Beyond the Eye: AI-Enhanced Visual Biomarker Discovery & Tracking for ALS

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INTRODUCTION

Amyotrophic Lateral Sclerosis (ALS) is a progressive degenerative neuromuscular disorder causing muscle weakness and impaired mobility. Clinical evaluations including rating scales, such as ALS Functional Rating Scale (ALSFRS-R) and Rasch Overall ALS Disability Score (ROADS), are generally carried out at 3 month intervals. As ALS progresses, attending clinics can become increasingly difficult requiring an increased use of telemedicine. Digital biomarkers offer an innovative solution for more sensitive detection of changes between clinic visits and remote monitoring of persons with ALS (PALS) unable to attend clinic. CaptureProof, a video capture application enhanced by artificial intelligence, may provide this solution through identifying visual biomarkers to remotely monitor ALS progression.

OBJECTIVE

The initial goal is to develop and validate a standardized video and photo capture protocol using a smartphone application (CaptureProof) in order to detect and monitor the progression of Amyotrophic Lateral Sclerosis (ALS).

METHODS

In order to generate visual biometric markers using CaptureProof's AI-Smart Medical Camera, to detect motor involvement in PALS and monitor ALS progression, PALS were recruited from the MDA/ALS clinic at Temple University for this single-arm study. Data collection occurred at Temple University during regular clinic visits or at patients' homes for those unable to attend. Using CaptureProof's smartphone application, participants were recorded performing specific tasks involving facial movement, speech, upper and lower extremity function, balance, and gait (including the Timed Up and Go test). Participants also completed ALSFRS-R and ROADS assessments. CaptureProof's proprietary algorithms analyzed the video data, generating biometric markers for each task by evaluating symmetry, fluidity, speed, range, and rate of movements. These markers were compared between PALS and healthy controls, as well as against self-reported ALSFRS-R and ROADS scores. The study was approved by the Institutional Review Board, and informed consent was obtained from all participants.

INITIAL RESULTS

Our preliminary data set includes 7 PALS (2 F, 5M), with an average age of 62 ± 6.11 years, a median disease duration of 25 months, and an average ALSFRS-R score of 30.57.

The findings support the potential for AI-enhanced video analysis in ALS monitoring. The detection of changes observed by video analysis not observed on self-reported scores, particularly in the TUG test, suggest that the video analysis was able to detect motor changes before they become apparent to patients themselves.

Timed-Up-and-Go: Compared to the normative reference value for 60-69 year-olds (8.1+/-0.9)[1], preliminary data shows an increased average TUG time in PALS (15.02+/-5.69 sec). Despite all subjects having an abnormal TUG time, four subjects reported dysfunction in walking on ALSFRS-R scores, while two patients reported no difficulties.

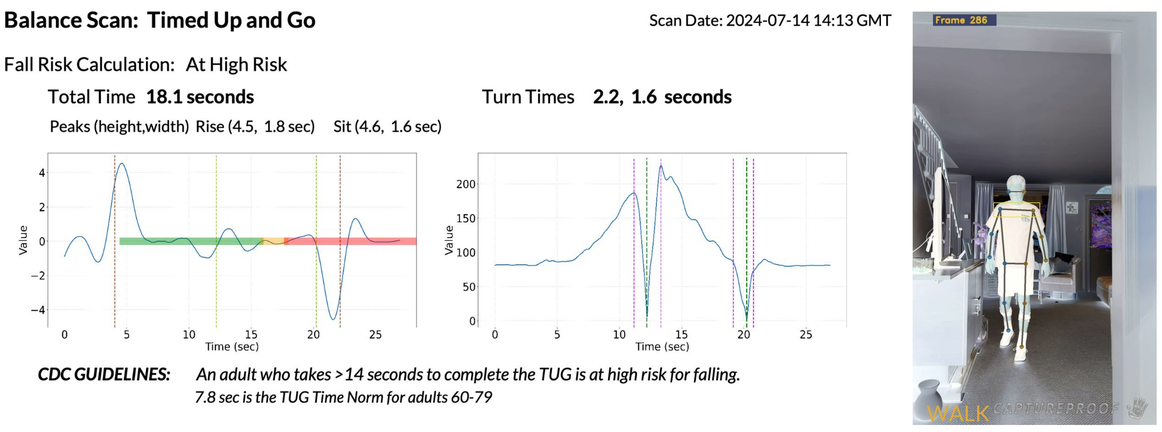
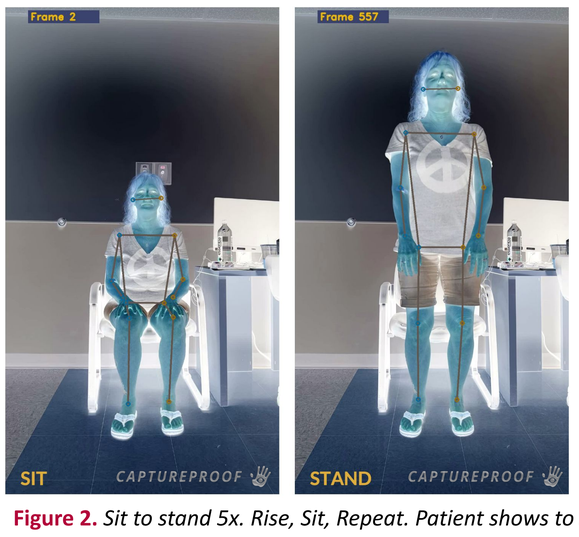


Figure 1. *Timed up and Go with Total time, Rise, Sit, Turn times at front and at sit. Patient shows to be at risk and is nearly 3x the average time for his age group.*

5-Repetition Sit to Stand: Sit to Stand was performed in 4 participants. Compared to normative reference value for 60-69 year olds (11.4 seconds)[2], preliminary data shows increased values in PALS (12.4 - 24.5s). ROADS scores associated with gait and climbing up stairs were normal for three participants, but abnormal for the single participant with highest sit-to-stand time of 24.5s.



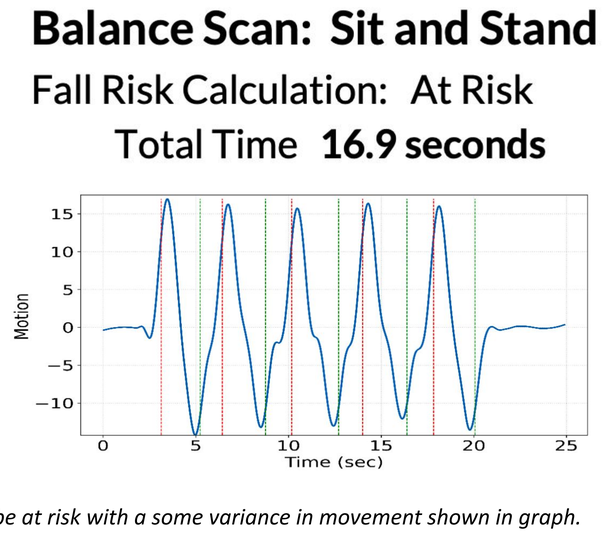


Figure 2. *Sit to stand 5x. Rise, Sit, Repeat. Patient shows to be at risk with a some variance in movement shown in graph.*

Finger Taps: Finger taps were recorded for 3 participants. Speed varied between 52.2 -148.1 taps per minute. Tap duration varied between 0.328-0.738 seconds. ALSFRS-R scores were normal for handwriting and using utensils, but ROADS scores for one participant were reported as abnormal for handwriting and using utensils.

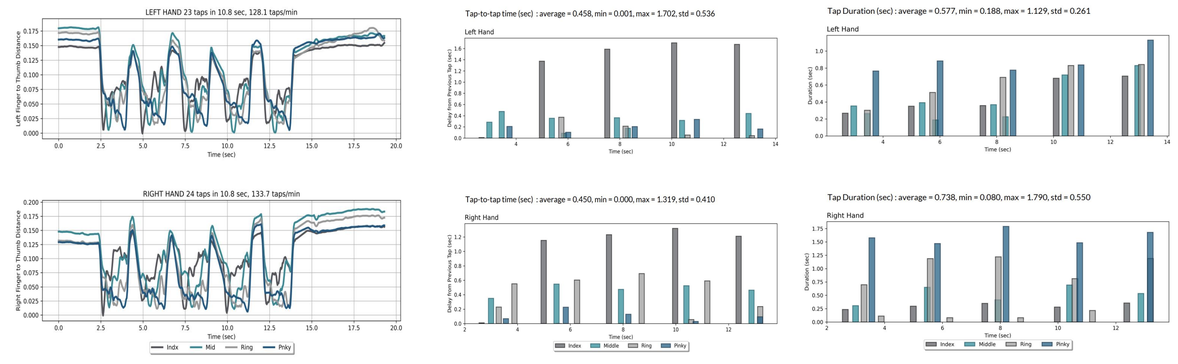


Figure 3. Finger Tap. Patients are instructed to tap each finger to thumb in a forward and reverse sequence.

Finger Spread: Initially-proposed metrics (distance from thumb to index finger, spread time) captured and are in development. Analysis of the best biometric and signal are under investigation. Clarity and sensitivity will increase with direct correlation to the sample size.

Figure 4. Finger Spread. Regular motion of fingers. Tremor is apparent at the start and end during the 3 second "hold still" periods.

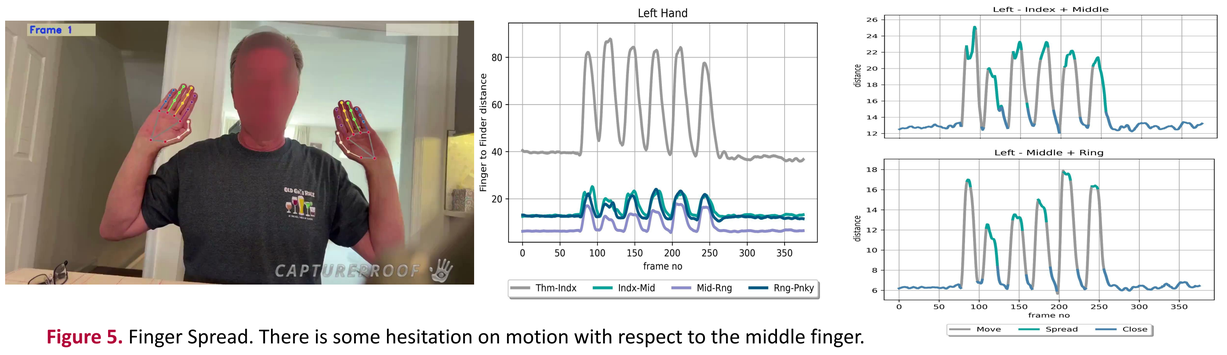


Figure 5. Finger Spread. There is some hesitation on motion with respect to the middle finger.

Facial Movements: Facial nerve involvement is observed. Asymmetry values were generated for each patient while performing facial movements, including eye blinks, puffing of cheeks, tongue motion. Waveforms using asymmetry values during motions were created. Analyses of waveforms are in progress.

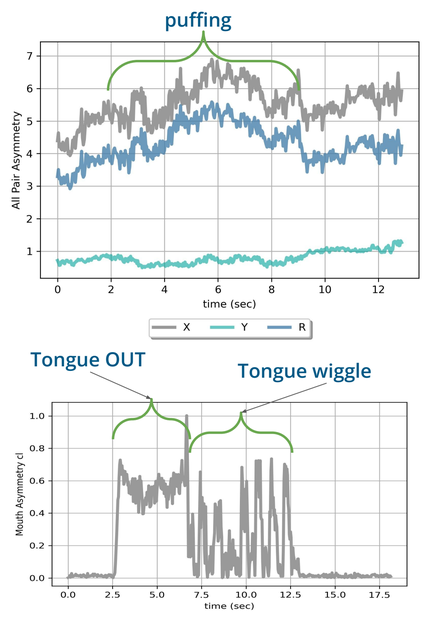


Figure 6. Face Motion. Facial Nerve is being observed through specific motion and identification of symmetry as well as fatigue is being considered.

Additional subject enrollment and longitudinal data collection and analysis is ongoing.

DISCUSSION

Our data suggests that CaptureProof accurately records features associated with ALS motor involvement that can be used to detect progression of functional changes. Further, decreased function was detected by video assessments of the TUG in all subjects, but not their functional rating scores, suggesting an increased sensitivity to motor involvement. This heightened sensitivity, particularly evident in TUG video results, highlights the utility of AI enabled video capture to detection motor changes, enable earlier intervention and track progression of ALS. Continued data collection will increase our sample size and additionally explore other motor tasks, biomarker metrics, correlations with ALS rating scales, and monitoring of disease progression longitudinally. The initial set of assessments will be exhaustive, and our goal is to identify the most sensitive movements to create a battery of tests to be performed in under 10 minutes.

In conclusion, AI enhanced video assessments can provide valuable digital biomarkers for ALS progression. This could lead to predictive models and personalized care strategies, while the potential for remote monitoring and enhance access to specialized ALS care.

REFERENCES

1. Bohannon RW. Reference values for the timed up and go test: a descriptive meta-analysis. J Geriatr Phys Ther. 2006;29(2):64-8. doi: 10.1519/00139143-200608000-00004. PMID: 16914068.
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