Balance Scan: Automation of the Timed Up and Go

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OVERVIEW

BACKGROUD: Falls among older adults are a growing problem in the United States. One in four older adults report falling. Although preventable, fall risk often goes unmanaged, leading to injury and, sometimes, death. In 2018, more than 32,000 older adults died as a result of falls, equating to 88 older adults every day. According to the CDC, death rates from falls have increased 30% in the last decade. Falls and fall-related injuries are only expected to increase as the population ages, diminishing quality of life for older adults and increasing healthcare expenses.[1]

RATIONALE: The road test done in ERs is not consistent or documented in a way for further review. The typical TUG is administered through direct observation of task completion. A proxy in the patients' home is desired. The TUG is a general physical performance test used to assess mobility, balance and locomotor performance in elderly people with balance disturbances. More specifically, it assesses the ability to perform sequential motor tasks relative to walking and turning.[2]

The "Get Up and Go" test (the original TUG) was developed by Mathias, Nayak, and Issacs in 1986. The TUG was published by Podsiadlo and Richardson in 1991 to address the issues of poor inter-rater reliability observed with intermediate scores in the "Get Up and Go". The TUG incorporates time as the measuring component to assess general balance and function.[3]

METHODS: Subjects were ager range 9 - 95 years old, they were tested in healthcare settings including the ED (Emergency Department) or in the patient's home. The set up consisted of a chair and a 3 meter (10 foot) path to stand, walk, turn, walk back and sit down. They patients were asked the STEADI Questionnaire. The TUG was graded for risk based on CDC guidelines. If the patient is over 12 seconds for the walk they are at risk. The movement was recorded with the CaptureProof mobile phone application.

Time of the walk (TUG time) was determined using 1 to 3 of the following methods.

(1) The provider observing the physical movement used a stopwatch to identify the time of movement.
(2) An independent provider reviewed the video and identified the frame numbers of start and stop time of the TUG.
(3) CaptureProof QA (quality assurance) team reviewed the video and confirmed the TUG time. CaptureProof's proprietary ML (machine learning) algorithm monitored patient movement and computed not only TUG total time, but also includes metrics of more body motions such as side-to-side listing, cadence and turn times.

RESULTS: In initial evaluation of the CaptureProof TUG software Machine Learning Automated Algorithm, the longest TUG time was for a subject aged 60 with TUG time of 52 seconds; the longest TUG time in the 65 and over category was 42 seconds. Agreement between human frame-by-frame analysis versus the ML automated algorithm was 91% for TUG times under 15 seconds and 77% for all cases. The agreement between the stopwatch and frame-by-frame analysis was 59%, and 56% between stopwatch and ML.

The major source of error was attributed to lose hospital gowns, which reduced the precision of detecting the human form. More of the subjects with shorter TUG times wore street clothing which tended to be tighter than hospital gowns. The video record permits establishing trends over time and indicate progress or regress. One parameter derived by ML is the time from the second turn (turn before sitting) to the time the subject is seated. Several subjects rushed to the chair and essentially rolled into the seat. Their turn-to-sit time was short < 0.7 seconds. Despite "safe" TUG their walk was not steady. Additional parameters are yet to be evaluated. These include listing and hip and knee positions.

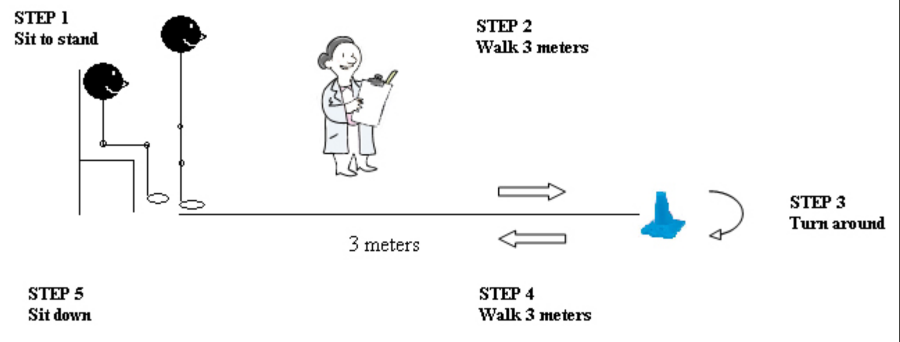
All ages 37% passed the TUG test with a TUG time of < 11 seconds, a category considered low risk. 13% of the subjects were at moderate risk, with TUG times between 11 - 13 seconds, 50% of the subjects were over 13 seconds.

Over 65 28% were at low or moderate risk of falling.

Assisted devices (walkers and canes) accounted for 20% of subjects; 88% had TUG times over 20 seconds. But not all assisted device patients were at risk despite the long TUG time based on medical evaluation.

CONCLUSIONS: Automated ML based measurement of TUG times provides greater accuracy and objectivity. Additionally, other motion parameters can be extracted. Three of these included side to side listing, turn time, and turn-to-sit time. More parameters can be extracted from the walking data; these include listing and hip and knee positions. The ability to archive data permits establishment of trends and assessment of progress.

FIGURE 1: TUG



RESULTS

TUG TIMES	At Risk < 13 sec	Moderate Risk 11-13 sec	Low/No Risk > 11 seconds
All	50%	13%	37%
Over 65	50%	9%	18%
40-65	18%	7%	18%

Range	Time	Age
All		
Fastest Patient	5.84	56
Slowest Patient	52.13	60
over 65		
Fastest Patient	6.27	66
Slowest Patient	42.01	69
40 - 65		
Fastest Patient	5.84	56
Slowest Patient	52.13	60
under 40		
Fastest Patient	6.94	9
Slowest Patient	18.32	32

DISCUSSION

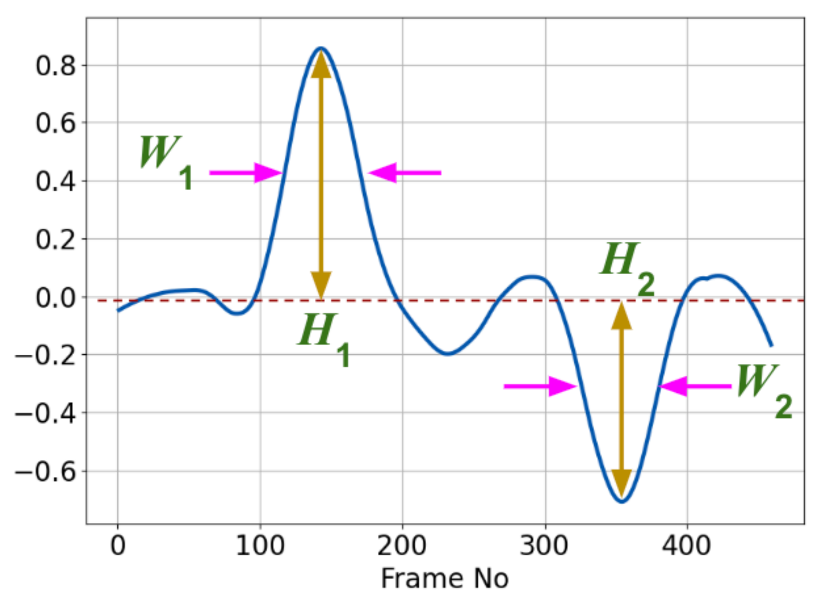
Why the difference between Algorithm (computer vision AI) and Video Times? How will this lead to improvements?

1) Observation error of video time is within a band of 0.33 sec
2) Gowning "error" - uncertainty due to poor algorithmic computation of body pose
3) Patient wiggling or fidgeting while sitting
4) Patient crosses or tucks legs
5) Short sit time at beginning or end of video - needs to be 3 sec
6) Patient struggling to get up - two or more attempts before either rising or sitting

Need to improve algorithm - but need more cases so far only 3

This is the cause of the largest discrepancies between algorithm and video time. Not all patients who use the assisted device and are over 12 seconds were "at risk" per medical evaluation. A further study to look at this group may provide better accuracy.

FIGURE 2: REPORT EXPLAINED



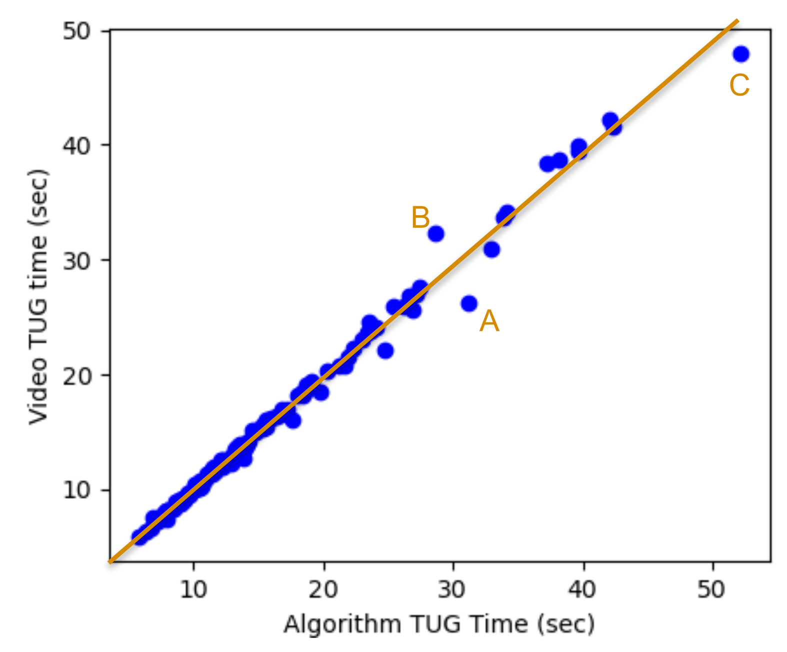
PEAKS HEIGHT & WIDTH

The peaks of the motion function show where the patient is in the process of standing and in the process of sitting.

The faster the patient rises or sits the height of a peak is expected to be higher and the width of a peak be smaller.

The slower the patient rises or sits the height of a peak is expected to be small and the width of a peak to be larger.

FIGURE 3: ALGORITHM vs VIDEO TUG



Alg-Vid Time	Value (sec) TUGs all	Value (sec) TUGs <15 sec
Mean (abs)	0.39	0.20
Mean	-0.06	0.05
Min	0.0	0.0
Max	4.91	1.07
Std Dev	0.73	0.18
Median	0.2	0.2

Video TUG time is based on visual inspection of video and manual recording of time subject start to rise from seat to time subject touches seat. Error in TUG time is 7 to 10 frames → 0.24 to 0.33 sec. (A) Patient with "box in front of walker. (B) Start and Stop too soon. The CV requires 3 seconds of stillness at the start and stop of the movement. (C) Struggling patient.

REFERENCES

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