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Editorial

# Environmental, infrastructural, and social drivers of physical activity in aging cities

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Untangling the complex interaction between human behavior and the environment is a cornerstone of modern public health research. Walking, the most common form of physical activity, is an ideal proxy to explore how lifestyle, environment, and infrastructure interact to influence health outcomes. This scenario is well illustrated in the study by Wakai et al. [1], in which authors offer a comprehensive, data-driven, and methodologically sophisticated exploration of these relationships through the integration of multiple variables recorded in Japanese urban centers. By using smartphone-derived steps as a metric of physical activity, authors examined the impact of temperature, transportation, and marital status on human mobility over time.

Cities worldwide are facing the converging challenges of population aging, declining physical activity, transformations in social organizations and behavioral patterns, and climate crisis. In this context, elucidating the impact of factors such as temperature variability, transport accessibility, and sociodemographic variables on mobility is essential for developing targeted public health interventions.

This editorial highlights and contextualizes four central themes emerging from the study: (1) the effect of environmental temperature and seasonality on walking behavior; (2) the impact of transportation infrastructure on physical activity; (3) implications for climate adaptation and global warming; and (4) the influence of marital status on mobility in urban settings.

## 1. Temperature, seasonality, and human locomotion

Wakai et al. [1] reported an M-shaped seasonal trend in average daily steps, peaking in spring and autumn and declining during summer and winter months. Using seasonal-trend decomposition via locally estimated scatterplot smoothing, authors identified a tight correlation between walking behavior and deviations from an optimal temperature of 14.3 °C. The symmetrical decline in step counts at both low and high temperatures aligns with the behavioral thermoregulation theory [2] and reinforces previous findings on the subject [3–5].

The 14.3 °C optimum may correspond to a climatological "comfort zone" beyond which thermal discomfort begins to impact willingness to engage in outdoor activities [5,6]. This view is further supported by prior studies showing that physical activity levels decline in the presence of temperature extremes, especially among older adults and individuals with cardiopulmonary conditions [7].

The public health implications of this scenario are considerable. Seasonal variation in walking behavior can lead to fluctuations of 2000–3000 steps per day, translating to meaningful changes in energy expenditure (~100–175 kcal for 70 kg person) and cardiometabolic risk. Notably, a meta-analysis has shown that each additional 1000 steps per day (~0.75 km for 70 cm stride length) reduce all-cause mortality risk by approximately 15 % [8]. Therefore, seasonal drops in physical activity reflect potential clinically relevant events with measurable health consequences.

## 2. Transportation infrastructure as a determinant of walking activity

Findings on the impact of transport infrastructure on urban mobility also present remarkable public health relevance. In comparing five government-designated Japanese cities, the authors identified a strik-

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ing difference in daily step counts between "higher activity" cities (i.e., Saitama, Kawasaki, Fukuoka) and "lower activity" cities (i.e., Kyoto, Kobe). The key differentiating factor was ordinary train use, which was significantly more frequent in the former group, while car use was inversely associated with step counts.

This finding reinforces longstanding evidence that transit-oriented urban development supports physical activity by integrating movement into daily routines [9–11]. Indeed, trains and subways require walking to, within, and from stations, thereby stimulating a more active lifestyle. Instead, car dependency reduces walking opportunities as highlighted by the inverse relationship between car use and physical activity observed globally [12–14]. Interestingly, the study by Wakai et al. [1] also shows that proximity to a large urban center increases train use and, indirectly, daily step counts. Thus, transportation infrastructure serves not only as a means of access, but also as a structural framework that influences daily health behaviors.

## 3. Climate change and the future of city walkability

The relationship between temperature and walking behavior is intrinsically connected to the domain of climate-sensitive epidemiology. As global temperatures continue to rise and climate variability increases, seasonal extremes are expected to become more frequent and severe, impacting outdoor physical activity during warmer months. Urban areas worldwide are already experiencing longer summers with more frequent heatwaves [15]. Rising temperatures will inevitably lead to a reduction in physical activity levels, especially among those who would benefit most from regular movement, such as older adults. This reduction in physical activity exacerbates the adverse health effects of heat exposure and contributes to the progression of mobility impairments and non-communicable diseases, triggering a feedback loop that further impacts population health and resilience in the face of climate change [16].

The reduction of walking activity during warmer months also amplifies urban health disparities [17]. Wealthier individuals can afford indoor gyms, climate-controlled environments, or private transportation. In contrast, those who are socioeconomically disadvantaged often rely on walking and public transit, which are both vulnerable to climatic disruption. Therefore, city planners and policymakers should prioritize the development of climate-resilient and accessible infrastructure (e.g., shaded walkways, expanded tree canopies, indoor walking spaces) to reduce the impact of rising temperatures on outdoor activity and ensure equitable access to safe, comfortable environments, especially for vulnerable populations.

## 4. Marital status and walking behavior

In a less explored yet critical area, Wakai et al. [1] examined the influence of marital status on walking behavior. Their results suggest that married and divorced/widowed men walked significantly more than women in the same categories, by approximately 1800 and 2400 steps per day, respectively, while step counts among unmarried individuals were comparable between sexes.

These results can be interpreted according to gendered domestic roles and sociocultural expectations in Japan. Previous surveys have shown that a large share of Japanese women reduce workforce participation following marriage or childbirth [18], which affects their daily activity patterns. Conversely, physical activity may increase in men post-marriage due to employment demands, commuting, or household errands, especially when spouses are homebound.

The finding that divorced or bereaved men continue to maintain higher activity levels suggests the persistence of work-related routines, while women in similar circumstances may not resume pre-marriage mobility levels. These differences have public health consequences as reduced mobility is strongly associated with frailty, depression, and disability [19,20]. Therefore, marital status should be viewed not as a mere demographic variable but as a proxy for structural and behavioral dynamics. Its inclusion in mobility studies is crucial, especially in aging societies where household compositions are rapidly evolving. Furthermore, public health strategies should account for these patterns by tailoring interventions, such as female-focused walking groups or urban design that supports caregiving roles, to promote mobility and well-being among women through marital transitions.

## 5. Conclusion

Understanding the complex interplay of environmental, infrastructural, and social factors is instrumental in promoting physical activity, particularly mobility, in aging urban populations. Seasonal temperature variations, access to transit-oriented infrastructure, and social determinants, such as marital status, all impact walking behavior and, hence, health outcomes in older adults. To mitigate the development of chronic conditions and frailty as well as support healthy aging, urban planning and public health authorities must develop integrated, adaptive approaches that enhance walking opportunities, ensure climate resilience, and address social disparities, especially those affecting vulnerable groups like older women. Creating age-friendly environments that promote safe, regular physical activity is essential for sustaining independence and improving quality of life in rapidly aging societies.

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No Generative AI or AI -assisted technologies were used in the writing process.

## Declaration of competing interest

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Emanuele Marzetti reports financial support was provided by Italian Ministry of Health. Riccardo Calvani reports financial support was provided by European Commission. Hélio Jose Coelho-Junior declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## References

[1] Wakai N, Yamada T, Tomoyama H, Iida S. Built-in healthcare applications reveal step changes associated with temperature, transportation, and marital status among urban cities in Japan. J Frailty Aging 2025;14:100059. doi:10.1016/j.tjfa.2025.100059.
[2] Weiss B, Laties VG. Behavioral thermoregulation. Science 1961;133:1338–44. doi:10.1126/science.133.3461.1338.
[3] Togo F, Watanabe E, Park H, Shephard RJ, Aoyagi Y. Meteorology and the physical activity of the elderly: the Nakanojo Study. Int J Biometeorol 2005;50:83–9. doi:10.1007/s00484-005-0277-z.
[4] Tucker P, Gilliland J. The effect of season and weather on physical activity: a systematic review. Public Health 2007;121:909–22. doi:10.1016/j.puhe.2007.04.009.
[5] McCormack GR, Friedenreich C, Shiell A, Giles-Corti B, Doyle-Baker PK. Sex- and age-specific seasonal variations in physical activity among adults. J Epidemiol Community Health 2010;64:1010–16. doi:10.1136/jech.2009.092841.

[6] Ho JY, Goggins WB, Mo PKH, Chan EYY. The effect of temperature on physical activity: an aggregated timeseries analysis of smartphone users in five major Chinese cities. Int J Behav Nutr Phys Act 2022;19:68. doi:10.1186/s12966-022-01285-1.
[7] Ho JY, Lam HYC, Huang Z, Liu S, Goggins WB, Mo PKH, et al. Factors affecting outdoor physical activity in extreme temperatures in a sub-tropical Chinese urban population: an exploratory telephone survey. BMC Public Health 2023;23:101. doi:10.1186/s12889-022-14788-0.
[8] Banach M, Lewek J, Surma S, Penson PE, Sahebkar A, Martin SS, et al. The association between daily step count and all-cause and cardiovascular mortality: a meta-analysis. Eur J Prev Cardiol 2023;30:1975–85. doi:10.1093/eurjpc/zwad229.
[9] Frank LD, Schmid TL, Sallis JF, Chapman J, Saelens BE. Linking objectively measured physical activity with objectively measured urban form: findings from SMARTRAQ. Am J Prev Med 2005;28(2 Suppl 2):117–25. doi:10.1016/j.amepre.2004.11.001.
[10] Sallis JF, Floyd MF, Rodríguez DA, Saelens BE. Role of built environments in physical activity, obesity, and cardiovascular disease. Circulation 2012;125:729–37. doi:10.1161/CIRCULATIONAHA.110.969022.
[11] Saelens BE, Handy SL. Built environment correlates of walking: a review. Med Sci Sports Exerc 2008;40(7 Suppl):S550–66. doi:10.1249/MSS.0b013e31817c67a4.
[12] Besser LM, Dannenberg AL. Walking to public transit: steps to help meet physical activity recommendations. Am J Prev Med 2005;29:273–80. doi:10.1016/j.amepre.2005.06.010.
[13] Mueller N, Rojas-Rueda D, Cole-Hunter T, de Nazelle A, Dons E, Gerike R, et al. Health impact assessment of active transportation: a systematic review. Prev Med 2015;76:103–14. doi:10.1016/j.ypmed.2015.04.010.
[14] Althoff T, Sosič R, Hicks JL, King AC, Delp SL, Leskovec J. Large-scale physical activity data reveal worldwide activity inequality. Nature 2017;547:336–9. doi:10.1038/nature23018.
[15] Mora C, Dousset B, Caldwell IR, Powell FE, Geronimo RC, Bielecki CR, et al. Global risk of deadly heat. Nat Clim Change 2017;7:501–6. doi:10.1038/nclimate3322.
[16] van Daalen KR, Tonne C, Semenza JC, Rocklöv J, Markandya A, Dasandi N, et al. The 2024 Europe report of the Lancet Countdown on health and climate change: unprecedented warming demands unprecedented action. Lancet Public Health 2024;9:e495–522. doi:10.1016/S2468-2667(24)00055-0.
[17] Cacciatore S, Mao S, Nuñez MV, Massaro C, Spadafora L, Bernardi M, et al. Urban health inequities and healthy longevity: traditional and emerging risk factors across the cities and policy implications. Aging Clin Exp Res 2025;37:143. doi:10.1007/s40520-025-03052-1.
[18] Gender Equality Bureau, Cabinet Office. Survey on marriage, work, and income in Japan, 2019. Available at https://www.gender.go.jp/english_contents/index.html (accessed on 13 June 2025)
[19] Halaweh H, Willen C, Grimby-Ekman A, Svantesson U. Physical activity and health-related quality of life among community dwelling elderly. J Clin Med Res 2015;7:845–52. doi:10.14740/jocmr2307w.
[20] Izquierdo M, de Souto Barreto P, Arai H, Bischoff-Ferrari HA, Cadore EL, Cesari M, et al. Global consensus on optimal exercise recommendations for enhancing healthy longevity in older adults (ICFSR). J Nutr Health Aging 2025;29:100401. doi:10.1016/j.jnha.2024.100401.