A Real-Time Artificial Intelligence-Based Gait Analysis Tool Identifies Gait Characteristics Associated with Pre-frailty and Cardiac Frail Patients

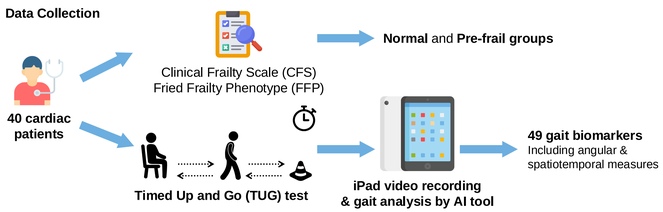
Leong Jia Juin Benjamin[2], Johnathan Loh[1], Ramanpreet Singh Pahwa[2], Richard Chang[2], Jie Wang[2], Bo Jun Meng[2], Lim Si Lin[1], Gina Lee[1], Hong Jie Ng[1], Loon Yee Teo[1], Angela Su-Mei Koh[1]
[1]National Heart Centre Singapore, Singapore. [2]Carecam Pte Ltd, Singapore.

BACKGROUND

Frailty, characterised by reduced physical performance and weakness, affects recovery and quality of life in cardiac patients. Emerging evidence has highlighted that gait alterations serve as early and objective markers of frailty, often preceding visible symptoms. Early detection enables timely interventions that can slow or even reverse functional decline. Advances in AI now allow for automated gait analysis, leveraging machine learning algorithms to identify and track subtle changes in movement patterns.

Automated AI methods have the potential to assist clinicians in the identification of frailty and bring to attention alterations in gait mechanics that may be perceptually inapparent. We hypothesize that AI can accurately assess frailty levels in cardiac patients through objective and accurate gait analysis, providing a cost-effective and scalable tool for clinicians.

METHODS

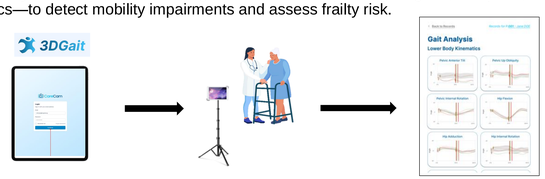


Statistical Analysis

- **Correlation Analyses** were conducted to explore associations between temporospatial biomarkers and frailty.
- **SPM1D** was applied to angular biomarkers to detect significant differences in gait phases between normal and pre-frail groups.
- **Univariate and Multivariate Logistic Regression** were used to analyze temporospatial biomarkers to determine their predictive value in distinguishing pre-frail individuals from the normal group.

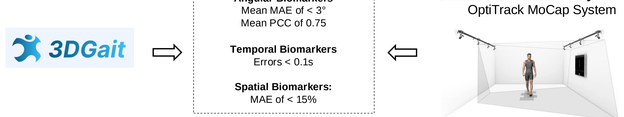
3DGait – AI-Powered Gait Analysis

3DGait is an **AI-driven, markerless gait analysis tool** that provides an precise evaluation of human gait. It captures 49 key gait biomarkers—spanning angular, temporal, and spatial metrics—to detect mobility impairments and assess frailty risk.



1 Camera | 1 Walk | 2 Minutes
Unlike traditional motion capture systems, 3DGait requires only 1 iPad camera, 1 short walk, and 2 minutes of processing time to provide a comprehensive gait analysis, making it an accessible and scalable solution for clinical use.

Accuracy of 3DGait



AI Gait Analysis Detects Early Frailty in Cardiac Patients

An AI-powered gait analysis tool captures **gait biomarkers, including angular, temporal and spatial** biomarkers.

Key biomarkers—such as **gait speed, stride speed, stride length, step duration, and joint kinematics**—correlate with frailty in cardiac patients.

Early detection enables timely interventions to prevent further decline.

SCAN ME

Scan the QR code to follow Carecam on LinkedIn, or contact us at enquiry@carecam.ai

ACC.25

RESULTS

Based on Correlation and SPM1D Analysis, Pre-frail Patients Exhibited:

Angular
- Reduced Hip Flexion
- Reduced Ankle Inversion
- Reduced Hip Internal Rotation

Temporal
- Reduced Step Speed
- Reduced Stride Speed
- Reduced Gait Speed
- Increased Double Support
- Increased Step Duration

Spatial
- Reduced Stride Length

Based Logistic Regression Analysis, the **Potential Predictors of Frailty** are:

DISCUSSION

Observed results align with possible frailty-related gait characteristics.

Angular Changes: Reduced Joint Angles
- **Reduced in hip flexion** during **mid-swing** and **terminal swing** phases could be due to reduced strength in the hip flexors.
- **Reduced ankle inversion** in the **terminal swing** phase may indicate decreased ankle stability, possibly due to weakened intrinsic foot muscles.
- **Reduced hip internal rotation** from **midstance** to **terminal stance** indicate altered pelvic control, possibly reflecting a compensatory mechanism for maintaining balance.

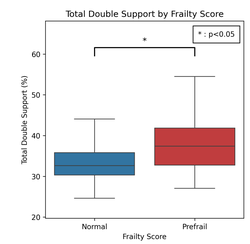
Temporal Changes: Cautious Gait Patterns
- **Reductions in step speed, stride speed, and overall gait speed** can likely stem from neuromuscular inefficiencies or reduced lower limb power
- **Increase in double support duration** suggests greater reliance on prolonged bilateral stance phases, a natural adaptation with lowered balance confidence.
- **Increase in step duration** may result from diminished neuromuscular control, where individuals prioritize stability over efficiency.

Spatial Changes: Shortened Gait Parameters
- **Reduced stride length** enhances stability and control, possibly due to lower limb weakness.

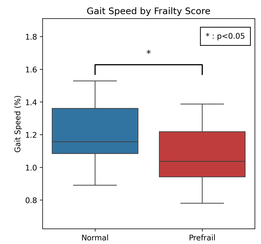
SPM1D ANALYSIS

SPM1D analysis of left hip internal rotation across the gait cycle, comparing normal and pre-frail groups. The statistical test identifies significant differences during midstance and terminal stance phases.

CORRELATION ANALYSIS



Comparison of Total Double Support (%) between Normal and Pre-frail individuals.



Comparison of Gait Speed (%) between Normal and Pre-frail individuals.