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EDITORIAL

Sitting less, moving more: the indoor built environment as a tool for change

Alexi Marmot and Marcella Ucci

The health risks of physical inactivity are widely understood as evidence has accumulated, particularly in the medical, public health, sport and exercise science disciplines. Physical inactivity is estimated to cause more than 5 million premature deaths annually across the globe – 9% of all deaths – mainly from coronary heart disease, high blood pressure, stroke, Type 2 diabetes, cancer, depression and falling, making it a health hazard similar to that of smoking and obesity (Lee et al., 2012). Sedentary behaviour, particularly prolonged periods of sitting, has been found to be a health hazard independent of physical inactivity (*e.g.* Parry & Straker, 2013). 'Sitting less and moving more' summarizes guidance that has been emerging from organizations focused on public health such as the Centers for Disease Control and Prevention (CDC) (2008), the World Health Organisation (WHO) (2010), and Public Health England, via Buckley et al. (2015). Campaigns and pressure groups have been forged, *e.g.* 'Get Britain Standing' and 'Stand Up Victoria' (Australia). Media reports headlined 'sitting is the new smoking', or similar, now appear with increasing regularity.

What is the role of the built environment, particularly the indoor built environment, in encouraging or discouraging physical activity (PA) and sedentary behaviour? 'Behaviour settings' and their influence on PA and sedentary choices have been articulated by Owen, Salmon, and Fotheringham (2000). They classify activities and behavioural choices in five contexts: community, home, occupational, educational and transport. Designers, owners and managers of those settings need solid guidance from the built environment research community about the characteristics of the places in which PA and non-sedentary behaviours are encouraged. The relationship between urban form, transportation and PA has been relatively well researched (Saelens & Handy, 2008). This *Building Research & Information* special issue focuses on the indoor built environment, particularly on the home, occupational and educational settings, where further knowledge of activity levels and the possibilities for change are needed. The guest editors were impressed by the international spread and scope of studies and literature reviews of the papers submitted from several countries around the world, and are grateful to the reviewers and authors who all worked to refine the papers included.

Based on existing research, the active design concept, as articulated in the *Active Design Guidelines* (Center for Active Design, 2010), and the UK's Design Council (2014) aimed to address health concerns such as obesity, framed as an energy expenditure problem associated with lack of PA (energy expenditure) and excessive food consumption (energy intake). Hence, active design principles were aimed at facilitating healthy eating and PA – particularly moderate to vigorous such as physical exercise and active travel (*e.g.* walking, cycling). For indoor environments, this agenda often meant that stair climbing was the main focus for active design studies/interventions. However, as previously stated, recent evidence from public health suggests that prolonged periods of sitting are associated independently with adverse health outcomes. In addition, for those populations who are most inactive, even small changes in activity levels and sedentary behaviour can be of value. Consequently, public health messages about the need to meet minimum PA targets (*e.g.* 10 000 steps daily) are now accompanied by another broader approach (Smith, Ekelund, & Hamer, 2015): people need to sit less, 'move around' more and preferably move 'more energetically', ideally in all aspects of their lives. This new understanding in turn means that a variety of aspects of the indoor environments could potentially play a more important role in active design. Such a role can change significantly depending on the type of activities and populations. From a built environment perspective, this can be translated into building types. This issue includes papers covering some key building types and populations: residential buildings for older people, schools and offices, thus providing an opportunity for identifying cross-cutting themes and differences.

The three papers in this special issue that address residential buildings for older people illustrate the richness and diversity of the topic. First, the conceptualization and operationalization of the behavioural outcome is quite different across the three studies. In 'The role of building design and interiors in aging actively at

home', Ahrentzen and Tural frame their systematic review around the notion of active living (AL), which:

> includes but goes beyond that of walking and 'active transportation' to activities such as gardening, walking pets, housework, and other ADLs [activities of daily living] and IADLs [instrumental activities of daily living].
>
> (p. 583)

These include activities appropriate to a residential setting, such as 'dressing oneself, preparing meals and cleaning up, housework, care of pets, functional mobility, and other common household task' (p. 583). On the other hand, in Lu, Rodiek, Shepley and Tassinary's 'Environmental influences on indoor walking behaviours of assisted living residents' – a quantitative cross-sectional study of older people in assisted living facilities, excluding cognitively impaired residents – the focus is on indoor walking behaviour with a distinction made between 'recreational' and 'utilitarian' walking. Conversely, in 'The home as enabler of active lifestyles among older people', Brookfield, Fitzsimons, Scott, Mead, Starr, Thin, Tinker and Ward-Thompson adopted a qualitative approach to examine 'the home's role in the active and sedentary behaviours of the older population' (p. 616), with a sample of 22 participants, of whom 15 are 'healthy', five are stroke survivors and two are community-dwelling older adults with a diagnosis of dementia. The heterogeneity of the issue is highlighted further by the Ahrentzen and Tural review paper that emphasizes two important aspects for this research field: (1) older adults, whilst sharing the same chronological age spectrum, are not a heterogeneous cohort; and (2) most studies sample specific contexts in relation to location, dwelling type and socio-economic status, amongst other variables. Hence, Ahrentzen and Tural highlight that:

> study findings of the role of BE [built environment] in active ageing may not be generalizable to other segments of the older population or their residential settings, but may be specific to time, place and circumstances of the research sample.
>
> (p. 597)

Finding the right balance between heterogeneity and homogeneity of the study sample is important, as demonstrated by Lu et al. Contrary to other studies, they did not find a significant association between recreational walking and environmental aspects of safety, aesthetics and comfort, possibly because of differences in the targeted population (*e.g.* age or health conditions) or homogeneity of the environment (*e.g.* the facilities may have had similar quantity/quality of lighting, sitting, artwork etc.).

The generalizability and applicability of research findings in this field is further hampered by a number of methodological issues. Ahrentzen and Tural's review emphasizes the need for more detailed measurements of built environment factors, AL outcomes/behaviour, as well as the lack of comprehensive theoretical approaches to inform study design and formulation of variables. For example, capturing both objective measurements of the built environment and subjective perceptions is important, as demonstrated by Lu et al. who found that 'perceiving the corridor as a looped path' was a significant factor associated with self-reported indoor recreational walking, while the corresponding objective measure was not significant in the multivariate model. Furthermore, 'approximately 39% of participants did not respond correctly to the question about whether 'the corridor is a looped path' (p. 612). In order to provide correct guidance to building and interior designers, it is important to understand how both perceptions and objective measurements correlate with the behavioural outcome, as well as how they relate to one another. Lu et al. also found that 'the number of stories of the building' had a negative impact on both indoor recreational and utilitarian walking. However, the authors highlight that the underlying reasons might differ, *e.g.* recreational walking may be discouraged by shorter corridors in multi-storey buildings, whilst accessibility may be an issue affecting utilitarian walking in such buildings. It appears, therefore, that the environmental variable 'number of storeys' could be a proxy for a variety of underlying mechanisms. This emphasizes not only the need for more detailed built environment metrics but also the importance of considering theory and hypothesis testing when developing such metrics.

Notwithstanding the heterogeneity of the research field, Ahrentzen and Tural formulate some important conclusions and recommendations, some of which have been mentioned above. One important and unsurprising finding is the dominance of accessibility and universal/inclusive design considerations in most studies and findings addressing older people in residential environments. This may be because the role of other aspects (*e.g.* environmental cues and ambient qualities) is less developed in current research theories and practice, but it could also be that barriers, supports and features that 'fit' (as defined by Ahrentzen and Tural) are the main design requirements for older people, while other aspects only come to the forefront once barriers are removed. This could also explain why the paper by Brookfield et al., investigating the links between the home environment and AL, primarily based on a deductive approach, ends up focusing primarily on features associated with accessibility and inclusive design.

The complexity of identifying meaningful and universally applicable design principles and guidelines is exemplified by the finding from Brookfield et al. that

stairs were seen as problematic by their older adult respondents, not only due to poor design features but also because climbing stairs was considered tiring or associated with fears of injury. On the other hand, for a smaller group in the study, the stairs, although tiring, 'were valued for introducing into the daily routine an appreciated episode of PA [physical activity]' (p. 623). This implies that flexibility and adaptability of design, as opposed to formulaic prescriptions, may be more appropriate to ensure that needs are met as they change over time or as building are inhabited by different people.

Moving now to the other end of the age spectrum, this special issue includes two papers focusing on indoor aspects of the school environment. Within non-domestic buildings, it is important to examine not only how the built environment may affect PA and sedentary behaviour but also how these are linked to 'human performance' issues, such as academic outcomes in the case of schools (or 'productivity' for the workplace). In 'Indoor school environments, physical activity, sitting behaviour, pedagogy: scoping review', Ucci, Law, Andrews, Fisher, Smith, Sawyer and Marmot examine the links between pedagogy, PA and sedentary behaviour in indoor school environments. The paper specifically addresses emerging aspects of active design as discussed above, namely the general idea of moving more and sitting less, without focusing especially on moderate-to-vigorous PA or physical education. Given the emphasis on exercise and physical education that dominates the literature, the review paper, perhaps unsurprisingly, finds a lack of research, especially on sitting. It also notes the relative paucity of studies in secondary schools. In primary schools, preliminary evidence indicates that PA can be integrated successfully within lessons, with benefits on behavioural outcomes and possibly academic performance too. The paper reviews a handful of studies that also examine the classroom environment, which is also the focus of the other paper on schools within this issue. The controlled intervention study in 'Modifying the classroom environment to increase standing and reduce sitting', by Aminian, Hinckson and Stewart, examines the impact of a 'dynamic classroom' environment on children's objectively measured sitting, standing and stepping behaviours within and outside school time, as well as the impact on pain, inattention and hyperactivity. The study replaced traditional desks and chairs with height-appropriate workstations in classrooms where Swiss balls, beanbags and a 'mat space' were also provided. The study findings are encouraging in suggesting that both pedagogic and PA/non-sedentary behaviours are improved by the intervention, although the authors point to the need for a larger-scale study with longer time frames. However, whilst the authors conclude that 'height-appropriate standing workstations can be successfully integrated into classrooms to increase overall standing and decrease sitting time' (p. 631), the paper also demonstrates how 'the devil is in the details', and how generalizability can be difficult. For example, the intervention was multifaceted and

> at times, children fought over the Swiss balls as no more than three children were allowed to use the balls in the classroom at one time because the teacher found them disruptive.
>
> (p. 641)

In fact:

> The teacher also suggested that a mixed set-up including a few seating desks, a few Swiss balls, more beanbags and the height-appropriate workstations would work better.
>
> (p. 641)

Furthermore, it was not possible to provide height-appropriate standing workstations for all children due to the variations in children's heights. The authors did not comment on whether specific space requirements are needed for a 'dynamic classroom' environment. The paper illustrates how difficult it can be to introduce changes to the physical environment without implicitly or explicitly involving the participants, which in turn makes it difficult to distinguish the effect of environmental changes alone. For example, the teacher in the intervention group was heavily involved in the recruitment and data-collection process, which might have glossed over different perceptions by pupils on the role and function of the physical changes in their classroom.

The impact of individual, interpersonal, organizational and physical environment aspects on PA and sedentary behaviour is emphasized in this issue by the cross-sectional study of office workers by Duncan, Short, Rashid, Cutumisu, Vandelanotte and Photnikoff entitled 'Identifying correlates of breaks in occupational sitting: a cross-sectional study'. The paper examines the self-reported frequency of breaks in sitting in 5531 office workers, stratified by office type (private-enclosed, shared, open-plan). The study found that demographic variables (age), interpersonal/organizational variables (job autonomy; workplace size) and spatial configuration aspects (local connectivity, co-worker proximity and visibility) are all associated with the frequency of breaks in sitting, and that the strength/direction of the association can vary by office type. These findings are an important first step in the understanding of complex phenomena where multilevel interventions may be required. However, depending on job role and organization type, some factors may also be interrelated, *e.g.* office type and job autonomy or spatial aspects such as co-worker proximity. Furthermore, perceptions of spatial environments may not coincide with objective measurements, as previously mentioned. For instance,

the metric 'visibility of co-workers' not only captured whether participants can see colleagues' workstations from their own desks but also if they frequently see people walking around their building, which could be also a sign of whether 'walking around the building' is considered 'socially acceptable' in the workplace.

It is worth noting that the two review papers in this special issue, while examining different building types, both highlight a lack of adequate theories and of frameworks for examining/defining built environment metrics. There is a lack of cross-sectional and intervention studies that are based on theory and/or used to develop/test clear theories and hypotheses. Similarly, there is a lack of systematic classification and understanding of how various aspects of the indoor built environment might impact on the agenda of 'sitting less and moving more'. Consequently, objective metrics may capture only some aspects of the indoor environment or could end up being proxies for one or more characteristics. It is interesting that in 2005, Zimring, Joseph, Nicoll, and Tsepas published an important paper on the role of building design on PA in which they discuss some key issues such as the importance of distinguishing between intentional activity (*e.g.* recreational walking with a specific intention to exercise) and instrumental/accidental (*e.g.* walking to a destination) or hybrid activity (choosing to walk to a destination). This is important when considering whether a change in the physical environment explicitly or implicitly relies on the occupant's motivation for being more active (or at least an awareness that being more active and sitting less is desirable), as opposed to an impulsive or habitual response. Zimring et al.'s paper also discusses matters of scale and of building design and construction phases, distinguishing between urban design, site selection and 'design, building design and building element design'. The building element they primarily address in their discussion is the design of stairs, whilst more recent active design approaches to reduce sedentary behaviours now focus on even smaller scale, and less permanent, elements such as furniture. In fact, there is a need to develop a taxonomy of building and interior aspects that may affect PA and sedentary behaviours for each building type and for different populations. The development of such taxonomies should be supported by cross-reference to a taxonomy of behavioural intervention types. For example, Hollands et al. (2013) use the nudge concept of 'choice architecture' interventions to change population health behaviour (including PA) via altering micro-environments. A broader approach may be valuable that maps all the likely mechanisms by which the indoor built environment may impact PA and sedentary behaviour, applying general frameworks and taxonomies originally developed by health psychologists (*e.g.* Michie, Atkins, & West, 2014).

The evidence from built environment research on PA and sedentary behaviour clearly lags behind that of medical, public health, sports and exercise sciences – especially for indoor environments. More research funding is needed internationally in order to gather sufficient robust evidence to guide policies to enhance desirable behaviours through the design and management of indoor built environments and the artefacts within. Such funding will enable knowledge to expand through more well-conceived studies, in more environments, with larger participant populations, based on sound theories and agreed taxonomies. Funding streams should allow for the truly cross-disciplinary collaborations needed. Projects need to reflect the role of indoor built environment factors on individual, social, organizational and policy levels. There is evidence from research on outdoor environments that both people *and* places must be targeted, with a need for:

> comprehensive long-term multi-pronged interventions [. . .] aimed at bringing about cultural shifts favouring physical activity over sedentary alternatives, and the creation of a supportive built environment. (Giles-Corti, 2006, p. 358)

There is a tendency, even in current learned discourse, to frame built environment elements as either a barrier or a trigger, whose removal or deployment respectively would obtain the desired outcome for PA and sedentary behaviours. However, the papers in this issue demonstrate that this is probably rare, and that changes to the built environment alone are rarely a factor 'nudging' people into the expected change. Hence, truly cross-disciplinary collaborations are essential.

Research is also needed on the endurance of the cultural assumptions and artefacts that contribute to a sedentary lifestyle, as well as the means by which unhelpful aspects of that culture may be changed. Ogden Nash pithily observed that 'people who work sitting down get paid more than people who work standing up'. Such culturally ingrained notions, deriving over the centuries from a time when only royalty and aristocracy owned furniture and sat frequently on thrones or seats, is today reinforced by ever-more-comfortable and affordable seating furniture. Deep cultural practices cannot be altered rapidly, and certainly not without weighty research evidence of the mal-effects of prolonged sitting. Change of this magnitude also demands significant, creative investment into the radical redesign of artefacts that currently encourage sitting such as sofas, office chairs and fixed-height desks in classrooms and workplaces. Through evidence-based design, they need to be reconceived as acceptable artefacts of new behaviours that people may wish to adopt. Providing adjustable sit–stand desks in a workplace is not enough – standing may be tiring, uncomfortable or cause musculoskeletal pain to

those unused to long periods of standing, and the social environment may not be conducive to some standing and overlooking seated others. Lessons of what works from research on behaviour change and positive change management need also to be understood and applied to change, for example, social norms around sitting and standing behaviours.

Research inside buildings has traditionally been hampered by data privacy and the need for permission to enter and conduct research, requiring both organizations and individual study participants to agree. The fabric of buildings, such as brick, steel and concrete, commonly interferes with some technologies for data gathering like global positioning systems (GPS), radio-frequency identification technology (RFID), infrared and internet signals (Spinney et al., 2015). Beyond the walls that shape buildings, satellite-based GPS technologies and public datasets from local and central governments, highways and transportation authorities provide urban researchers with vast, informative datasets on where, when and how people move in the external environment outside buildings. Yet the indoor environment is where most people in Western societies spend about 90% of their time (compared with 5% in transit and 5% outdoors) (Klepeis et al., 2001). The research limitations on the indoor built environment may soon diminish. New and emerging technologies such as biometric data from wearables on metrics including step count, heart rate, caloric expenditure plus laser-point mapping from mobile phones may soon permit a greater understanding of where, when and how people act and move within buildings. The editors anticipate, therefore, that future research will be better able to illuminate the role of the indoor built environment and its artefacts on PA and sedentary behaviours. This will lead to further developments in the potential for evidence-based changes in policy, design and management of the indoor built environment and how it is used.

The hope is that this special issue adds to the scientific cross-disciplinary understanding of activity within different environments which will eventually provide a more complete spectrum of knowledge that spans from active cities and landscapes to active buildings, active furniture and artefacts, and, above all, active minds and behaviours.

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