Objective assessment of functional mobility using the TUG test

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***Abstract*— The advent of wearable sensors has made clinical assessment of movement possible in the home and community environments. The TUG test is perhaps the most commonly used clinical mobility assessment. Objective assessment of mobility tests using wearable sensors can improve the precision of clinical assessment and does not require specialist clinical expertise. We introduce a novel method to characterize mobility, using body-worn IMU sensors and the TUG test. The TUG test is broken down into the constituent elements of mobility (Speed, Variability, Symmetry, Transfers, Turning). A mobility score for each element is calculated by comparing each subject's sensor data against reference values derived from a population of 1,495 subjects.**

I. Introduction

Mobility is routinely assessed in the clinical environment, however an increasing shift towards primary and community care is driving a need for the assessment of mobility in non-standard clinical environments, by care professionals without specific expertise in mobility assessment. A variety of mobility assessments are in widespread clinical use; the Timed Up and Go (TUG) test [1], also known as the Up and Go (TUG) test is perhaps the most commonly used. TUG has been shown to have application in the assessment of falls, rehabilitation and general mobility assessment in a variety of clinical populations including geriatrics, stroke, rehabilitation and neurology. Objective assessment of mobility tests using wearable sensors can improve the precision of clinical assessment and support the assessment of mobility by clinical personnel without specialist expertise.

II. Data

The mobility of 1,495 subjects (981 F, 514 M, mean age of 71.3±12.5 years) was assessed while carrying out the Timed Up and Go (TUG) test using a body-worn inertial sensor based mobility assessment platform (QTUG™, Kinesis, Dublin, Ireland). Participants were assessed as part of a variety of research projects carried out between 2008 and 2017. All studies had local ethical approval. Each subject wore a wireless inertial measurement unit (IMU), containing a tri-axial gyroscope and a tri-axial accelerometer on each leg below the knee and were instructed to complete the TUG test "*as fast as safely possible*"; subjects were instructed to stand-up, walk 3m, turn through 180°, walk back to the chair and sit back down. Participants had a mean time to complete the TUG test of 11.3±5.2 seconds and a mean gait velocity of 103.7±31.0 cm/s.

III. Methods

The sensor data for each subject was processed using a previously reported algorithm [2, 3] for assessment of gait and mobility. 57 features were calculated from the sensor data for each subject (known as the QTUG parameters), in order to characterize mobility.

Mobility issues are identified by grouping the 57 calculated mobility parameters into five functional categories: Speed, Variability, Symmetry, Transfers, Turning.

Mobility issues per functional category are identified by calculating a z-score calculated for each QTUG parameter per group; $z = \frac{x-\mu}{\sigma}$ where μ is population mean for a given parameter *x*, and σ is the population standard deviation. The population data are stratified by gender to produce gender-specific values for population mean and standard deviation. The mean z-score per group is then calculated; if $|z_\mu| \geq 2$, group is determined to be out of normal range. An estimate of the percentile is calculated by applying the normal cumulative distribution function $P = \frac{1}{2}\left[1 = erf\left(\frac{x-\mu}{\sigma\sqrt{2}}\right)\right]$ to each parameter.

Positive parameters are defined as those for which a large value is considered to be a clinical indicator of good mobility (e.g. gait velocity), whereas a negative parameter is one where a large value is one where a large value is considered to be a clinical indicator of poor mobility (e.g. TUG time). A neutral parameter is then defined as one that does not fit into either category. If the mean mobility score (express as a percentage) for a category is above 70% the subject may have an impairment in that functional category.

IV. Discussion

We propose a novel method to objectively characterize mobility using body-worn IMU sensors and a large reference data set. We believe this method could facilitate screening for mobility impairment in the community, without the necessity for in-depth clinical expertise in mobility assessment.

References

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