 6000 times. It has been validated and associated with adverse outcomes in the community, acute care, and nursing home setting. The TUG requires participants to integrate several movement subtasks together for its successful completion. When it was first developed, a stopwatch was used to measure the duration of the TUG. The total time to complete the TUG is associated with poorer motor function

This work was supported in part by National Institutes of Health grants R01AG17917, R01AG022018, RO1NS078009, and R01AG47976.
The authors declare no conflicts of interest.
* Address correspondence to Jeffrey M. Hausdorff, PhD, Department of Neurology, Tel Aviv Sourasky Medical Center, 6 Weizman Street, Tel Aviv 64239, Israel.
E-mail address: jhausdor@tlvmc.gov.il (J.M. Hausdorff).

http://dx.doi.org/10.1016/j.jamda.2016.06.025
1525-8610/

and has been shown to predict a variety of adverse health outcomes associated with aging.[1–3]

The successful performance of a specified motor task like the TUG depends on the integration and timing of the several subtasks necessary to meet the overall task demands. Our group and others have employed an instrumented TUG[1,2,4–10] and have shown that the TUG can be decomposed into several different subtasks. Objective measures extracted from these recordings show preferential impairment and prolongation of distinct subtasks underlying a completed TUG that may account in part for the heterogeneity of gait and balance impairment in older adults. The total TUG duration is composed of the duration of the individual subtasks plus the duration of the transitions between each of its subcomponents. Prior TUG studies have quantified the duration of the individual subtasks,[1,2,4–10] but have not investigated the timing between the individual TUG subtasks. The inter-relationship between the duration during the transition between TUG subcomponents, gait and balance capacity, and disability is unknown.

To fill this gap and provide a more complete characterization of a completed TUG, we examined data from 1055 older adults without dementia who wore a whole-body sensor to record TUG performance during annual gait testing in the community setting. These analyses focused on the duration for the final turn to sit because the beginning and end times of both subtasks are easily identified and this transition may be associated with increased risk of falls.[11] Because a prolonged total TUG duration is associated with poorer function and increased disability, we tested the hypothesis that a longer duration between its subtasks (the interval between the final turn to the sitting subtask) is associated with poorer motor and cognitive performance and more disability in older adults.

Methods

Participants

Participants were from 2 ongoing community-based cohort studies of aging. The Memory and Aging Project and the Minority Aging Research Study.[12,13] Because both studies employ common data collection and operational methods, we combined their data for these analyses. These studies have rolling admission and the whole-body worn sensor (as described below) was added to both studies in 2011. For these analyses, we included all cases that had completed TUG testing with the whole-body sensor and did not have clinical dementia or Parkinson disease. At the time of these analyses, 1159 participants had undergone TUG testing with the sensor at least once. We excluded 100 cases with clinical dementia and 4 participants diagnosed with Parkinson disease, leaving 1055 cases for these analyses. The study was conducted in accordance with the latest version of the Declaration of Helsinki and was approved by the institutional review board of Rush University Medical Center.

Instrumented TUG Testing

Participants performed the TUG while wearing a body-fixed sensor as previously described.[1,2,9] A portable small, light-weight body-fixed sensor (DynaPort MiniMod Hybrid Module, McRoberts B.V., The Hague, The Netherlands) was worn on a neoprene belt placed on the lower back at the level of anterior iliac crest. The sensor weighs 74 g, and its dimensions are $87 \times 45 \times 14$ mm. The device includes a triaxial accelerometer (sensor range and resolution are ± 2 g and ± 1 mg, respectively) and a triaxial gyroscope (sensor range and resolution are $\pm 100°$/s and $\pm 0.0069°$/s, respectively).

Six acceleration and angular velocity signals are recorded continuously during TUG testing. Signals include 3 acceleration axes: vertical acceleration, medio-lateral acceleration, anterior-posterior acceleration, and 3 angular velocity axes: (1) yaw—the rotation around the vertical axis; (2) pitch—the rotation around the mediolateral axis; and (3) roll—the rotation around the anterior-posterior axis. The 6 signals were saved on a secure digital card at a sample frequency of 100 Hz. After testing was completed, the data was transferred to a personal computer for further analysis (Matlab; Mathworks, Natick, MA).

TUG Subtasks Measures

Participants performed the TUG twice. The present analysis was performed on the second trial. Previously published algorithms[1,2,9] were used to derive measures of the TUG subtasks: sit to stand, walking, turning, and stand to sit. Our analyses focused on the final 2 subtasks. We measured the duration of the entire turn to sit interval (ie, from the beginning of the final turn to the end of the final sit subtasks). As illustrated in Figure 1, we also measured the interval between the 2 subtasks [ie, the duration between the end of the turn (determined by the yaw axis[4,9]) and the beginning of the stand to sit subtask (determined by the anterior-posterior axis[1,2,9]).

Assessment of Other Covariates

Demographic variables

Age was based on date of birth and date of TUG; sex, years of education, and race were obtained at baseline interview.

Motor assessments

Several instruments were employed to measure motor function. Parkinsonian symptoms: Trained nurses assessed 26 items from the motor section of the Unified Parkinson Disease Rating Scale. Four previously established scores for parkinsonism (ie, gait disturbance, bradykinesia, rigidity, and tremor) were derived from these 26 items.[14] Other motor performances: We also assessed gait speed, which was based on time to complete a walking task. Mobility disability: Rosow-Breslau Scale was used as a self-report measure of mobility disability.

Cognitive assessment and clinical diagnoses

Participants underwent a uniform structured clinical evaluation, as described elsewhere.[13,15–17] Summary scores for 5 cognitive abilities were derived from 19 cognitive tests: episodic memory, semantic memory, working memory, perceptual speed, and visual spatial.[15,18] Higher scores reflect better performance.

Statistical Analysis

We first examined the inter-relationship between the turn-to-sit duration [ie, from the beginning of the final turn (T1) to the end of the sitting subtask (S2)] (Figure 1) and the other TUG measures derived from the whole-body sensor using linear regression (enter method) with the duration of the turn-to-sit and the squared duration of turn-to-sit as predictors, adjusted for age and sex. Then, we examined the clinical correlates between the interval between the 2 subtasks [ie, the interval between the end of the final turn (T2) to the start of the sitting subtask (S1)] (Figure 1) and between motor and cognitive performance measures using linear regressions (enter method, with the interval between the 2 subtasks as an output), adjusted for age, sex, height, weight, race, and years of education. Beta values and 95% confidence intervals (CIs) are reported for the regression analyses. All data was assessed for normality using the Kolmogorov-Smirnov test. Corrections for multiple comparisons were made using the Benjamini-Hochberg method.[19] Because of the lack of normality, Mann-Whitney tests were used for between group comparisons, while group values are reported as mean $\pm$ standard deviation. Statistical analyses were carried out using SPSS v 19 (SPSS Inc, Chicago, IL).