

Integrating accelerometry, GPS, GIS and molecular data to investigate mechanistic pathways of the urban environmental exposome and cognitive outcomes in older adults: study protocol

Hunter RF, **Cleland CL**, Trott M, **Kucukali H**, O'Neill S, Mullineaux ST, Kee F, McKinley JM, Neville CE, O'Hara L, Marr C, McAlinden M, Ellis G, McKnight AJ, Schipperijn J, McHugh-Power J, Duong T, McGuinness B on behalf of the SPACE team.
We also wish to acknowledge funding and support from NICOLA and HCAP

BACKGROUND & AIM

Maintaining cognitive health in later life is a global priority. Encouraging individuals to make healthy behaviour changes, and the provision of supportive urban environments can help maintain cognitive health, thus preventing or delaying the progress of dementia and cognitive decline.

This study aims to use granular measures of the urban environment exposome (built, natural and social) and of physical activity, to explore how these interact with a person's biology to ultimately influence cognitive health.

METHODS

Design: Cohort study

Participant recruitment (n=400)

- Northern Ireland Cohort for the Longitudinal study of Ageing (NICOLA)
- Harmonised Cognitive Assessment Protocol (HCAP)

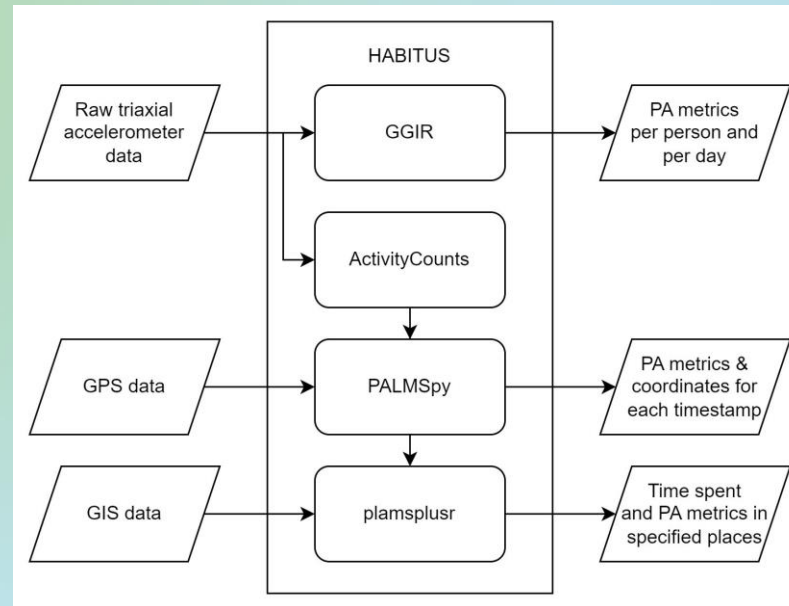
Measurements

- Hip-worn (Fig.1) 7-day sensor
 - Accelerometer – Actigraph wGT3XP-BT
 - Global Positioning System (GPS) – Qstarz BT-Q1000XT
- Geographical Information Systems (GIS) data (Table 1).
- Blood-derived biochemical, genetic and epigenetic data
- Neuropsychological tests (Table 2)

Fig.1. Sensor placement



Fig.2. Data integration process



DATA ANALYSIS

1. Total Effect Analysis

- Focuses on the total effect of physical activity, measured as daily moderate-to-vigorous physical activity (MVPA), on cognitive function (MMSE score).
- Uses directed acyclic graphs and multivariable linear regression with doubly robust estimators for causal effect estimation.

2. Mediation Analysis

- Examines the mediation effects of variables physical activity on the environment-cognition relationship using latent change score mediation within a Structural Equation Modeling (SEM) framework
- Employs causal inference approaches to dissect direct, indirect, and interactive environmental effects on cognitive function.

3. Compositional Analysis

- Compares cognitive health impacts of redistribution of different movement behaviours (sedentary, light, and moderate-to-vigorous activity) in different settings (e.g., UGBS vs. other areas) using multivariate analysis of variance.
- Applies isometric log-ratio transformation to model the association of time spent in different movement behaviours during waking hours and cognitive health. Minute-by-minute isotemporal substitutions will be made from one behaviour to another whilst holding the remaining behaviours constant.

CONCLUSION

- This study provides evidence of links between urban environmental factors and cognitive health in older adults
- Advances methods for integrating and analysing data from accelerometry, GPS, GIS, and cognitive health.
- Uses a large sample with a comprehensive cognitive assessment to in-depth analysis of causal mechanisms of cognitive decline in older adults.
- Allows analysis of environmental exposome measures within a complex system framework.
- Enables future researchers to create and analyse detailed temporospatial datasets using established methods.

This work was supported by **UK Research and Innovation** [ES/V016075/1]

DATA INTEGRATION

HABITUS The Human Activity Behaviour Identification tool and data Unification System is being used to process and integrate the accelerometer, GPS and GIS data (Fig.2).

Physical activity metrics calculated from the accelerometer data are linked to coordinates from the GPS device by timestamp. Then it is mapped to environmental data from GIS by coordinates.

Data integration enables the calculation of time spent in every physical activity intensity (i.e., sedentary behaviour and light, moderate and vigorous physical activity) or travel mode (i.e., active or passive), in every pre-determined space (e.g., home, parcel, local neighbourhood, and green and blue space).

Table 1: GIS data

Densification
Infrastructure
Land use
Natural environment
Transportation
Air, noise and light pollution
Soil geochemistry
Social environment
Other

Table 2: Neuropsychological tests

Mini Mental State Examination (MMSE)	Constructional Praxis – Immediate
HRS-TICS	Symbol-Digit Modalities Test
CERAD Word List Recall – Immediate	Constructional Praxis – Delayed
Animal Retrieval Fluency	Wechsler MS IV – Delayed
Letter Cancellation	Wechsler MS IV – Recognition
Backward Count	Number Series
10/66 Respondent and Community Screening Instrument for Dementia	Raven's Standard Progressive Matrices
CERAD Word List Recall – Delayed	Trail Making
Wechsler MS IV – Immediate	CES-D Depressive Symptoms
CERAD Word List Recognition	