Beyond Perception: Physiological Insights into How Older Adults Navigate Stress in Urban Complexity A. Torku, A. P. C. Chan. *Gerontechnology* 25(s)

Purpose Active ageing depends on everyday mobility, yet older adults' outdoor time, trip frequency, and trip distance continue to decline [1,2]. Because environmental barriers interact with age-related changes in capability, stress and mobility limitation may arise when environmental demands exceed a person's functional capacity [3,4]. Current methods for detecting stressful conditions in the built environment are often inefficient and insufficiently human-centred. This study examines whether physiological responses measured by wearable sensors vary between stress and non-stress urban conditions experienced by older adults and explores how these signals can complement existing approaches to assessing age-friendliness. **Method** Physiological indicators, including heart rate variability and electrodermal activity, together with perceived stress ratings, were collected from ten older adults during a structured urban walk. The characteristics of the walking path were concurrently assessed by two trained observers. Participants wore sensors capturing heart rate variability (HRV) and electrodermal activity (EDA); GPS and time stamps aligned signals to segment-level observations. Pre-processing removed artefacts and normalised signals within participants. Analyses proceeded on individual and aggregate levels. We used Wilcoxon signed-rank tests to compare HRV and EDA features between perceived stress and non-stress conditions within participants and across the cohort. We examined individual differences (sex, body mass index [BMI]) using stratified tests. To probe spatial patterns, we conducted (i) clustering of physiological responses across all participants and related clusters to the perceived segment classification, and (ii) spatio-temporal clustering to detect intra-segment variation of physiological responses within stress and non-stress conditions. **Results and Discussion** On average, participants exhibited statistically significantly higher physiological responses in segments perceived as non-stress than in segments perceived as stress (Wilcoxon signed-rank, $p < 0.05$). Women showed significantly higher physiological responses to non-stress segments than men ($p < 0.05$). Under stressful environmental conditions, participants with BMI > 24.9 showed elevated physiological demand, indicating greater sensitivity to environmental challenges. Clustering analyses revealed coherent groups of physiological responses that aligned with perceived classifications, while spatio-temporal profiles uncovered micro-zones within segments where responses intensified (e.g., at abrupt kerb transitions or near noisy intersections), as shown in Figure 1. These findings highlight that personal factors (sex, BMI) and time-varying environmental factors shape the effectiveness and interpretability of wearable physiological sensing. Importantly, results demonstrate that wearable sensing can complement existing environmental audits, providing objective markers of arousal that go beyond perception to spotlight subtle stressors otherwise missed by conventional assessments. Integrating physiological insights into age-friendly street design and maintenance (e.g., targeted surface repairs, improved crossing timing/geometry, noise and clutter mitigation) may better support older adults' mobility within complex urban settings.

References

1. Shumway-Cook, A., Patla, A., Stewart, A., Ferrucci, L., Ciol, M. A., & Guralnik, J. M. (2003). Environmental components of mobility disability in community-living older persons. *Journal of the American Geriatrics Society*, *51*(3), 393-398.
2. Portegijs, E., Rantakokko, M., Viljanen, A., Rantanen, T., & Iwarsson, S. (2017). Perceived and objective entrance-related environmental barriers and daily out-of-home mobility in community-dwelling older people. *Archives of Gerontology and Geriatrics*, *69*, 69-76.
3. Lawton, M. P. (1982). Competence, environmental press, and the adaptation of older people. *Aging and the Environment: Theoretical Approaches*, 33-59.
4. Webber, S. C., Porter, M. M., & Menec, V. H. (2010). Mobility in older adults: A comprehensive framework. *The Gerontologist*, *50*(4), 443-450.

Keywords: Older adult, mobility, urban stress, heart rate variability, electrodermal activity
Affiliation: School of Civil Engineering, University of Leeds, UK
Email: a.torku@leeds.ac.uk
Acknowledgement: Supported by: Research Grant Council of Hong Kong; Department of Building and Real Estate, The Hong Kong Polytechnic University; and School of Civil Engineering, University of Leeds.

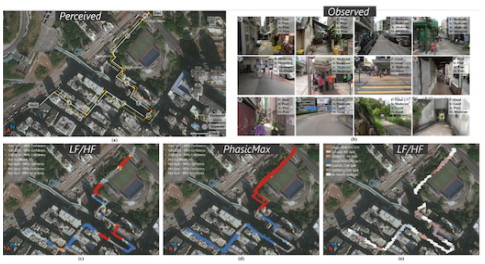

Figure 1: Result comparison: observers' audit, older adults' perceived and physiological response