



Digital Phenotyping For Remote Monitoring Of Cognition In Early Alzheimer's Disease

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BACKGROUND

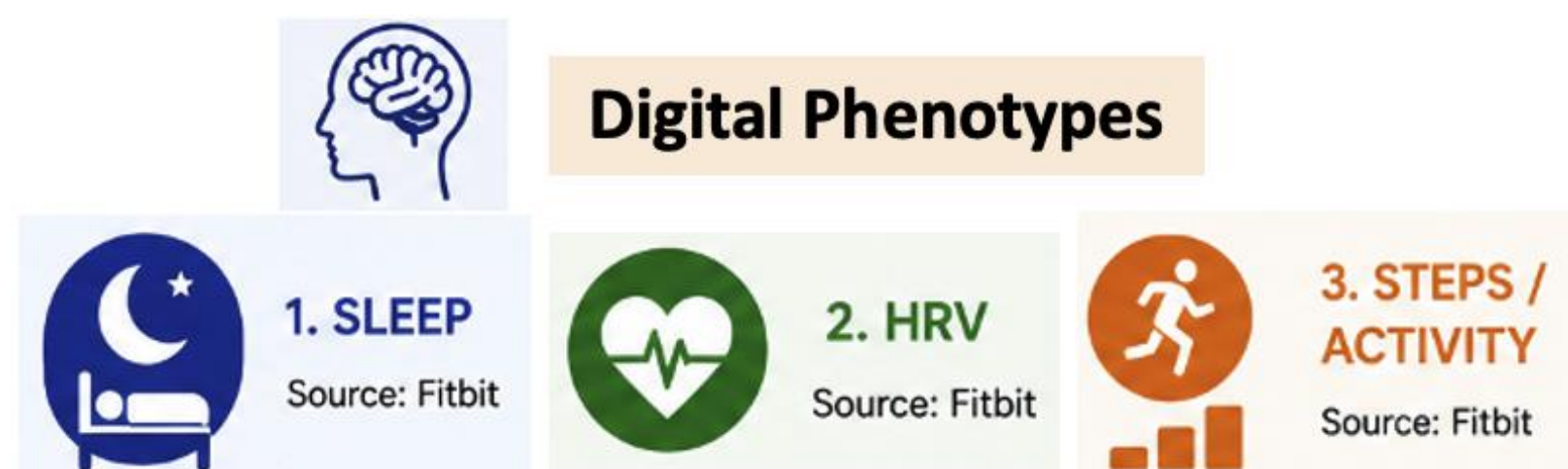
- Identification of cognitive decline in early Alzheimer's disease (AD) is crucial as this enables timely intervention to delay disease progression.
- Traditional clinic-based brief assessments are typically episodic, subjected to practice effects and limited in ecological validity, hence restricting its sensitivity in detecting subtle cognitive changes.
- The increasing use of digital wearables among older adults presents a valuable opportunity as these technologies enable the real-time, passive monitoring of behaviors and physiological markers that may predict cognitive changes with minimal disruption to an individual's daily routines¹.

AIM

- Using sensor data from a wrist-worn fitness tracker, we evaluated the correlations of physical activity, sleep, and physiological measures with cognitive test scores in patients with early-stage AD.

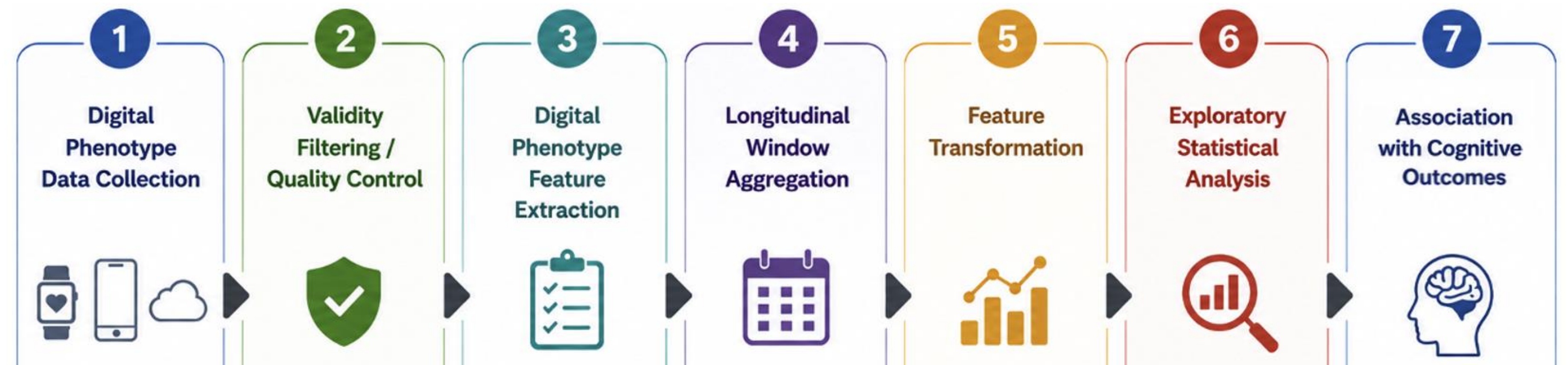
METHODOLOGY

- 43 Study Participants with early AD (Mild Cognitive Impairment or Mild Dementia), aged 68.9±9.2 years, 55.8% female and 12.2±3.5 years of education, were recruited from specialist memory clinics in Singapore.
- All participants underwent a Montreal Cognitive Assessment (MoCA) and wore a Fitbit Fitness Tracker for at least thirty days.
- Fitbit wear time was estimated with the presence of heart rate measurements indicating periods during which the device was worn.
- Passive data captured include sleep, heart rate and heart rate variability and steps from the wearable device (Fitbit)



- Spearman correlation analyses were conducted to examine associations between the Fitbit-derived digital measures and MoCA scores.
- Necessary privacy- and security-preserving controls are implemented to comply with healthcare regulations².

Digital Phenotyping Data Processing Pipeline



- Raw Fitbit records were collected for all participants.
- Data Filtering was performed to ensure data quality digital features were derived from the cleaned data.
- Features were aggregated over a rolling 7-day (day/night) window to capture short-term trend of a week.
- Box-Cox transformation was applied to normalize feature distributions.
- **Valid Day:** when a participant wears the Fitbit for at least 10 hours and records a minimum of 100 steps.
- **Valid Night:** A sleep record was considered valid if the sleep onset occurred between 8:00 PM and 8:00 AM. To ensure consistent alignment of overnight sleep periods, each record was assigned to the date corresponding to 8:00 PM. For eg, a sleep episode starting at 2:00 AM on June 28 would be attributed to the night of June 27.

RESULTS

- Device adherence has been sustained around 85 percent or above among the Study Participants

Table: Spearman Correlation Analysis Between Wearable-Derived Measures and MoCA Scores

Digital Phenotyping Feature	Spearman Correlation (r)	p value	Correlation Strength
Heart Rate Variability (HRV)	0.381	0.01	Light
REM Sleep	0.319	0.04	Light
Deep Sleep	0.494	0.00	Moderate
Wake Stage Ratio	-0.395	0.01	Light
Deep Sleep Ratio	0.434	0.00	Moderate
Sleep efficiency	0.355	0.02	Light
Sleep to Wake Ratio	0.395	0.01	Light
Median Steps	0.575	0.00	Moderate

CONCLUSION

- We observed consistent association of Fitbit-derived digital measures with MoCA scores in individuals with early-stage AD
- The strongest signals come from sleep architecture and activity
- Our findings highlight the potential of digital wearable measures as scalable digital biomarkers for remote monitoring of cognitive health, complementing clinic-based assessments.
- As part of a global effort to adapt dementia prevention models for diverse settings, this work adds a crucial cognitive monitoring layer by establishing individual baselines, detecting early changes between clinical visits, and connecting individuals with appropriate interventions

REFERENCES

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- 2 Wang X, Vouk N, Heaukulani C, Buddhika T, Martanto W, Lee J, Morris RJ. HOPES: An Integrative Digital Phenotyping Platform for Data Collection, Monitoring, and Machine Learning J Med Internet Res 2021;23(3):e23984