博士学位論文

Workplace Neighbourhood Built Environment and Workers' Physically-Active and Sedentary Behaviours

ワーカーにおける職場近隣の環境と身体活動および座位行動

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Jan 2022

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Author's Declaration

I declare that the work in this thesis was carried out in accordance with the requirements of Waseda University's regulations. Except where indicated by specific reference in the text, the work is the author's own work. Work done in collaboration with, or with the assistance of, others, is indicated as such. The author compiled data for this thesis, conducted all the analyses, wrote and explained the results of this thesis. Any views expressed in the thesis are those of the author.

Part of the work forming basis of this thesis has been published as one systematic review entitled "Workplace neighbourhood built environment and workers' physically-active and sedentary behaviour: a systematic review of observational studies" (*International Journal of Behavioral Nutrition and Physical Activity*, 2020. 17: 148) and one research article entitled "Workplace Neighbourhood Built-Environment Attributes and Sitting at Work and for Transport amongst Japanese Desk-Based Workers" (*Scientific Reports*, 2021. Accepted).

Table of contents

List of Tables

List of Figures

List of Appendix

Chapter 1. Introduction

1.1 Sedentary pattern with less physical activity amongst workers as an emerging public health priority

The two main behaviours amongst individuals' waking hours – physical activity and sedentary behaviour – play important roles in building an individual's healthy lifestyle.[1] Physical inactivity, which is usually characterised by less amount of physical activity as well as higher time spent being sedentary, is amongst the main risk contributors to mortality; it has been estimated to cause around 3.2 million deaths worldwide.[2] Lancet published a study reported that a reduction in physical inactivity may increase the overall life expectancy amongst the world's population by 0.7 years.[3] Previous research has shown that both an increased amount of physical activity and decreased time in sedentary behaviour are independently associated with better health such as a lower incidence of non-communicable diseases,[3, 4] a greater level of mental health[5, 6] and work productivity and/or performance.[7, 8] Longitudinal studies also reported that greater amount of physical activity was associated with a lower risk of incident obesity, regardless of time of sedentary behaviour.[9]

Due to the occupational style changes from involving many physical demands to

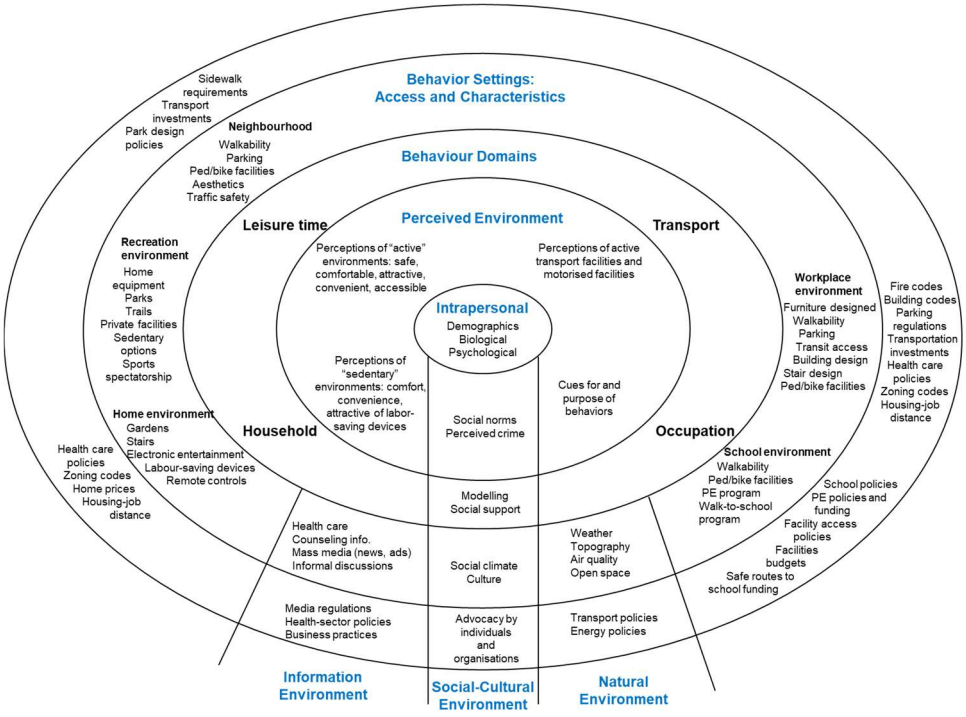
desk-based tasks, adults spend less time of their working hours on physically-active behaviours but more time on sitting overtime. A large proportion of desk-based workers spend the majority (77%-82%) of their work hours being sedentary;[10-12] the proportion of time spent sedentary at work is markedly greater than during non-working hours.[10, 11] Furthermore, the occupational sitting tends to be accumulated in longer bouts: studies from Australia found that approximately 17%-42% of the occupational sitting spent on prolonged sitting bouts of at least 30 minutes amongst desk-based workers (e.g., those who work in the office, call centre, and customer service).[12, 13] Consistent evidence has linked a large amount of time continued with being sedentary with the risk of cardio-metabolic diseases[14] and premature all-cause mortality.[15, 16] Therefore, exposure to excessive workplace sitting amongst desk-based workers is an emerging and important public health priority.[17]

A meta-analysis of prospective cohort studies investigating physical activity and prevention of coronary heart diseases showed that individuals who spent 150 and 300 minutes per week of moderate-intensity physical activity for leisure had a 14% and 20% lower risk of coronary heart diseases than those who reported none of any leisure-time physical activity.[18] The results suggested that a higher amount of physical activity was associated with a relatively low risk of coronary heart diseases.

1.2 Importance of investigations into potentially influential workplace neighbourhood built-environment attributes of health behaviours

Ecological models of health behaviour suggest that individuals' physically-active[19] and sedentary behaviours[20] may be influenced by multidimensional factors, including intrapersonal (e.g., sociodemographic, biological, and psychological characteristics), interpersonal (e.g., social support and modelling), environmental attributes, and organisational policies. The framework of ecological models for physical activity and sedentary behaviour is shown in Figure 1.1.

Figure 1.1 Ecological models of four domains of physical activity and sedentary behaviour (Sources: References 19-20)



The ecological models of behaviour cover a range of factors relevant to different subsamples. Overall, many influential factors to be physically-active and sedentary behaviours are likely to operate similarly for different subsamples such as children and adolescents, working adults, and the elderly population. By contrast, some of the influential factors may be distinct for specific subgroups. For example, the workplace environment may be more relevant to workers whilst the school environment may be more relevant to school-aged students, compared with the counterparts, due to the specific subsample spending most of the time in the designated setting.[10-12]

Built-environment attributes related to the workplace setting comprises the built-environment attributes inside (i.e., interior), on the land parcel of the building, and the neighbourhood around the workplace. The relevant built-environment attributes can be inside the workplace building (e.g., workstations and spatial layout of workplace buildings) and outside but still on the building's land parcel (e.g., exclusive car parking for workers in the workplace buildings). The broadly-defined workplace neighbourhood built-environment attributes include a wide range of attributes such as walkability, destination access, and safety surrounding the workplace, which is not located on the precinct.

Building on a growing body of evidence in built-environment attributes related to physical activity, a recent science advisory statement from the American Heart Association recognised the role of activity-supportive neighbourhood built-environment design in promoting active living and improving population health.[21] However, a large number of current studies into neighbourhood built-environment attributes only focused on where individuals live rather than where they work.[22, 23] Amongst the research relevant to the workplace built-environment attributes, most of them examined interior/indoor built-environment attributes, accounting for direct and/or indirect impacts on physically-active and sedentary behaviours during work hours.[24-27] However, in addition to the indoor environment of such workplaces, in which some characteristics are known to be related to workers' sitting time,[28, 29] the external environment surrounding the workplace (i.e., workplace neighbourhood) may be also relevant in this context. In particular, they may affect behaviours during work breaks and commuting when desk-based workers would not be constrained by their work-related tasks. Additionally, a greater capacity to do the higher intensity of physical activity e.g., moderate-to vigorous-intensity physical activity such as walking and cycling amongst workers whilst investigating the broader built environment beyond the workplace setting e.g., workplace building and its precinct.[30] Given that occupational sitting tends

to be accumulated in longer bouts,[12, 13] workplace neighbourhoods where it is easier to interrupt sitting may be conducive to lower amounts of sitting at work.

Mixed results have previously been found in relation to the workplace neighbourhood built environment and physical activity.[31, 32] For example, a study from the USA found inconsistent associations between different measures of workplace neighbourhood walkability and total physical activity at work.[31] Another study conducted in Japan found that the perceived workplace neighbourhood walkability was not associated with recreational physical activity.[32] Only one recent review has tried to summarise existing evidence on the associations of the built-environment attributes outside the workplace with workers' physically-active and sedentary behaviours.[33] The recent review found consistent and supporting evidence in the height-adjusted, treadmill, or stationary high workstations increased workplace standing and reduced sitting behaviours.[33] By contrast, it was understudied regarding the overall workplace building design and inconclusive results was found for associations of physical activity with most workplace neighbourhood attributes including population density, local destination access, and traffic safety.[33] Further systematic synthesis and investigations are needed.

1.3 A literature review of workplace neighbourhood built-environment attributes in workers' physically-active and sedentary behaviours

1.3.1 Protocol of the review

The protocol of this systematic review was published on the International Prospective Register of Systematic Reviews (PROSPERO) on 2 December 2019 (registration number: CRD42019137341). The protocol has been updated and available from https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42019137341. Findings from this chapter were published in Lin CY, et al. International Journal of Behavioral Nutrition and Physical Activity. 2020; 17(1): 148[34] (see Appendix A for the full article).

1.3.2 Database search strategy

The database search of this systematic review was conducted in October 2019 based on the suggestions from Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[35] Systematic searches were conducted based on nine electronic databases: PubMed, Web of Science, PsycINFO, Scopus, Transport Research International Documentation, MEDLINE, Cochrane, Embase, and CINAHL.

We used Google Scholar (https://scholar.google.com.tw/) to check if we missed some important relevant studies. The last search was carried out at the beginning of January 2020.

We used three sets of search terms. The first term was words relevant to the built-environment attributes under the workplace context such as workplace, worksite, and neighbourhood. The second and third terms were words related to physically-active behaviour (physical activity and walking) and sedentary behaviour (sedentary behaviour and prolonged sitting), respectively. Table 1.1 shows details of the search terms and syntax used for the search.

Table 1.1 Search terms and syntax details for the literature search

Set	Concept	Search Statement
1	Physically-active behaviour	(physical activity OR walking).ti.
2	Sedentary behaviour	(sedentary behaviour OR prolonged sitting).ti.
3	Environmental variables under the context of workplace	(workplace OR work site OR worksite OR office environment OR work space).ti. AND (neighbourhood OR walkability OR destination OR sidewalk OR pathway OR connectivity OR aesthetic OR safety).tx.
4	Combine sets	1 OR 2 AND 3
5	Limit	peer-reviewed journal articles.pt.
6	Limit	English.la.
7	Limit	January 2000-October 2019.dt.
8	Combine sets	Limit 4 to 5, 6, and 7

1.3.3 Screening

The systematic database search produced 2,077 articles after removing duplicates. These articles were primarily screened by two independent reviewers (CYL, the author of this thesis, and YL, the co-author of this published systematic review). There were several inclusion criteria, as follows –

i) published after 2000 in peer-reviewed journals;

ii) full-text was written in English;

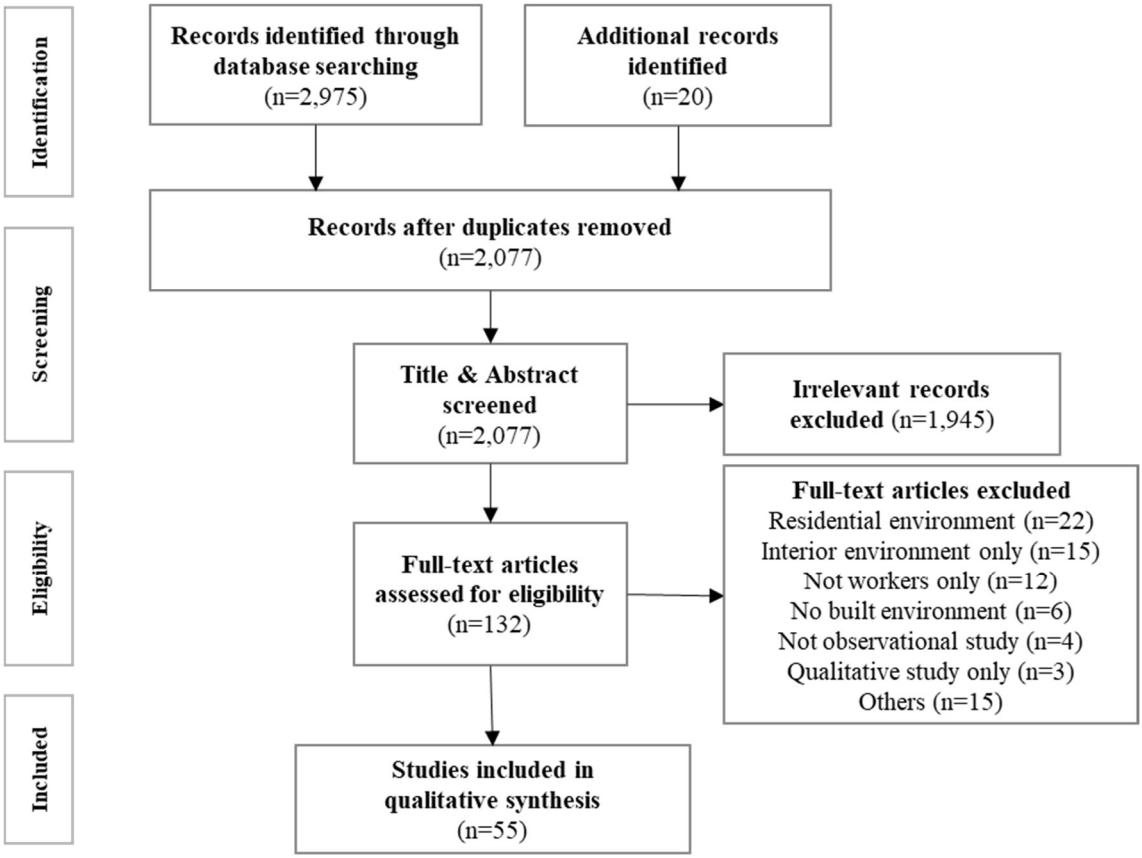
iii) observational studies with quantitative analyses; and

iv) estimated associations of self-reported or objectively-measured built-environment measures around the workplace with physical activity or sedentary behaviour amongst workers.

We restricted the systematic review on articles published after the year 2000, as studies on this topic started to emerge and keep growing around that time.[33] Studies examining only other sorts of environmental measures, for example, social (e.g., supports from supervisors/colleagues), informational (e.g., posters/boards on the wall or programmes), and interior (e.g., workstations) environmental attributes, which not taken into account 'neighbourhood' workplace built-environment attributes were excluded.

We would like to target workers who engage in sedentary work patterns in a primary work location (e.g., desk-based office workers); however, many studies did not highlight the occupational composition of the worker sample recruited. Therefore, we conducted a process of elimination, namely studies that focused on blue-collar workers, clinical nurses, and drivers were excluded from this review. Furthermore, we also excluded some of the studies due to they included both workers and non-workers together, without a stratified analysis showing results amongst workers. The screening process based on title and abstract removed 1,945 articles. Two independent reviewers (CYL and YL) read the full text of the remaining 132 articles to further check their eligibility. The two reviewers (CYL and YL) consistently identified 55 articles to be included in the review during this process.[31, 32, 36-88] The consistency of the screening process between the two reviewers was more than 95%, indicating high consistency in screening the eligibility of potentially relevant articles. Figure 1.2 shows the flow chart illustrating the process of database search and screening.

Figure 1.2 Flow chart of the literature search process



1.3.4Data extraction

All essential information from the full-texts of the eligible articles was extracted by one reviewer (CYL) and cross-checked by the second reviewer (YL). The main information was extracted and organised to evaluate the quality of articles, as follows –

i) study country/location;

ii) sample;

iii) study design;

iv) built-environment attributes and measurement methods (i.e., perceived or audited);

v) outcome variables and measurement methods (i.e., reported or objectively-measured); covariates; and

vi) main findings.

Associations between built-environment attributes and physically-active and/or sedentary variables were reported in several differential ways, including Spearman or Pearson correlation coefficients, linear regression beta coefficients, and odds ratios estimated using logistic regression.

The outcome variables i.e., physically-active and sedentary behaviours were categorised into total and different domains, including at work, transport-related, and leisure-time, based on the definitions employed in each study.

Referring to and adapting the categories of neighbourhood built-environment attributes employed in the previous reviews,[22, 23, 89] the workplace neighbourhood built-environment attributes investigated in the articles were divided into five categories (Figure 1.3):

i) Composite environmental indices: a) a composite index including multiple neighbourhood built-environment attributes across different types. For example,

neighbourhood walkability calculated the population or residential density, land use mix, and connectivity. b) a composite index mixing neighbourhood built-environment attribute(s) with other attributes rather than neighbourhood one such as interior built environment and/or workplace policies together (e.g., a scale measuring facilities around workplace, social climate, and organisational supports). Generally, a higher composite index such as walkability within an individual's workplace neighbourhood indicated an activity-supportive neighbourhood that was assumed to be associated with a higher level of physical activity whilst a lower level of sedentary behaviour across domains.

ii) Route-related attributes: where included routes for pedestrians or cyclists and street connectivity or intersection density, indicating the level of connecting multiple areas. A higher level of connecting different areas through the routes in the workplace neighbourhoods was hypothesised to be associated with a higher level of physical activity whilst a lower level of sedentary behaviour across domains, as more connected routes were more convenient for workers to walk or cycle from one area to another area.

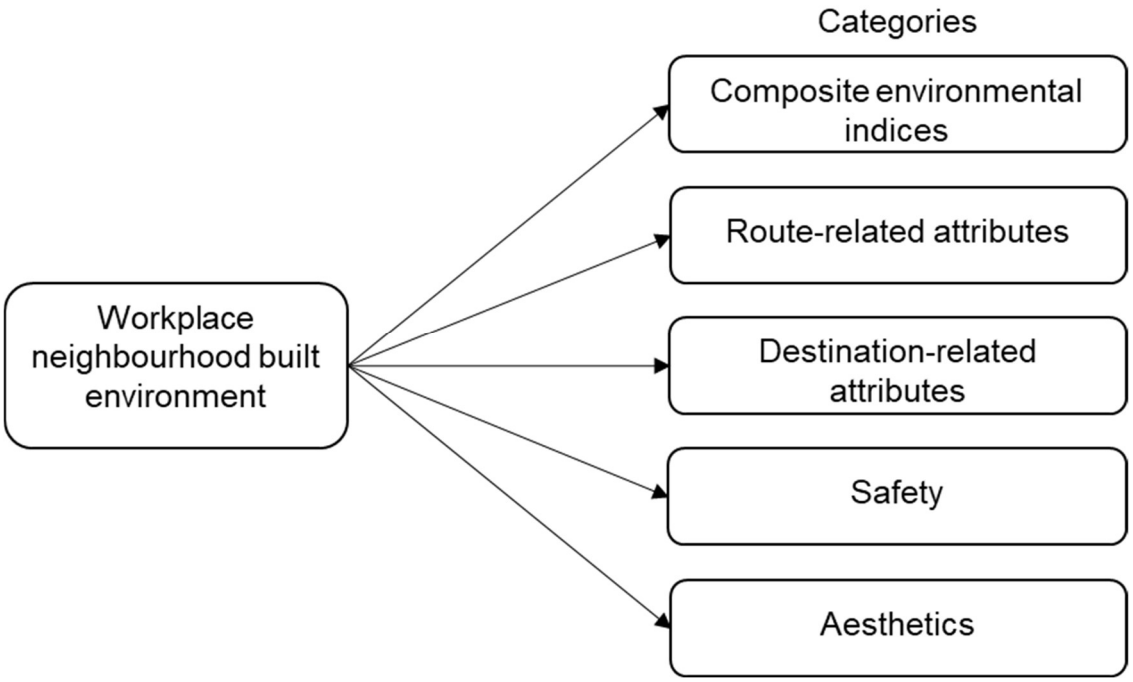
iii) Destination-related attributes: these included the presence, density, and diversity of destinations that were assumed to increase physical activity such as shops, transport

stops, recreational facilities; and the distance between workplace and home or city centre. Of note, the presence of car parking, which was specifically examined as a matter of convenience to drive cars (i.e., a type of sedentary transport behaviour), was also examined in some studies. We divided all of them into the same category but highlighted the difference in their assumptions and discussed them further in different ways.

iv) Safety: these comprised a low volume of traffic for pedestrians and bicyclists, low crime rates, and lighting along the commuting routes. A higher level of traffic or crime safety around the workplace was assumed to be helpful to create more opportunities and increase workers' intentions to engage in physical activity with less time being sedentary within the workplace neighbourhoods.

v) Aesthetics: these included general aesthetics, greenness, and being free of litter. Generally, a higher level of aesthetics in the workplace neighbourhood was hypothesised to stimulate workers' happiness and in turn an increased intention for the engagement of physical activity with less time being sedentary in the workplace neighbourhoods.

Figure 1.3 The framework applied in this systematic review



1.3.5Quality assessment

The scientific rigour of the selected articles was reviewed and assessed by two independent reviewers (CYL and YL), using the study quality assessment tool for observational cohort and cross-sectional studies published by the National Institutes of Health.[90] The details of this assessment tool were shown in Appendix Table 1. Each article was assessed against 14 criteria, including items relevant to the research aim, participants, measurements, and statistical analysis. Based on the guidance for the assessment tool,[90] the research aim was assessed based on its importance and explicit

description. Detailed information such as the demographic, location, and inclusion criteria provided showing a higher probability to replicate the study. Studies using a reliable and valid measurement of variables, employing multiple measurements to examine the robustness, and considering the potentially important covariates were typically evaluated with higher quality scores. Each article was given a quality rating of good, fair, or poor according to the scoring guidelines. Disagreements were discussed between the two raters until consensus was reached. Due to the majority of the reviewed studies were of good (58.2%) or fair (40.0%) quality, we did not weight study findings based on their rigour. There was moderate agreement between the two independent raters on the quality assessment of the included studies; the percentage of overall agreement was 85.5%, and Cohen's Kappa coefficient was 0.69.

1.3.6 Synthesis of research findings

The associations of workplace built-environment attribute with physically-active, or sedentary behaviours were extracted and coded into "+" (statistically significant positive association), "–" (statistically significant negative association), and "N" (statistically non-significant association). If a study reported findings from multiple models, only the results of the most adjusted models (i.e., the model adjusted for most

covariates in each study) were used. If a study reported findings from a composite score as well as its components, the results of each component were extracted. Furthermore, if a study showed results for both the overall sample and subsamples, the results from the subsamples were primarily extracted. We summarised the findings for each domain of physically-active and sedentary behaviours separately to distinguish their potentially differential associations with built-environment attributes. This literature review section identified an association to be statistically significant if the p-value of an observed correlation/association was lower than 0.05.

1.3.7 Study characteristics

Cross-sectional studies accounted for 85.5% of the 55 included articles (Table 1.2). The follow-up period implemented in the eight longitudinal studies ranged from one month[40, 87, 88] to seven years.[79] Nearly half studies reviewed (n = 26) were included in the recent review by Zhu et al.,[33] whilst the other 29 studies were novel to this literature review section. Amongst the articles reviewed, most of the studies were undertaken in the US (n = 25, 45.5%) and the UK (n = 13, 23.6%), accounting for around 70% of all studies.

All of the studies reviewed recruited working adult samples whilst some of them examined the associations investigated for particular population subsamples. There were five studies identified the workers with specific nationalities.[39, 56, 71, 87, 88] Two studies examined the associations with targeting working women,[58, 83] parents with children,[44, 70] and commuters from home to workplace (i.e., those who did not work from home),[54, 66] respectively. One study targeted samples working in specific institutes such as a university[48] and local governments,[85] respectively. The sample sizes of these reviewed studies ranged from 26 to 111,808, of which three had a sample size lower than 100[43, 73, 87] and five with a sample size larger than 10,000.[56, 71, 78, 81, 85]

The studies reviewed predominantly investigated physical activity (n = 52) whilst only few of them investigated sedentary behaviour (n = 7). There were four of them investigated both physically-active and sedentary behaviours. The transport domain was examined the most in relation to both physical activity (40 out of 52 studies) and sedentary behaviour (7 out of 7 studies). Almost half studies used validated measures for outcome variables, including accelerometers[31, 41, 43, 60, 73, 80, 82, 83] and reliable and validated questionnaires.[36, 37, 41, 46-48, 51, 52, 54, 56, 57, 64, 65, 69, 70, 74, 81, 84, 87, 88] Of note, a certain number of studies (n = 28) assessed reported physically-active and sedentary behaviours without reporting whether or not the single questions or questionnaires

measured had been examined their reliability or validity before; therefore, we regarded them as non-reliable and non-validated measures.

More than half studies measured perceived built-environment attributes (n = 29, 52.7%), around one-third (34.5%) of them objectively measured the built-environment attributes, and 12.7% included both perceived and objectively-measured built-environment attributes in their studies. The most commonly used definition of the perception of workplace neighbourhood was a vague boundary e.g., near or surrounding the workplace without a specific distance or time. Whilst buffers were applied to define workplace neighbourhoods, usually in those used objective measures, a 400-[60, 77, 83] or 800-metre radius[31, 60, 65, 84] and the network buffer[38, 43, 60, 66, 84] were the most frequently used buffer size and type, respectively.

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Adams (2016)[69]	676 employed adults, UK	Recruited employees through five employers in England; Cross-sectional	i. Walking routes (Route-related; P) ii. Walking pavements (Route-related; P) iii. Maintained pavements (Route-related; P) iv. Safe to cross the road (Safety; P) v. Dangerous traffic for walking (Safety; P) vi. Crime rate (Safety; P) vii. Routes are well lit (Safety; P) viii. Free of litter/graffiti (Aesthetics; P) ix. Walking routes are well signposted (Safety; P) x. Public transport (Destination-related; P)	a. Time spent walking to and from work (Transport PA; R)	i-a. + ii-a. + iii-a. + iv-a. N v-a. N vi-a. N vii-a. N viii-a. N ix-a. N x-a. +	Sex, age, car ownership, distance lived from work, free car parking at work, and organisation
Adams (2017)[75]	1,544 employed adults, UK	Recruited employees through five employers in England; Cross-sectional	i. Distance to home (Destination-related; P)	a. Time spent walking to and from work (Transport PA; R)	i-a. N	Age, car ownership, free car parking at work, work-related PA, occupation, work pattern, perceived barriers, and psychosocial factors
Adlakha (2015)[64]	2,015 employed adults, USA	A multistage sampling frame was used to randomly select adults form list-assisted telephone random-digit-dialling methods; Cross-sectional	i. Healthy restaurants (Destination-related; P) ii. Transit stop (Destination-related; P) iii. Sidewalks (Route-related; P) iv. Shops, stores, or markets (Destination-related; P) v. Facilities to bicycle (Route-related; P) vi. Recreation facilities (Destination-related; P) vii. Crime rate (Safety; P) viii. Dangerous traffic for pedestrian (Safety; P)	a. Work PA (Occupational PA; R) b. Travel PA (Transport PA; R) c. Leisure PA (Recreational PA; R) d. Total PA (Total PA; R)	i-a. N; i-b. +; i-c. +; i-d. N ii-a. N; ii-b. N; ii-c. N; ii-d. + iii-a. N; iii-b. N; iii-c. N; iii-d. + iv-a. N; iv-b. +; iv-c. N; iv-d. N v-a. +; v-b. +; v-c. +; v-d. + vi-a. N; vi-b. +; vi-c. +; vi-d. N vii-a. –; vii-b. N; vii-c. N; vii-d. N viii-a. N; viii-b. N; viii-c. N; viii-d. N	Sex, age, ethnicity, education, and income

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Almeida (2014)[57]	6,261 employed adults, USA	Recruited employees in working in medium-sized workplaces in Virginia and Colorado; Cross-sectional	i. Outdoor space (Composite index; O)	a. Moderate activity and strength-training activities (Total PA; R)	i-a. N	Sex, age, ethnicity, and education
Badland (2008)[38]	364 employed adults not working from home, New Zealand	A random sample selected from electric telephone white pages; Cross-sectional	i. Residential density (Destination-related; O) ii. Mixed land use (Destination-related; O) iii. Street connectivity (Route-related; O) iv. Distance to home (Destination-related; O)	a. Transport-related PA (Transport PA; R)	i-a. N ii-a. N iii-a. + iv-a. –	Sex, age, ethnicity, education, household income, and require automobile for work
Badland (2010)[42]	1,188 employed adults not working from home, New Zealand	A random sample selected from electric telephone white pages; Cross-sectional	i. Car parking (Destination-related; P) ii. Workplace located in an urban area (Destination-related; O) iii. Distance to home (Destination-related; O)	a. Commuting to work by public transport (Transport PA; R)	i-a. – ii-a. + iii-a. N	Sex, age, sample weighting, residential accessibility to public transport, access to private automobile, current driving license, and require automobile for work
Barrington (2015)[65]	1,007 employed adults, USA	Recruited employees working in the Seattle area through workplaces; Longitudinal (follow-up: 2 years)	i. Intersections (Route-related; O) ii. Residential units (Destination-related; O) iii. Food destinations (Destination-related; O) iv. Activity destinations (Destination-related; O)	a. Total free-time PA (Recreational PA; R) b. Total walking (Total PA; R)	i-a. N; i-b. N ii-a. N; ii-b. + iii-a. NR; iii-b. N iv-a. N; iv-b. N	Sex, age, ethnicity, education, household income, manual occupation, intervention arm, worksite parcel size, and worksite internal environment variables, and worksite SES

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Batista Ferrer (2018)[80]	654 employed adults, UK	A convenience sample of employees was recruited from 87 workplaces in urban areas in England and Wales; Cross-sectional	i. Distance to home (Destination-related; O) ii. Perceptions of the commuting environment (Composite index; P)	a. Incorporating PA during the commute (Transport PA; O) b. Commuting to work by walking (Transport PA; O) c. Commuting to work by public transport (Transport PA; O)	i-a. –; i-b. –; i-c. NR ii-a. NR; ii-b. NR; ii-c. +	BMI and occupational activity (for a) Workplace, access to car, and availability of workplace car parking (for b) Age, access to car, workplace, availability of workplace car parking, and combines commute with caring responsibilities (for c)
Biswas (2018)[81]	60,650 employed adults, Canada	A multistage sampling frame was used to select households across Canada randomly; Cross-sectional	i. Combination of all (Composite index; P) ii. Combination of walking and playing place (Composite index; P) iii. Combination of walking place, gym, fitness class, showers/change rooms, and health programs (Composite index; P) iv. Combination of walking place, showers/change rooms, and health programs (Composite index; P) v. Combination of walking place and showers/change rooms (Composite index; P)	a. Leisure-time PA (Recreational PA; R)	i-a. + ii-a. + iii-a. + iv-a. + v-a. N	Sex, age, ethnicity, marital status, immigrant, education, BMI, dietary intake, smoker status, alcohol consumption, perceived health and mental health, income, hours worked per week, working at home, job stress, physical demands of work, and season

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Bjorkelund (2016)[70]	709 employed parents not working from home, Norway	Recruited employed parents of children in 6th and 7th graders at 27 randomly selected schools in two Norwegian counties; Cross-sectional	i. Distance to home (Destination-related; P) ii. Traffic safety (Safety; P)	a. Walking to work (Transport PA; R) b. Cycling to work (Transport PA; R) c. Driving to work (Transport SB; R)	i-a. –; i-b. –; i-c. + ii-a. +; ii-b. +; ii-c. N	Sex, education, ethnicity, access to cars/bikes, and attitudes (for a and b) Sex, education, ethnicity, access to cars/bikes, attitudes, and leisure-time PA (for c)
Bopp (2012)[49]	375 employed adults, USA	Recruited local employees working in Manhattan, Kansas, through community listservs, links from local websites, and fliers; Cross-sectional	i. Travel time to home (Destination-related; P) ii. Lack of sidewalks (Route-related; P) iii. Difficult terrain (Safety; P)	a. Walking to work (Transport PA; R) b. Biking to work (Transport PA; R) c. Driving to work (Transport SB; R)	i-a. –; i-b. N; i-c. + ii-a. N; ii-b. N; ii-c. N iii-a. N; iii-b. N; iii-c. N	Sex, age, ethnicity, education, self-efficacy, ecological friendly attitude, employment level, occupation classification, employment length, perceptions of co-worker's active, barriers, and motivations
Bopp (2013)[51]	1,234 employed adults not working from home, USA	A convenience sample was recruited in medium-large cities in the mid-Atlantic region of the U.S. through email addresses directly or listserv, e-newsletter, or mass email; Cross-sectional	i. Lack of bike lanes (Route-related; P) ii. Lack of walking/biking paths (Route-related; P) iii. Lack of sidewalks (Route-related; P) iv. Traffic volume (Safety; P) v. Crime level (Safety; P) vi. Difficult terrain (Safety; P) vii. Distance to home (Destination-related; P)	a. Work-related active commuting (Transport PA; R)	i-a. N ii-a. N iii-a. N iv-a. N v-a. N vi-a. N vii-a. N	Sex, age, ethnicity, marital status, BMI, number of children, number of chronic disease, active commuting beliefs, perceived behavioural control, self-efficacy, income, employment categories, employment length, number of cars in the household, social support, and residential environments

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Bopp (2014)[58]	709 employed women not working from home, USA	A convenience sample was recruited in medium-large cities in the mid-Atlantic region of the U.S. through email addresses directly or listserv, e-newsletter, or mass email; Cross-sectional	i. Lack of bike lanes (Route-related; P) ii. Lack of walking/biking paths (Route-related; P) iii. Lack of sidewalks (Route-related; P) iv. Traffic volume (Safety; P) v. Crime level (Safety; P) vi. Difficult terrain (Safety; P) vii. Travel time to home (Destination-related; P)	a. Active commuting to work (Transport PA; R)	i-a. N ii-a. N iii-a. N iv-a. N v-a. N vi-a. N vii-a. N	Age, number of chronic diseases, perceived health status, self-efficacy, and perceived behavioural control
Bopp (2014)[59]	997 employed adults not working from home, USA	A convenience sample was recruited in medium-large cities in the mid-Atlantic region of the U.S. through email addresses directly or listserv, e-newsletter, or mass email; Cross-sectional	i. Lack of bike lanes (Route-related; P) ii. Lack of walking/biking paths (Route-related; P) iii. Lack of sidewalks (Route-related; P) iv. Traffic volume (Safety; P) v. Crime level (Safety; P) vi. Difficult terrain (Safety; P) vii. Travel time to home (Destination-related; P)	a. Active commuting to and from work (Transport PA; R)	<u>Older adults</u> i-a. N ii-a. N iii-a. N iv-a. N v-a. NR vi-a. N vii-a. – <u>Younger adults</u> i-a. N ii-a. N iii-a. N iv-a. N v-a. N vi-a. N vii-a. N	Sex, BMI, number of children, number of chronic diseases, number of cars in the household, self-efficacy, perceived behavioural control, perceived health status, behavioural beliefs, marital status, ethnicity, income, education, employment, social support, and residential environment

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Buehler (2012)[50]	5,091 employed adults, USA	A national survey to recruit a random sample of address list-based households; Cross-sectional	i. Distance to home (Destination-related; P)	a. Biking to work (Transport PA; R)	i-a. –	Sex, age, ethnicity, household income, access to cars/bikes, residential population density, residential area, bikeway supply, season, and workplace policies
Carlson (2018)[82]	1,085 employed adults not working from home, USA	Employees were selected randomly from households systematically selected to vary in land use patterns and income; Cross-sectional	i. Land use mix (Destination-related; P) ii. Street connectivity (Route-related; P) iii. Walking/cycling facilities (Route-related; P) iv. Aesthetics; (Aesthetics; P) v. Traffic safety (Safety; P) vi. Pedestrian safety (Safety; P) vii. Crime safety (Safety; P)	a. Total active transport (Transport PA; R) b. Active transport around work (Transport PA; R) c. Active transport to/from work (Transport PA; R) d. Total MVPA (Total PA; O)	i-a. +; i-b. +; i-c. +; i-d. N ii-a. N; ii-b. +; ii-c. N; ii-d. N iii-a. N; iii-b. N; iii-c. +; iii-d. N iv-a. N; iv-b. N; iv-c. N; iv-d. N v-a. N; v-b. +; v-c. +; v-d. N vi-a. N; vi-b. +; vi-c. N; vi-d. + vii-a. –; vii-b. –; vii-c. N; vii-d. +	Sex, age, education, ethnicity, vehicles per adult, marital status, people per household, time at address, city, and clustering of participants within block groups
Christiansen (2017)[76]	4,764 employed adults, Norway	A national survey was randomly sampled amongst residents in each county in Norway; Cross-sectional	i. Distance to home (Destination-related; P) ii. Limited parking availability (Destination-related; P) iii. Land use mix (Destination-related; O) iv. Distance to the city centre (Destination-related; O)	a. Trip from home to work by car (Transport SB; R)	i-a. + ii-a. – iii-a. – iv-a. +	Age, education, household income, and residential environment

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Clark (2016)[71]	15,200 employed English adults, UK	A national survey of multistage sampling and the same individuals are re-interviewed in each wave; Longitudinal (follow-up: 1 year)	i. Distance to home (Destination-related; P) ii. Change in the distance to home between wave 1 and wave 2 (Destination-related; P)	a. Car commuting to work (Transport SB; R) b. Active commuting to work (Transport PA; R) c. Commute mode switch from car to non-car (Transport PA; R) d. Commute mode switch from non-car to car (Transport SB; R) e. Commute mode switch from active to non-active (Transport SB; R) f. Commute mode switch from non-active to active (Transport PA; R)	i-a. +; i-b. –; i-c. NR; i-d. NR; i-e. NR; i-f. NR ii-a. NR; ii-b. NR; ii-c. –; ii-d.+; ii-e. +; ii-f. –	Sex, age, education, employment type, household income, attitudes, household car ownership, current driving license, and residential environment (for a-b) Sex, age, education, employment type, household income, attitudes, household car ownership, current driving license, residential environment, and change in life events (for c-f)
Dalton (2013)[52]	1,124 employed adults, UK	Recruited employees working in Cambridge through workplaces; Cross-sectional	i. Distance to the nearest bus stop (Destination-related; O) ii. Distance to the nearest railway station (Destination-related; O) iii. Number of bus stops (Destination-related; O) iv. Number of destinations in working area (Destination-related; O) v. Distance to home (Destination-related; O)	a. Public transport use to work (Transport PA; R) b. Biking to work (Transport PA; R) c. Walking to work (Transport PA; R)	i-a. N; i-b. N; i-c. N ii-a. N; ii-b. N; ii-c. N iii-a. N; iii-b. N; iii-c. N iv-a. +; iv-b. +; iv-c. N v-a. N; v-b. –; v-c. –	Sex, age, limiting illness , deprivation, education, children in household, car ownership, type of work, residential environment, and car parking availability

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
de Geus (2008)[39]	343 employed Flemish adults not working from home, Belgium	Recruited employees via newsletter distributed in Flanders and contacted local cycle communities for having enough cyclists; Cross-sectional	i. Traffic danger (Safety; P) ii. Bicycle lanes (Route-related; P) iii. Crime rate (Safety; P)	a. Cycling for transport (Transport PA ; R)	i-a. N ii-a. N iii-a. N	Education
Forsyth (2014)[60]	446 employed adults not working from home, USA	A randomly selected sample of a residential area at first, and all households were invited in the second stage; Cross-sectional	i. Housing density (Destination-related; O) ii. Access points (Destination-related; O) iii. Percentage of commercial land use (Destination-related; O)	a. Travel PA (Transport PA; O) b. Leisure PA (Recreational PA; O) c. Total PA (Total PA; O)	i-a. +; i-b. N; i-c. + ii-a. N; ii-b. N; ii-c. N iii-a. +; iii-b. N; iii-c. N	Sex, age, ethnicity, education, marital status, housing tenure, household income, household size, PA at work, and neighbourhood clustering
Handy (2011)[45]	420 employed adults not working from home, USA	A random sample of residents for each of the six communities in the U.S.; Cross-sectional	i. Distance to home (Destination-related; P) ii. Dangerous for bicycling (Safety; P)	a. Commuting to work by bicycle (Transport PA; R)	i-a. – ii-a. N	Sex, housing tenure, biking comfort, commuting beliefs and preference
Hamre (2014)[61]	4,630 full-time employed adults, USA	A national survey to recruit a random sample of address list-based households; Cross-sectional	i. Distance to home (Destination-related; P)	a. Public transport use to work (Transport PA; R) b. Walking to work (Transport PA; R) c. Cycling to work (Transport PA; R)	i-a. N; i-b. –; i-c. –	Sex, age, ethnicity, household income, access to cars/bikes, residential population density, residential area, transit access, bikeway supply, season, and worksite policies
Heinen (2013)[53]	4,171 employed adults, Netherlands	Recruited employees of large organisations and residents of working age in Delft and Zwolle; Cross-sectional	i. Distance to home (Destination-related; O)	a. Cycling to work (Transport PA; R)	i-a. –	Sex, age, ethnicity, access to cars/scooters/bikes, purpose to use, sampling area, attitude, social support, facilities at work, and work policies

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Gehrke (2017)[77]	655 employed adults, USA	A national survey randomly sample household within Oregon and invite to participate through mail and telephone; Cross-sectional	i. Activity density (Destination-related; O) ii. Employment density (Destination-related; O) iii. Population density (Destination-related; O) iv. Retail density (Destination-related; O) v. Urban living infrastructure density (Destination-related; O) vi. Employment entropy (2 types of calculation) (Destination-related; O) vii. Employment-population balance (3 types of calculation) (Destination-related; O) viii. Block area (Destination-related; O) ix. Block density (2 types of calculation) (Destination-related; O) x. Connected node ratio (Route-related; O) xi. Connectivity index (4 types of calculation) (Route-related; O) xii. Cul-de-sac density (Route-related; O) xiii. Intersection density (Route-related; O) xiv. Intersection-Cul-de-sac ratio (Route-related; O) xv. The proportion of local roads (Route-related; O) xvi. The proportion of primary roads (Route-related; O) xvii. The proportion of secondary roads (Route-related; O) xviii. Street network density (Route-related; O)	Work-based walking (Transport PA; R)	i-a. N ii-a. N iii-a. + iv-a. N v-a. N vi-a. –, N vii-a. N, N, N viii-a. N ix-a. +, N x-a. N xi-a. N, N, N, N xii-a. N xiii-a. N xiv-a. N xv-a. N xvi-a. N xvii-a. N xviii-a. N	Sex, employment, and private vehicle ownership

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Karusisi (2014)[62]	4,127 employed adults, France	Employees were recruited from a free medical check-up offered by National Health Insurance System; Cross-sectional	i. Destinations density around the workplace (Destination-related; O)	a. Walking for transport (Transport PA; R)	i-a. +	Sex, age, marital status, education, occupation, homeownership, perceived financial strain, household income, and the level of human development of the country of birth
Li (2018)[32]	2,843 employed adults, Japan	A prospective cohort study of local government workers in a central part of Japan; Cross-sectional	i. Walkability (Composite index; O) ii. Number of parks/green spaces (Destination-related; O) iii. Number of sports facilities (Destination-related; O)	a. Habitual walking during leisure-time (Recreational PA; R) b. Habitual exercise during leisure-time (Recreational PA; R)	<u>Men</u> i-a. N; i-b. N ii-a. N; ii-b. N iii-a. N; iii-b. N <u>Women</u> i-a. N; i-b. N ii-a. N; ii-b. N iii-a. N; iii-b. N	Age, education, marital status, office worker, BMI, smoking status, alcohol consumption, sleeping hours, eating breakfast every day, depression, history of hypertension or diabetes, residential environment
Lucove (2007)[37]	987 employed adults, USA	A random sample selected from residential household phone numbers; Cross-sectional	i. A safe place to walk outside work (Safety; P)	a. Any leisure-time PA (Recreational PA; R) b. Work-break PA (Recreational PA; R) c. Overall PA (Total PA; R)	i-a. N; i-b. N; i-c. N	Sex, age, ethnicity, education, physical disability, and general health
Macdonald (2019)[84]	513 employed adults, UK	A random sample selected from the electoral roll within local authority; Cross-sectional	i. Access to public PA facilities (Destination-related; O) ii. Access to private PA facilities (Destination-related; O)	a. PA (Total PA; R)	i-a. N ii-a. N	Sex, age, and income deprivation

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Mackenbach (2016)[72]	482 employed adults, New Zealand	A national survey of multistage stratified sampling; Cross-sectional	i. Population density (Destination-related; O) ii. Housing density (Destination-related; O) iii. Apartment density (Destination-related; O) iv. Job accessibility (Destination-related; O) v. Land use mix (Destination-related; O) vi. Number of bus stops (Destination-related; O) vii. Number of rail stations (Destination-related; O)	a. Active commuting to work (Transport PA; R)	i-a. N ii-a. – iii-a. N iv-a. + v-a. + vi-a. N vii-a. +	Sex, age, income, household type, season, day of the week, and trip distance
Marquet (2018)[83]	147 full-time employed women not working from home, USA	A convenience sample of women living in the U.S; Cross-sectional	i. Walkability (Composite index; O) ii. Walk Score (Composite index; O) iii. Vegetation index (Aesthetics; O)	a. Total MVPA while at work (Occupational PA; O) b. Total MVPA around the workplace (Occupational PA; O)	i-a. +; i-b. + ii-a. N; ii-b. N iii-a. –; iii-b. –	Age, having children, income, work–home distance, amount of non-work PA
Marquet (2019)[31]	119 employed adults, USA	A multistage sampling frame was used to select adults form list-assisted telephone random-digit-dialing methods randomly; Cross-sectional	i. Perceived walkability (Composite index; P) ii. Walkability (Composite index; O) iii. Walk Score (Composite index; O) iv. Vegetation index (Aesthetics; O)	a. Active minutes at work (Occupational PA; O)	i-a. + ii-a. N iii-a. + iv-a. N	Sex, BMI, income, work type, residential walkability, outside work PA

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Merom (2008)[40]	794 employed adults not working from home, Australia	A random sample selected from electric telephone white pages; Longitudinal (follow-up: 1 month)	i. Distance to home (Destination-related; P)	a. Single-day active commuting to work (Transport PA; R) b. Usual active commuting to work (Transport PA; R)	i-a. –; i-b. N	Age, education, marital status, BMI, self-efficacy, active commuting beliefs, and total PA
Panter (2011)[46]	1,164 employed adults, UK	Recruited employees working in Cambridge through workplaces; Cross-sectional	i. Public transport (Destination-related; P) ii. Little traffic (Safety; P) iii. Routes for walking (Route-related; P) iv. Safe to cross the road (Safety; P) v. Dangerous for cyclists (Safety; P) vi. Routes for cycling (Route-related; P) vii. Distance to home (Destination-related; P)	a. Walking to work (Transport PA; R) b. Cycling to work (Transport PA; R)	<u>With car availability in household</u> i-a. +; i-b. NR ii-a. –; ii-b. N iii-a. N; iii-b. NR iv-a. N; iv-b. N v-a. NR; v-b. N vi-a. NR; vi-b. + vii-a. –; vii-b. NR <u>Without car availability in household</u> i-a. N; i-b. NR ii-a. N; ii-b. N iii-a. N; iii-b. NR iv-a. N; iv-b. N v-a. NR; v-b. N vi-a. NR; vi-b. N vii-a. –; vii-b. NR	Sex, current driving licence, and attitude of car use (for a) Sex, education, weight status, limiting illness, number of children, car ownership, and attitude of car use (for b)
Panter (2013)[54]	419 employed car commuters to work, UK	Recruited employees working in Cambridge through workplaces; Cross-sectional	i. Distance to home (Destination-related; P) ii. Supportive environment (Composite index; P)	a. Incorporating walking or cycling into car journeys to work (Transport PA; R)	i-a. N ii-a. +	BMI, work type, deprivation, workplace car parking, attitude towards car, social norm, and habit strength for car use

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Panter (2011)[47]	1,279 employed older adults, UK	A prospective cohort of adults who registered at 121 General Practices within Norwich and surrounding towns; Cross-sectional	i. Route-length ratio (Route-related; O) ii. Main or secondary road on the route (Route-related; O) iii. Land use mix (Destination-related; O) iv. Density of road traffic accidents (Safety; O) v. Distance to home (Destination-related; O)	a. Active commuting to work (Transport PA; R)	<u>Men</u> i-a. N ii-a. NR iii-a. NR iv-a. N v-a. – <u>Women</u> i-a. NR ii-a. – iii-a. NR iv-a.NR v-a. –	Age, social class, BMI, habit for walking or cycling for transport, and residential urban-rural status, and residential road density
Panter (2013)[55]	655 employed adults, UK	Recruited employees working in Cambridge through workplaces; Longitudinal (follow-up: 1 year)	i. Distance to home (Destination-related; P) ii. Destinations within walking distance (Destination-related; O) iii. Public transport (Destination-related; P) iv. Little traffic (Safety; P) v. Walking routes (Route-related; P) vi. Safe to cross the road (Safety; P) vii. Dangerous for cyclists (Safety; P) viii. Cycling routes (Route-related; P)	a. Uptake of walking (Transport PA; R) b. Uptake of cycling (Transport PA; R) c. Uptake of alternatives to the car (Transport PA; R) d. Maintenance of walking (Transport PA; R) e. Maintenance of cycling (Transport PA; R) f. Maintenance of alternatives to the car (Transport PA; R)	i-a. N; i-b. N; i-c. N; i-d. N; i-e. N; i-f. N ii-a. N; ii-b. N; ii-c. N; ii-d. N; ii-e. N; ii-f. N iii-a. +; iii-b. NR; iii-c. N; iii-d. N; iii-e. NR; iii-f. N iv-a. N; iv-b. N; iv-c. N; iv-d. N; iv-e. N; iv-f. N v-a. N; v-b. NR; v-c. N; v-d. N; v-e. NR; v-f. N vi-a. N; vi-b. N; vi-c. N; vi-d. N; vi-e. N; vi-f. N vii-a. NR; vii-b. N; vii-c. N; vii-d. NR; vii-e. N; vii-f. N viii-a. NR; viii-b. +; viii-c. +; viii-d. NR; viii-e. N; viii-f. N	Sex, age, weight status, education, number of children, housing tenure, home location, area-level deprivation, residential environment, attitude to use car, perceived behaviour control, social norm, habit strength, and workplace car parking

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Panter (2014)[63]	655 employed adults, UK	Recruited employees working in Cambridge through workplaces; Longitudinal (follow-up: 1 year)	i. Public transport (Destination-related; P) ii. Little traffic (Safety; P) iii. Walking routes (Route-related; P) iv. Safe to cross the road (Safety; P) v. Dangerous for cyclists (Safety; P) vi. Cycling routes (Route-related; P)	a. Change in time spent walking on the commute (Transport PA; R) b. Change in time spent cycling on the commute (Transport PA; R) c. Change in percentage of car-only trips on the commute (Transport SB; R) d. Uptake of walking on the commute (Transport PA; R) e. Uptake of cycling on the commute (Transport PA; R) f. Uptake of an alternative to the car on the commute (Transport PA; R)	i-a. N; i-b. NR; i-c. N; i-d. N; i-e. NR; i-f. + ii-a. N; ii-b. N; ii-c. N; ii-d. N; ii-e. N; ii-f. N iii-a. N; iii-b. NR; iii-c. N; iii-d. N; iii-e. NR; iii-f. N iv-a. N; iv-b. N; iv-c. –; iv-d. N; iv-e. N; iv-f. N v-a. NR; v-b. N; v-c. +; v-d. NR; v-e. N; v-f. – vi-a. NR; vi-b. N; vi-c. N; vi-d. NR; vi-e. N; vi-f. N	Sex, age, education, season, housing tenure, household composition, access to cars/bikes, current driving licence, and limiting illness
Paul (2019)[85]	23,231 full-time employed adults working in the U.S. Department of the Interior, USA	Employees working in the U.S. Department of the Interior were emailed an invitation to participate and hyperlink to the survey; Cross-sectional	i. Distance to home (Destination-related; O) ii. Workplace located in a non-metro area (Destination-related; O)	a. Commuting to work by walking (Transport PA; R) b. Commuting to work by cycling (Transport PA; R) c. Commuting to work by non-active mode incorporating walking/cycling (Transport PA; R)	i-a. –; i-b. –; i-c. N ii-a. +; ii-b. –; ii-c. –	Sex, age, and residential environment

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Piatkowski (2015)[66]	2,030 employed bicycling commuters, USA	Participants were drawn from individuals that sign-up to receive more information about "Bike to Work Day"(BTWD) online and solicited via email to participate; Cross-sectional	i. Distance to home (Destination-related; P) ii. Street link-to-node ratio (Route-related; O) iii. Intersection density (Route-related; O) iv. Safety and infrastructure (Composite index; P) v. Relative convenience (Composite index; P)	a. Biking to work on BTWD (Transport PA; R) b. Occasional commuter (Transport PA; R)	i-a. –; i-b. –; ii-a. N; ii-b. N iii-a. N; iii-b. N iv-a. N; iv-b. N v-a. –; v-b. –	Sex, age, ethnicity, household size, education, household income, car availability, attitude and perception factors, and residential environment
Pritchard (2019)[86]	195 employed adults, Norway	A fixed sample which the same group of participants working in intra-city workplaces responded to both surveys; Cross-sectional	i. Distance to home (Destination-related; O)	a. Commuting to work by public transport (Transport SB; R) b. Commuting to work by car/motorcycle (Transport SB; R)	i-a. +; i-b. +	Access to car/bicycle, having children, and paid parking around workplace
Prodaniuk (2004)[36]	897 employed adults, Canada	Employees working in three large organisations located in Western Canada were sent a research invitation within the internal mail system of the workplace; Cross-sectional	i. Perceived Workplace Environment Scale (Composite index; P)	a. Workplace PA (Occupational PA; R) b. Leisure-time PA (Recreational PA; R)	i-a. +; i-b. +	Workplace
Quinn (2017)[78]	111,808 employed adults, USA	A national survey of random sampling using a telephone survey of landline numbers; Cross-sectional	i. Distance to home (Destination-related; P) ii. Travel time to home (Destination-related; P)	a. Commuting to work by walking (Transport PA; R) b. Commuting to work by cycling (Transport PA; R)	i-a. –; i-b. – ii-a. –; ii-b. –	Sex, age, ethnicity, education, household income, and geographic location

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Rafferty (2016)[73]	26 full-time office workers, UK	A convenience sample of employees at Glasgow Caledonian University recruited by email; Cross-sectional	i. Distance to home (Destination-related; O)	a. Number of steps (Total PA; O) b. Total time spent in MVPA (Total PA; O) c. Steps were taken during the commute (Transport PA; O) d. Time spent in MVPA during the commute (Transport PA; O)	i-a. N; i-b. N; i-c. N; i-d. N	NA
Schoner (2015)[67]	614 employed adults, USA	Sample of residents from five corridors in the U.S.; Cross-sectional	i. Distance to home (Destination-related; O)	a. Participation in bicycle commuting to work (Transport PA; R)	i-a. –	Age, employment, residential preference, travel attitudes, and residential environment
Schwartz (2009)[41]	117 employed adults, USA	Convenience sample selected from 1 zone in Maryland; Cross-sectional	i. Without cul-de-sacs (Route-related; P) ii. Four-way intersections (Route-related; P) iii. Sidewalks (Route-related; P) iv. Bicycle or pedestrian trails (Route-related; P) v. Trees along the streets (Aesthetics; P) vi. Free from litter (Aesthetics; P) vii. Traffic danger (Safety; P) viii. Crosswalks and pedestrian signals (Safety; P)	a. Total number of walking trips taken from the workplace (Transport PA; O) b. Steps were taken at or near work (Occupational PA; O) c. Average weekday steps (Total PA; O)	i-a. +; i-b. N; i-c. N ii-a. N; ii-b. N; ii-c. N iii-a. +; iii-b. N; iii-c. N iv-a. N; iv-b. N; iv-c. N v-a. N; v-b. N; v-c. N vi-a. +; vi-b. N; vi-c. N vii-a. N; vii-b. N; vii-c. N viii-a. +; viii-b. N; viii-c. N	NA

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Troped (2010)[43]	87 employed adults, USA	A fixed follow-up sample limited to trail users; Cross-sectional	i. Intersection density (Route-related; O) ii. Land use mix (Destination-related; O) iii. Residential population density (Destination-related; O) iv. Housing unit density (Destination-related; O) v. Vegetation index (Aesthetics; O)	a. MVPA within 1 km of the workplace (Occupational PA; O)	i-a. N ii-a. N iii-a. + iv-a. + v-a. N	Sex, age, ethnicity, and education
Umstattd (2011)[48]	173 university employees, USA	A convenience sample of university employees; Cross-sectional	i. Worksite Supportive Environments for Active Living Surveys (Composite index; P)	a. MVPA (Total PA; R)	i-a. N	Sex, age, ethnicity, health status, position type, self-regulation, self-efficacy, and social support
Watts (2013)[56]	48,916 employed Canadian adults not working from home, Canada	A multistage sampling frame was used to select households across Canada randomly; Cross-sectional	i. Access to PA amenities (Composite index; P)	a. Leisure-time PA (Recreational PA; R)	i-a. +	Sex, age, income, and education
Watts (2016)[74]	1,538 employed young adults, USA	Employees were recruited from the third wave of a 10-year longitudinal study in young people who progressed from adolescence to young adulthood; Cross-sectional	i. Distance to fitness facilities (Destination-related; P) ii. Distance to home (Destination-related; P)	a. MVPA (Total PA; R) b. Time spent in walking or biking to get places (Transport PA; R)	i-a. N; i-b. NR ii-a. N; ii-b. –	Age, ethnicity, and socio-economic status

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Wen (2010)[44]	888 employed parents not working from home, Australia	Employed parents of students studying in public primary schools located in the inner west of Sydney were recruited; Cross-sectional	i. Public transport (Destination-related; P) ii. Car parking (Destination-related; P) iii. Reputation for a safe place (Safety; P) iv. Distance to home (Destination-related; P)	a. Travel to work by car (Transport SB; R)	i-a. – ii-a. + iii-a. N iv-a. N	Clustering by the school and the within-school intraclass correlation for travel to work by car
Yang (2015)[68]	1,332 employed adults not working from home, USA	Multistage stratified sampling using list-assisted telephone random-digit-dialling; Cross-sectional	i. Healthy restaurants (Destination-related; P) ii. Transit stop (Destination-related; P) iii. Sidewalks (Route-related; P) iv. Shops, stores, or markets (Destination-related; P) v. Facilities to bicycle (Route-related; P) vi. Recreation facilities (Destination-related; P) vii. Crime rate (Safety; P) viii. Dangerous traffic for pedestrian (Safety; P) ix. Distance to home (Destination-related; O)	a. Public transport use (Transport PA; R) b. Active commuting (Transport PA; R)	i-a. N; i-b. N ii-a. N; ii-b. N iii-a. N; iii-b. N iv-a. N; iv-b. N v-a. N; v-b. N vi-a. N; vi-b. + vii-a. N; vii-b. N viii-a. N; viii-b. N ix-a. N; ix-b. –	Sex, age, BMI, household car ownership, and education (for a) Sex, age, BMI, and household car ownership (for b)

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Yang (2017)[79]	2,757 employed adults, UK	Recruited employees registered at 121 General Practices within Norwich and surrounding towns; Longitudinal (follow-up: 7 years)	i. Distance to home (Destination-related; O) ii. Route length ratio (Route-related; O) iii. Main road on the route (Route-related; O) iv. Secondary road on route (Route-related; O) v. Main or secondary road along route (Route-related; O) vi. Number of streetlights along route (Safety; O) vii. Land use mix (Destination-related; O) viii. Density of road traffic accidents (Safety; O) ix. Density of fatal and serious road traffic accidents (Safety; O)	a. Uptake of active commuting (Transport PA; R) b. Maintenance of active commuting (Transport PA; R)	i-a. –; i-b. – ii-a. N; ii-b. N iii-a. N; iii-b. N iv-a. N; iv-b. N v-a. –; v-b. – vi-a. +; vi-b. NR vii-a. N; vii-b. N viii-a. N; viii-b. N ix-a. N; ix-b. N	Sex, age, BMI, and residential environment
Zhang (2019)[87]	98 employed Chinese adults, China	A convenience sample recruited from two-night schools offered by two universities in Beijing and Shanghai, China; Longitudinal (follow-up: 1 month)	i. Residential density (Destination-related; P) ii. Land-use diversity (Destination-related; P) iii. Land-use accessibility (Destination-related; P) iv. Street connectivity (Route-related; P) v. Aesthetics (Aesthetics; P) vi. Walking infrastructure (Route-related; P) vii. Traffic safety (Safety; P) viii. Crime safety (Safety; P)	a. Transport-related cycling at time 1 (Transport PA; R) b. Transport-related cycling at time 2 (Transport PA; R)	i-a. N; i-b. N ii-a. N; ii-b. N iii-a. N; iii-b. N iv-a. N; iv-b. N v-a. N; v-b. N vi-a. N; vi-b. N vii-a. N; vii-b. N viii-a. N; viii-b. N	NA

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

Table 1.2 Characteristics and findings of observational studies examining associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours (continued)

The lead author (Year)	Sample	Sample and Study design	Built environment attributes	PA and SB	Results of the most adjusted models	Covariates
Zhang (2019)[88]	157 employed Chinese adults, China	A convenience sample recruited from two-night schools offered by two universities in Beijing and Shanghai, China; Longitudinal (follow-up: 1 month)	i. Walkability (Composite index; P)	a. Transport-related walking at time 1 (Transport PA; R) Transport-related walking at time 2 (Transport PA; R)	i-a. N; i-b. N	Sex, age, marital status, education, number of children, BMI, income level, and general health

Note: PA, physical activity; SB, sedentary behaviour; O, objectively-measured; P, perceived; R, reported; +, positive association; N, non-significant association; −, negative association; NR, not reported; NA, not applicable; BMI, body mass index; MVPA, moderate-to-vigorous physical activity

1.3.8 Neighbourhood built-environment attributes of physically-active and sedentary behaviours

Detailed syntheses of the study findings with numbers were shown in Table 1.3. The findings were reported according to “instances” rather than “studies”, as most of the studies reported multiple associations of several built-environment attributes with different domains of physically-active and sedentary behaviours. Overall, there were 455 instances from 55 reviewed studies in the analysis, nearly half instances were relevant to destination-related attributes (193 out of 455), followed by safety (111 out of 455) and route-related attributes (105 out of 455). Furthermore, the majority of these identified instances examined physical activity (431 out of 455), particularly in transport settings, accounting for three-fourths of these instances for physical activity (325 out of 431). Only 24 out of 455 investigated sedentary behaviour with all of them focused on the transport domain.

Table 1.3 Workplace neighbourhood built-environment attributes and workers' physically-active and sedentary behaviours: summary of instances

Workplace neighbourhood built-environment attributes	Physical activity and sedentary behaviour	Quality assessment of the study											
		Good			Fair			Poor			Total		
		+	N	−	+	N	−	+	N	−	+	N	−	Sum
Composite environmental indices	Physical activity													
	Total	0	1	0	0	1	0	0	0	0	0	2	0	2
	Work	2	2	0	3	1	0	0	0	0	5	3	0	8
	Transport	0	4	2	2	0	0	0	0	0	2	4	2	8
	Leisure-time	5	1	0	1	4	0	0	0	0	6	5	0	11
	(sub-total)	7	8	2	6	6	0	0	0	0	13	14	2	29
	Sedentary behaviour													
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0
	Work	0	0	0	0	0	0	0	0	0	0	0	0	0
	Transport	0	0	0	0	0	0	0	0	0	0	0	0	0
	Leisure-time	0	0	0	0	0	0	0	0	0	0	0	0	0
	(sub-total)	0	0	0	0	0	0	0	0	0	0	0	0	0
Route-related attributes	Physical activity													
	Total	0	7	0	2	0	0	0	0	0	2	7	0	9
	Work	0	5	0	1	1	0	0	0	0	1	6	0	7
	Transport	10	51	2	2	17	1	0	0	0	12	68	3	83
	Leisure-time	0	1	0	1	1	0	0	0	0	1	2	0	3
	(sub-total)	10	64	2	6	19	1	0	0	0	16	83	3	102
	Sedentary behaviour													
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0
	Work	0	0	0	0	0	0	0	0	0	0	0	0	0
	Transport	0	2	0	0	1	0	0	0	0	0	3	0	3
	Leisure-time	0	0	0	0	0	0	0	0	0	0	0	0	0
	(sub-total)	0	2	0	0	1	0	0	0	0	0	3	0	3
Destination-related attributes	Physical activity													
	Total	2	9	0	1	3	0	0	2	0	3	14	0	17
	Work	2	1	0	0	4	0	0	0	0	2	5	0	7
	Transport	37	55	2	22	17	2	0	2	0	59	74	4	137
	Leisure-time	0	5	0	2	10	0	0	0	0	2	15	0	17
	(sub-total)	41	70	2	25	34	2	0	4	0	66	108	4	178
	Sedentary behaviour													
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0
	Work	0	0	0	0	0	0	0	0	0	0	0	0	0
	Transport	0	1	4	2	1	7	0	0	0	2	2	11	15
	Leisure-time	0	0	0	0	0	0	0	0	0	0	0	0	0
	(sub-total)	0	1	4	2	1	7	0	0	0	2	2	11	15

Table 1.3 Workplace neighbourhood built-environment attributes and workers' physically-active and sedentary behaviours: summary of instances (continued)

Workplace neighbourhood built-environment attributes	Physical activity and sedentary behaviour	Quality assessment of the study											
		Good			Fair			Poor			Total		
		+	N	−	+	N	−	+	N	−	+	N	−	Sum
Safety	Physical activity													
	Total	2	4	0	0	2	0	0	0	0	2	6	0	8
	Work	0	2	0	1	1	0	0	0	0	1	3	0	4
	Transport	7	70	4	0	8	0	0	0	0	7	78	4	89
	Leisure-time	0	2	0	0	2	0	0	0	0	0	4	0	4
	(sub-total)	9	78	4	1	13	0	0	0	0	10	91	4	105
	Sedentary behaviour													
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0
	Work	0	0	0	0	0	0	0	0	0	0	0	0	0
	Transport	0	2	2	0	2	0	0	0	0	0	4	2	6
	Leisure-time	0	0	0	0	0	0	0	0	0	0	0	0	0
	(sub-total)	0	2	2	0	2	0	0	0	0	0	4	2	6
Aesthetics	Physical activity													
	Total	0	3	0	0	0	0	0	0	0	0	3	0	3
	Work	0	3	2	0	1	0	0	0	0	0	4	2	6
	Transport	1	7	0	0	0	0	0	0	0	1	7	0	8
	Leisure-time	0	0	0	0	0	0	0	0	0	0	0	0	0
	(sub-total)	1	13	2	0	1	0	0	0	0	1	14	2	17
	Sedentary behaviour													
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0
	Work	0	0	0	0	0	0	0	0	0	0	0	0	0
	Transport	0	0	0	0	0	0	0	0	0	0	0	0	0
	Leisure-time	0	0	0	0	0	0	0	0	0	0	0	0	0
	(sub-total)	0	0	0	0	0	0	0	0	0	0	0	0	0

1.3.8.1 Composite environmental indices

There were 14 instances where an association was investigated between a composite index of the workplace neighbourhood and an outcome of physical activity. All measured neighbourhood walkability, an indicator combining density of population or residence, land use mix, and street connectivity, except one measuring the combination of the presence of facilities and routes for walking through an audit

tool.[57] Most of the instances relevant to neighbourhood walkability were objectively measured by geographic information systems based on established indices (n = 7) and Walk Score® (n = 3) whilst the remainder perceivably measured neighbourhood walkability (n = 3). Of 14 instances where composite indices were estimated, only four showed statistically significant positive associations with physical activity;[31, 83] all of which were relevant to the work domain. More than 70% of the instances reported were statistically non-significant.

There were 15 instances used composite indices comprising not only neighbourhood built-environment attributes but also other attributes e.g., organised sports teams and classes in the workplace neighbourhood. The majority of the instances (n = 9) found positive associations with physical activity, mostly relevant to the leisure domain. The remainder of instances found either statistically non-significant[48, 66, 81] or negative associations[66] relevant to physical activity.

No instances in the associations of composite indices with sedentary behaviour were estimated in the reviewed studies.

1.3.8.2 Route-related attributes

Most of the instances relevant to route-related attributes to investigate the

associations with physical activity estimated routes for pedestrians or cyclists and street connectivity, particularly in the transport domain, which accounted for 81% of the instances. Around 16% of the 102 instances reported statistically significant positive associations with physical activity.[38, 41, 46, 55, 64, 69, 82] By contrast, the majority of instances (n=83) were statistically non-significant. However, three instances were statistically negatively associated with physical activity; all of which were relative to the transport domain.[47, 79]

All three instances of estimating an association of route-related attributes with sedentary behaviour found that routes for pedestrians or cyclists were not statistically associated with transport-related sedentary behaviour.[49, 63]

1.3.8.3 Destination-related attributes

The majority of the instances relevant to destination-related attributes examined the presence, density, and diversity of destinations in the workplace neighbourhood to estimate their associations with physical activity, particularly during transport settings, accounting for 77% of the instances reviewed. Nearly 40% of the 178 instances which estimated destination-related attributes were found to be positively associated with physical activity with statistical evidence, mostly relevant to the transport domain. By

contrast, more than 60% of the instances were statistically non-significant. Furthermore, four instances were found to be negatively associated with transport-related physical activity;[42, 72, 77, 85] of which one negative association estimated car parking, the attribute for higher convenience to driving cars, with transport-related physical activity.[42] The features of these destination-related attributes identified in the positive and negative associations were different. The presence or density of shops, transport stops, and recreational facilities were more identified in the positive associations; by contrast, all of the negative associations identified that longer distance between workplace and home and car parking surrounding workplace were associated with lower levels of physical activity in the transport domain.

Most instances i.e., 11 out of 15 reported statistically negative associations of destinations-related attributes with sedentary behaviour; all of which were relevant to the transport domain.[44, 49, 70, 71, 76, 86] The majority of these destination-related attributes estimated in the reviewed studies were the distance between workplace and home. Furthermore, the only two instances examining car parking showed statistically positive associations with sedentary behaviour in the transport domain.[44, 76] The remaining instances showed statistically non-significant associations.[44, 63] Lower levels of diversity of destination-related attributes was estimated in sedentary behaviour than in physical activity; a higher proportion of instances estimated the

distance between workplace and home with sedentary behaviour than physical activity.

1.3.8.4 Safety

The instances relevant to neighbourhood safety around the workplace mostly measured the traffic safety (e.g., low volume of traffic for pedestrians and bicyclists) and crime safety (e.g., low crime rates). Lower than 10% of the 105 instances of examined associations of safety with physical activity were found to be statistically positive associations.[41, 64, 70, 79, 82] Over 85% of the instances were not statistically significant. Additionally, there were four instances where safety was statistically negatively associated with physical activity in the transport domain.[46, 63, 82]

The majority of the instances (4 out of 6) in relation to associations of traffic/crime safety with sedentary behaviour showed statistically non-significant associations. The remaining instances suggested that perceiving it to be safer to cross the road and cycle was associated with a lower likelihood of car-only trips.[63] All of the instances were examined in the transport context.

1.3.8.5 Aesthetics

All but 3 of the 17 instances examining associations of workplace neighbourhood aesthetics with physical activity were not statistically significant. One instance relevant to perceptions that streets were free from the litter was statistically-positive associated with transport-related physical activity;[41] two instances objectively measured greenness were found to be statistically-negative associated with work-related physical activity.[83]

None of the instances estimated indicators of workplace neighbourhood aesthetics with any domains of sedentary behaviour.

1.4 A requirement of exploring associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours by domain

Previous reviews have shown that the relevant environmental correlates may differ between different domains of physically-active[23] and sedentary behaviours.[22] Identifying correlates of physically-active and sedentary behaviours at work and for transport that add to the total volume of daily physically-active and sedentary time can assist in developing health promotion strategies relevant to desk-based workers. The leisure domain of behaviours is another major domain of behaviour that

contributes to daily time. By contrast, leisure-time physically-active and sedentary behaviours (e.g., watching TV) are unlikely to take place in workplace neighbourhoods but more likely to occur in locations beyond the immediate workplace setting. Therefore, leisure-time behaviours are assumed to be less likely associated with the built-environment attributes in the workplace neighbourhoods. However, the association of workplace neighbourhood built-environment attributes with leisure-time physical activity and sedentary behaviour may still exist due to other factors such as a non-leisure and leisure trade-off and thus need to be explored.

1.5 Japan: a brief introduction of the research setting

This section briefly introduces the geography of Japan by focusing on rapid changes in its population mobility, economic state, and urbanisation level (Section 1.5.1). Sections 1.5.2 and 1.5.3 presents a brief discussion of the epidemiology of physically-active and sedentary behaviours and work hours and culture in Japan. This background information is crucial for the later discussions on the case study in Japan.

Japan is an island country located in the North Pacific Ocean. This country comprises four main islands – Hokkaido, Honshu, Kyushu, and Shikoku – and forms an extended curve. There are eight regions of Japan: Hokkaidō, Tōhoku, Kantō,

Chūbu, Kansai, Chūgoku, Shikoku, and Kyūshū and Okinawa. These categories of region are not the administrative units officially but are usually used for Japan's official statistics since 1905.

1.5.1 Population mobility and rapid changes in urbanisation level

Japan is amongst the representative most densely populated countries. This country experienced a rapidly changing society and developed a unique geographic and urban context. Full-scale urbanisation in Japan started in the latter half of the 1950s and reached a peak around 1965, during the post-war period.[91] Compared with the US, where spends more than hundreds of years experiencing urbanisation, Japan became amongst the developed countries with 15 years only. A large and marked population mobility phenomenon occurred from rural to urban areas during the period of rapid urbanisation; the percentage of urban population increased 20% within two decades.[91] To date, more than 90% of the population lived in urban areas,[92] indicating a serious issue of extremely high population density in urban areas of Japan and the imbalance between areas of resource allocation.

The economic expansion during the rapid development of urbanisation greatly impacts the overall level of economic structure. Workers across areas with the country

in the secondary and tertiary industrial sectors increased by nearly 20 million, mainly attributable to the increases in the rates of Tokyo, Hanshin, and the Chukyo metropolitan areas.[91] The increase in the number of workers over the three metropolitan areas accounted for 58% of the national increase.[91] The gross national product showed an almost seven-fold increase during the post-war period. Based on the nominal gross domestic product (GDP), Japan is now the third-largest economy worldwide and still shows an annual 3.3% growth rate in GDP from 2020 to 2021.[93] However, economic inequalities are also observed in Japan. The ratio of the mid-60% household income (i.e., the values at 80% divided by the values at 20%) was around six, higher than the corresponding figure (5.4) in countries of the Organization for Economic Cooperation and Development (OECD) in 2018.[94]

1.5.2 The epidemiology of physical activity and sedentary behaviour amongst adults

Physical activity levels worldwide extracted data for adults from 122 countries reported the mean accumulated minutes of moderate-to vigorous-intensity physical activity is around 35.5 minutes per day in males and 32.0 minutes per day in females.[95] In Japan, an accelerometer-based study showed that adults on average spent 361.5 minutes (≈ 6 hours) per day in light-intensity physical activity and 47.1 minutes per day in moderate-to vigorous-intensity physical activity. Furthermore, most of the

moderate-to vigorous-intensity physical activity lasted shorter than 10 minutes, irrespective of males (85.1%) and females (87.3%).[96] The amount of high intensity of physical activity (i.e., moderate-to vigorous-intensity physical activity) in Japanese adults seemed to be slightly higher than the worldwide level.

It has been suggested that adults spent at least five hours per day being sedentary in Japan, in keeping with the findings from 20 countries studied.[97] The study using accelerometer-based sedentary data seemed to contribute to a higher time being sedentary (7.0-8.3 hours per day)[98, 99] than studies using self-reported data (5.3-6.0 hours per day).[97, 100] Furthermore, a certain number of the long sedentary time result from prolonged bouts of being sedentary. Around 30% of the Japanese adult population accumulated in prolonged bouts with 30 minutes or above, with a 9.2-break per sedentary hour.[98] The daily time spent on prolonged sedentary behaviours accounted for 34.4% of overall sedentary time, with 9.4 breaks per day.[99]

In terms of sedentary behaviour, domain-specific sedentary time is usually individually investigated in Japanese adults. For example, a study reported that Japan's adult population aged 40-69 years and who lived in cities engaged in screen-based sedentary behaviours for around 2 hours per day.[101] In the general population, screen-based sedentary behaviours such as television viewing and

computer or digital device use have been suggested to be the major contributor to daily sedentary activities.[102] Additionally, other domains of sedentary behaviour such as sitting at work, may be the dominant sedentary behaviour for certain subgroups such as workers, particularly those who have desk-based occupations.[103]

1.5.3 Workplace pattern amongst workers

As Japan experienced rapid industrialisation and urbanisation between the 1950s and 1970s,[91] with the rapid economic growth between the 1970s and 1990s.[104, 105] The occupation type has been altered to the secondary/tertiary industrial sectors. More and more workers involved in mainly desk-based occupations. The number of clerical employees in Japan increased nearly 10% from 2011 (12.3 millions) to 2020 (13.5 millions).[106] An "overtime culture" has emerged in Asian countries, particularly amongst full-time and permanent workers. In Japan, overtime work is regarded to be positively associated with occupational prestige.[107] Due to the overwork culture, it is common for Japanese workers to dedicate themselves to work and cultivate extreme work habits.

According to the Japanese legislative restriction, the maximum work hour rages 40-48 hours per week. However, the government loosens the restriction and allows a

maximum of 100 hours per month or 720 hours per year for the overtime hours; the employers can slack the limit of work hours under several special circumstances such as an exceptionally exhausting period due to unexpected volumes of complaints from customers or sudden changes in product requirements from clients. A government survey conducted in 2016 found that more than one-quarter of all Japanese companies demand 80 hours of overtime (i.e., access in required work hours) each month. According to the estimates from the OECD, on average, 22% of all Japanese workers spend 50-hour access for work during a week, which was far than that reported from the Japanese government's statistics (38 hours) in 2019.[108] The extreme overwork culture results in a specific work culture named "Karoshi" in Japan. The term "Karoshi" was first developed and used in the late 1970s in the country.[109] The "Karoshi" culture indicates mortality or permanent disability from cerebrovascular diseases and/or heart diseases resulted from overwork; however, this culture did not include detrimental health outcomes such as traffic accidents due to the fatigue caused by overwork. Given that occupational sitting tends to be accumulated in long bouts,[12, 13] strategies based on the workplace context with opportunities for being away from sitting in the office environment may be conducive to lower amounts of sitting at work.

1.6 Research gaps and aims / questions

There were 455 instances from 55 studies of estimated associations were included in this section. Most instances of potential relationships of workplace neighbourhood built-environment attribute with total or domain-specific (work-related, transport-related, and leisure-time) physical activity were statistically non-significant. However, destination-related attributes including longer distances from workplace to home and access to car parking were statistically positively associated with car driving, a transport domain of sedentary behaviour.

The findings reinforce the case for urban design and/or planning policies on designing and constructing mixed-use neighbourhoods in which opportunities are provided to live closer to workplaces with short commute distances as well as have access to a higher density of diverse services and facilities.

Based on the review findings, this body of previous relevant research is limited in several important ways. First, previous studies mostly focused on physically-active and sedentary behaviours in the transport domain with less attention to other domains such as work-related and leisure-time behaviours. However, previous reviews have shown that built-environment correlates of physical activity[23] and sedentary behaviour[22] may vary by domain. Identifying correlates of both physically-active and

sedentary behaviours in diverse domains can provide relevant information to develop more comprehensive behavioural change strategies in workers.

Second, there were only three studies out of 55 were conducted in Asian countries.[34] Evidence from Asian countries is needed, as workplace cultures and contexts are likely to differ between Asian and Western countries. One such difference is the hours spent at work. The average work hours per week in workers, both full-time and part-time employed, from Asian countries such as China (46.1 hours), South Korea (40.4 hours), and Japan (37.8 hours) are longer than the hours in Western countries such as the US (36.9 hours) and the UK (35.9 hours).[108] Another difference is the built environment where the workplace is situated. Compared with cities in Western countries, built environment patterns (e.g., street network, land use, and access to public transport) are likely to be different, primarily due to the higher population densities in Asian countries.[110]

The overall aim of this thesis is to investigate the associations of environmental perceptions and objective measures of the workplace neighbourhood with physically-active and sedentary behaviours at work, for transport, and during leisure amongst desk-based workers in Japan. Specifically, it will address the following research questions:

i) Are people working in perceived walking-supportive neighbourhood built-environment attributes associated with more work-related physical activity and less sitting at work and to what extent can such variation be explained?

ii) Are people working in perceived walking-supportive neighbourhood built-environment attributes associated with more transport-related physical activity and less sitting time in transport modes such as cars and public transports, and to what extent can such variation be explained?

iii) Are there any potential associations of the perceived walking-supportive built-environment attributes surrounding the workplaces with leisure-time physical activity and sedentary behaviour?

iv) Are the observed associations with three domains of physically-active and sedentary behaviours for workers' perceptions similar to that of objectively-measured neighbourhood walkability?

Chapter 2. Methods

2.1 Introduction

This chapter describes the recruitment of participants (Section 2.2), data used in this thesis (Section 2.3 to 2.5), and statistical methods used for the analyses (Section 2.6). The methods used in this thesis are mostly standard statistical approaches adopted by many previous studies of physically-active or sedentary behaviours, e.g., hurdle models, multivariate linear regression models. We also conducted sensitivity analyses to examine the robustness of the research findings.

2.2 Participants

Data from an online survey conducted through a Japanese internet research service company (MyVoice Communication, Inc. Tokyo, Japan) in February 2019 was used for the study. This company retains around a million individuals across Japan voluntarily registered as panel members with detailed socio-demographic data. Potential participants aged 20-59 years with full-time jobs (n = 45,659) were randomly selected based on the database and received an invitation email about this study via their company's system. These potential participants were equally stratified by gender and age groups (20-29, 30-39, 40-49, and 50-59 years) to minimise the

possibility of selection bias due to being overrepresented in specific demographic subgroups. The potential participants received an email invitation with a specific link to access an online questionnaire. A total number of 3,200 workers signed an online informed consent form and completed the questionnaire (response rate = 7.0%). Each participant received reward points valued at 1.5 USD as an incentive after they completed the survey. The analysis was limited to the participants who reported desk-based employment (n=2,265). The Institutional Ethics Committee of Waseda University (2020-135) approved this study.

2.3 Data for physical activity and sedentary behaviour

Both measures of physical activity and sedentary behaviour were assessed using different questionnaires. We did not use the same questionnaire to measure both physical activity and sedentary behaviour because the globally validated questionnaire – the Global Physical Activity Questionnaire (GPAQ) – measured sedentary behaviour with one question "The following question is about sitting or reclining at work, at home, getting to and from places, or with friends including time spent sitting at a desk, sitting with friends, travelling in car, bus, train, reading, playing cards or watching television, but do not include time spent sleeping." The question for sedentary behaviour summed all domains including at work, for transport, and leisure.

Therefore, we used another validated questionnaire specifically for sedentary behaviour to assess the time spent on domain-specific sedentary behaviours. However, due to the design of two different questionnaires, we could not identify the time spent on physical activity on workdays and non-workdays separately as such information was unavailable. By contrast, we could distinguish the time spent on sedentary behaviours on workdays and non-workdays.

2.3.1 Physical activity

The daily average time spent on physical activity was assessed using the GPAQ,[111] which has been validated in adults in several countries.[112] The questionnaire was used to assess the estimated physical activity in a typical week for three different domains i.e., at work, transport-related, and leisure-time, respectively.[113] Information on the frequency (i.e., "In a typical week, on how many days do you do moderate- or vigorous-intensity activities as part of your work?") and duration (e.g., "How much time do you spend doing moderate- or vigorous-intensity activities at work on a typical day?") were multiplied and divided by seven days to estimate daily minutes of moderate-vigorous physical activity (MVPA) for both the work and leisure domains. Attached are examples for vigorous-intensity physical activity e.g., carrying or lifting heavy loads and for moderate-intensity physical activity such as brisk walking or

carrying light loads were provided with the questionnaire. In terms of the transport domain, the frequency and duration of any walking and cycling activities were summed without separating the intensity. All GPAQ data were checked for valid responses following the standardised procedures provided by the World Health Organization.[113]

2.3.2 Sedentary behaviour

A validated Japanese questionnaire,[114] which seeks to assess sedentary time in six specific behaviours across three domains (related to work, transport, and leisure) separately for workdays and non-workdays, was used (Appendix Table 2). Participants were asked to report their daily average sedentary time for each behaviour over the previous week. We used three specific sedentary behaviours on workdays: sitting time at work; sitting time in cars; and sitting time in public transport. The other three leisure sedentary behaviours on the whole week: television viewing (i.e., watching television, videos, and DVDs), internet use through a computer, mobile phone, or tablet for non-work purposes, and other leisure time not including watching television, videos, and DVDs. This questionnaire has shown moderate to high test-retest reliability (intraclass correlation coefficient [ICC] = 0.83) for the work domain with a 1-week recall period.[114] The criterion validity of all-domain sedentary

time for workdays (rho = 0.57, $p < 0.001$) and the whole week (rho = 0.49, $p < 0.001$), comparing the questionnaire with accelerometer, is moderate.[114]

Based on the rationales and assumptions (see Section 1.3), workplace neighbourhoods may increase the time spent being physically-active at work (e.g., walking meetings around the workplace) and during transport (e.g., active commuting to and from the workplace), as well as decrease the sitting behaviours at work and sedentary transport modes. Therefore, we used their daily average sedentary time at work and for transport on workdays in the analysis. By contrast, a compensation effect would be examined in physically-active and sedentary behaviours during leisure, which would likely occur elsewhere, due to the changes occurring in the workplace contexts. We used the daily average leisure-time sedentary minutes across subdomains over the previous seven days, both workdays and non-workdays, in the analysis.

2.4 Data for workplace neighbourhood built-environment attributes

2.4.1 Perceived workplace neighbourhood built environment

The Abbreviated Neighborhood Environment Walkability Scale Japanese version (ANEWS-J) was used to measure environmental perceptions in the workplace

neighbourhood. Workplace neighbourhood was defined as within a 10- to 15-minute walk from the workplace. A total of six subscales were assessed: land use mix diversity (16 items), land use mix access (6 items), street connectivity (3 items), availability and quality of walking/cycling infrastructures (4 items), aesthetics (4 items), and crime safety (5 items). The Cronbach's α, an indicator of internal consistency, for land use mix diversity, land use mix access, street connectivity, availability and quality of walking/cycling infrastructures, aesthetics, and crime safety were 0.91, 0.65, 0.64, 0.72, 0.73, and 0.56, respectively. We did not include the subscales of residential density, which was not applicable to the study, and traffic safety due to low internal consistency (α = 0.26).[115] The details of the modified ANEWS-J used in this study were provided in Appendix Table 3. All subscale items were rated on a four-point scale, except for those to assess land use mix diversity (six-point scale). Scoring the subscales followed the procedures of ANEWS-J published online (http://www.tmu-ph.ac/pdf/ANEWS_Jpn_ver3.pdf). Higher scores indicate greater walkability. ANEWS-J has been found to have acceptable test-retest reliability (ICCs = 0.76-0.96) for residential neighbourhoods.[116] We examined the test-retest reliability of ANEWS-J for workplace neighbourhood in a subsample of participants (n = 200). Participants reported their perceptions of their workplace

neighbourhood environment twice within two weeks. The test-retest reliability of ANEWS-J was moderate to high for all subscales (ICC = 0.57-0.87) (Table 2.1).

Table 2.1. Intraclass correlation coefficients (ICCs)[a] and 95% confidence intervals (CIs) of the six subscales of the modified Abbreviated Neighborhood Environment Walkability Scale Japanese version.

Subscales	ICC	(95% CI)	p value
Land use mix diversity	0.87	(0.82 , 0.90)	<0.001
Land use mix access	0.82	(0.77 , 0.87)	<0.001
Street connectivity	0.57	(0.43 , 0.67)	<0.001
Walking and cycling facilities	0.77	(0.70 , 0.83)	<0.001
Aesthetics	0.73	(0.65 , 0.80)	<0.001
Crime safety	0.78	(0.71 , 0.83)	<0.001

[a] The evaluation of level of consistency using ICCs can refer to the Section 3.6.3.

2.4.2 Objectively measured workplace neighbourhood walkability

The level of walkability in workplace neighbourhoods was estimated using Walk Score®. Walk Score® is a freely available composite measure to identify the walkable level of neighbourhoods. This measure would not be constrained by data which released by the government. It is a measure of access to local destinations, using a distance-decay function to multiple destinations such as stores, restaurants, banks, parks, and schools, with adjustment by two street connectivity metrics: intersection density and block length.[117] Walk Score® can be assigned to locations (e.g., postcodes or addresses) and is normalised between 0 and 100. A higher Walk Score® indicates that there are more destinations within walking distance. Walk Score® uses

open-source data such as Google, Education.com, and Open Street Map as the source data to identify relevant destinations.[117] Walk Score® has been confirmed as a valid measure to assess neighbourhood walkability in Japan.[118] Around 60% of the participants provided their seven-digit workplace postcodes. Of these, Walk Score® was available for nearly 90% of them. Each workplace postcode was manually entered into the Walk Score® website (www.walkscore.com) to obtain the score in July-August 2020. Since Walk Score® was negatively skewed (median score = 82, 25th percentile = 63, 75th percentile = 94), we used Walk Score® as a categorical measure. We classified participants into three groups according to Walk Score®: car-dependent (0-69); somewhat walkable (70-89); and very walkable (90–100). The three groups were categorised based on the official guideline with taking into account the raw distribution of the Walk Score®.

2.5 Covariates

Individual-level covariates included gender, age group (20-29, 30-39, 40-49, or 50-59 years), marital status (not married or married), educational level (tertiary education or below tertiary education), individual annual income (< 4,000,000 or ≥ 4,000,000 yen), and work hours per week. The work hours were assessed using the question "How many hours have you worked in the last 7 days?" The workplace-level

covariate was organisation size, which was measured by the self-reported number of workers in the participant's workplace (< 29, 30-99, ≥ 100 employees, or missing). Considering the transport modes and leisure-time behaviours substantially depends on whether or not keeping the possession of driver licence, the possession of driver licence was explicitly adjusted for when examining the behaviours in two domains.

2.6 Statistical analysis

2.6.1 Spearman's rank-order correlation for examining the correlations between perceived workplace neighbourhood built-environment attributes and objectively measured neighbourhood walkability

Spearman's rank-order correlation was used to examine the correlations between perceived workplace neighbourhood built-environment attributes and objectively measured neighbourhood walkability. The correlation coefficient (ρ or rho) is calculated with a nonparametric measure on an ordinal scale, providing both the strength (i.e., the value of the number, ranging from 0 to 1) and direction (i.e., plus or minus) of the associations observed. The p value estimated could provide statistical evidence for the confidence in the strength of correlation.

2.6.2 Pearson's Chi-square tests and one-way analysis of variance or independent t-tests for identifying the characteristics by subsample category

Differences in characteristics across four subsample categories, according to the valid responses for the perceptions and objectively-measured built-environment attributes or walkability attributes and physically-active and sedentary behaviours, were examined using Pearson's Chi-square (x^2) tests for categorical variables and one-way analysis of variance (ANOVA) or independent t-tests for continuous variables. The null hypothesis for these tests assumes the distributions (i.e., proportions) for categorical variables or mean values for continuous variables are equal over the subgroups. The three tests are all applied to evaluate the possibility of the observed differences between the studied variables that are not arising by chance.

To identify if a marked attrition bias for the sample recruitment, we used x^2 tests to examine differences in the demographic characteristics, including gender, age group, marital status, educational level, individual income, driving licence, and size of the workplace between the included and the excluded participants.

2.6.3 Cronbach's α and intraclass correlation coefficient (ICC) for estimating the reliability of built environment attributes

The Cronbach's α was used to estimate the level of internal consistency between several items within the same built-environment subscale and ICCs were used to examine the level of test-retest reliability for environmental perceptions. Both the α and ICCs range from 0 to 1. It has been suggested that α values were divided into low (< 0.30), moderate (0.30-0.70), and high (> 0.70) levels of internal consistency.[119] According to a previous suggestion of reporting ICCs, values were categorised into low (< 0.50), moderate (0.50-0.75), high (0.75-0.90), and excellent reliability (> 0.90).[120] Low level of internal consistency indicated by α across the items assessing each of the built-environment attributes indicates the concept behind each of the items may be different and could not represent the same targeted built-environment attribute well. A low level of test-retest reliability presented less confidence in the use of this measurement over different timing and the responses from the questionnaire were not highly reliable.

All the above-mentioned statistics, including Spearman's rank-order correlation, Pearson's Chi-square tests, one-way ANOVA or independent t-tests, Cronbach's α,

and ICCs, were conducted using SPSS 23 (IBM Corp, Armonk, NY), and the level of significance was set at $p < 0.05$.

2.6.4 Hurdle models for investigating associations of built environment with domain-specific physical activity

For domain-specific physical activity, in which there were excessive zero counts, we used hurdle models to investigate the associations. This approach has been used in previous studies whilst investigating into the amount of physical activity;[121, 122] it can deal with continuous physical activity data with excess zeros and positive skewness due to the model treats participation and the time spent physically-active (conditional on participation) separately.[123] A hurdle model consists of two stages. The first stage estimates the odds ratios (ORs) and 95% confidence intervals (CIs) of participation in physical activity (none versus any) for each workplace neighbourhood attribute and Walk Score® category. The second stage estimates the unstandardised regression coefficients (β) and 95% CIs for non-zero minutes of physical activity (i.e., excluding those without any domain-specific physical activity). Each workplace neighbourhood perception was standardised (i.e., z score) and examined individually in the models. The mid-category of Walk Score® was used as the reference group.

2.6.5 Multivariate linear regression models for investigating associations of built environment with domain-specific sedentary behaviour

We used multivariate linear regression models to investigate the associations of workplace neighbourhood built-environment attributes with several sedentary behaviours over domains. The unstandardised regression coefficients (β) and 95% CIs, corresponding to one standard deviation (SD) increment of perceived built-environment attributes were estimated for the associations. We also calculated β and 95%CI for the Walk Score® category, using the mid category (somewhat walkable) as the reference.

2.6.6 Sensitivity analysis for the associations of Walk Score® with physical activity and sedentary behaviour by including missing values of Walk Score®

We have conducted sensitivity analyses by including participants with missing or invalid Walk Score® as the additional category to examine the robustness of the results. The missing/invalid Walk Score® category was not significantly associated with the sitting time, but this category appears to be significantly different from the categories of car-dependent and very walkable for sitting in cars and from the category of car-dependent for sitting in public transport (the regression coefficient for

the missing/invalid being outside of the 95% CI). This suggests that participants without Walk Score® may be different from some other Walk Score® categories (refer to Section 5.5.1.

Unadjusted and adjusted models were both performed to examine no over-adjustment issues in the hurdle and linear regression models. All regression analyses, both hurdle models and multivariate linear regression models, were conducted using Stata 15 (Stata Corp, College Station, Texas, USA), and the statistically significant level was set at $p < 0.05$.

Chapter 3. Workplace Neighbourhood Built-Environment Attributes and Physically-Active and Sedentary Behaviours across Domains amongst Desk-Based Workers in Japan

3.1 Introduction

This chapter describes the characteristics of participants and presents findings from the investigation into correlations between perceived activity-supportive workplace neighbourhood built-environment attributes and objectively-measured neighbourhood walkability, and their associations with domain-specific physically-active and sedentary behaviours in Japanese desk-based workers. In particular, it provides an insight into the potential environmental strategies and approaches in the Asian workplace context indicated by long work hours. Section 3.2 first presents the participants' sociodemographic, workplace-related, and behavioural characteristics across four subsamples and tests the possible attrition bias. Section 3.3 identifies the correlations between perceived workplace neighbourhood built-environment attributes and Walk Score®. Results of the correlations observed are helpful to further examination of their associations with behaviours. Sections 3.4 to 3.9 present a series of associations between environments and behaviours varied by domain.

3.2 Characteristics of participants

Valid responses on the workplace neighbourhood built-environment attributes and physically-active and sedentary time were categorised into i) the overall samples for physical activity (2,261 desk-based workers reporting environmental perceptions and physical activities); ii) Walk Score® subsample for physical activity (1,224 providing workplace postcodes that generated valid Walk Score® from the first category); iii) the overall sample for sedentary behaviour (2,141 desk-based workers reporting environmental perceptions and sedentary behaviours); and iv) Walk Score® subsample for sedentary behaviour (1,164 providing workplace postcodes that generated valid Walk Score® from the third category) (Figure 3.1).

The majority of the participants (80%) were company employees. We examined the differential sociodemographic characteristics amongst the participants included (2,141 overall sample for sedentary behaviour which showed a larger loss of participants) and the excluded to examine the attrition bias. There were no differences in gender ($p = 0.19$), marital status ($p = 0.70$), educational level ($p = 0.67$), individual income ($p = 0.98$), and size of organisation ($p = 0.64$) were found between the participants who were included and excluded (Table 3.1), indicating no marked attrition bias, although a marginal difference in age group ($p = 0.046$) was found.

Figure 3.1 Flow chart of the analysed participants

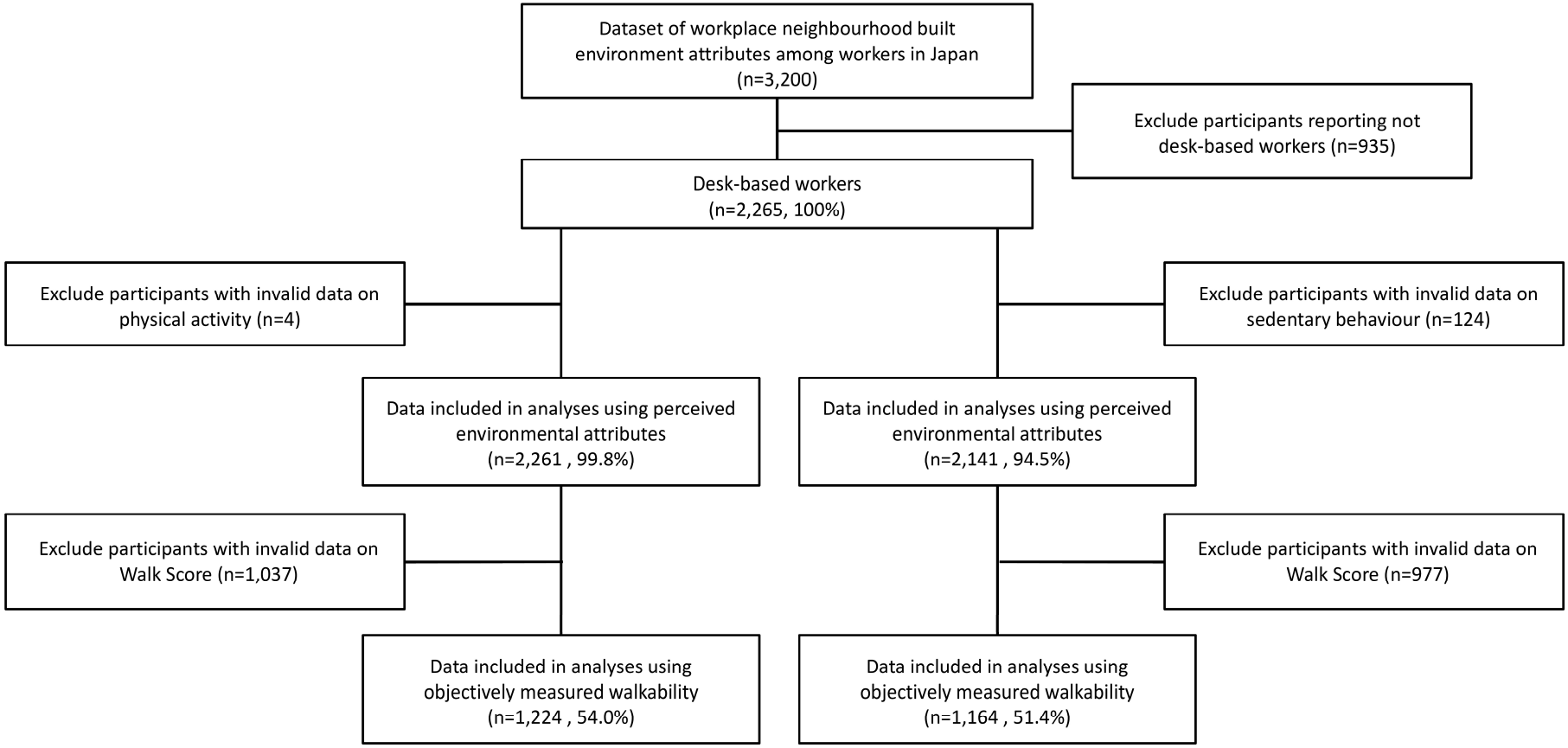


Table 3.1 Sociodemographic characteristics between the participants included (n = 2,141) and excluded (n = 124)

Characteristics	Included (n = 2,141)		Excluded (n = 124)		p
	N	%	N	%	
Gender					ns
Men	1027	48.0%	67	54.0%	
Women	1114	52.0%	57	46.0%	
Age group (year)					0.046
20-29	504	23.5%	25	20.2%	
30-39	534	24.9%	45	36.3%	
40-49	551	25.7%	28	22.6%	
50-59	552	25.8%	26	21.0%	
Marital status					ns
Married	953	44.5%	53	42.7%	
Not married	1188	55.5%	71	57.3%	
Educational level					ns
Have tertiary education	1842	86.0%	105	84.7%	
Below tertiary education	299	14.0%	19	15.3%	
Annual income (yen)					ns
≥ 4,000,000 yen	1038	48.5%	60	48.4%	
< 4,000,000 yen	1103	51.5%	64	51.6%	
Organisation size					ns
Small (≤ 29 workers)	511	23.9%	33	26.6%	
Medium (30-99 workers)	310	14.5%	13	10.5%	
Large (≥ 100 workers)	1252	58.5%	74	59.7%	
Missing	68	3.2%	4	3.2%	

Note: ns, non-significant

The Walk Score® website did not generate available Walk Score® for all the participants who provided a workplace postcode due to the limited data for spatial details from Japan. The comparison in characteristics between those who reported valid Walk Score® (n = 1,164) and those who reported missing/invalid Walk Score® (n = 977) was also shown in Table 3.2. There were some differences in the demographic characteristics between these groups. However, they did not differ in the sitting time and environmental perceptions, suggesting that those without Walk Score may not be systematically different from the sample with Walk Score® in terms of the key measures.

Table 3.2 Comparison of the characteristics of participants who reported valid Walk Score® (n = 1,164) and those who did not report valid Walk Score® (n = 977)

Characteristics	Those who reported valid Walk Score® (n=1,164)		Those who did not report valid Walk Score® (n=977)		p
	N or mean	% or SD	N or mean	% or SD	
Gender					0.026
Men	584	50.2%	443	45.3%	
Women	580	49.8%	534	54.7%	
Age group (year)					0.001
20-29	243	20.9%	261	26.7%	
30-39	278	23.9%	256	26.2%	
40-49	320	27.5%	231	23.6%	
50-59	323	27.7%	229	23.4%	
Marital status					0.002
Married	554	47.6%	399	40.8%	
Not married	610	52.4%	578	59.2%	
Educational level					ns
Have tertiary education	1006	86.4%	836	85.6%	
Below tertiary education	158	13.6%	141	14.4%	
Annual income (yen)					0.010
≥ 4,000,000 yen	594	51.0%	444	45.4%	
< 4,000,000 yen	570	49.0%	533	54.6%	
Driving licence					ns
Yes	1050	90.2%	870	89.0%	
No	114	9.8%	107	11.0%	
Work hours per week, mean (SD)	45.0	13.8	44.4	12.8	ns
Organisation size					<0.001
Small (≤ 29 employees)	345	29.6%	166	17.0%	
Medium (30-99 employees)	160	13.7%	150	15.4%	
Large (≥ 100 employees)	627	53.9%	625	64.0%	
Missing	32	2.8%	36	3.7%	
Sitting time at work (hour/day), mean (SD)	6.4	2.6	6.4	2.6	ns
Sitting time in car (hour/day), mean (SD)	0.4	0.7	0.4	0.8	ns
Sitting time in public transport (hour/day), mean (SD)	0.4	0.7	0.5	0.8	ns
Perceived environment attributes, mean (SD)					
Land use mix diversity	3.0	0.9	2.9	0.9	ns
Land use mix access	2.9	0.6	2.9	0.6	ns
Street connectivity	2.8	0.7	2.8	0.7	ns
Walking and cycling facilities	2.5	0.7	2.6	0.7	ns
Aesthetics	2.3	0.7	2.3	0.7	ns
Crime safety	3.0	0.5	3.0	0.5	ns

Note: SD, standard deviation; ns, non-significant

[a] Difference across subsample categories was tested using x^2 for categorical variables and t-tests for continuous variables.

Participants' characteristics, neighbourhood built-environment attributes, and physically-active and sedentary behaviours were shown in Table 3.3. Participants

spent on average about 6 hours and 20 minutes per workday sitting at work, with less than one-fourth of them engaged in any work-related physical activity. By contrast, more than half of them were involved in physical activity for the transport domain and spent less than half an hour using cars or public transport on workdays. Around one-third of participants spent on leisure-time physical activity and amongst those who did the leisure-time physical activity, they spent around a half-hour per day on average. Participants spent nearly two hours per day in a regular week watching television for leisure outside of work.

Nearly 70% of the workplaces, reported by those providing valid workplace postcodes, were located in walkable neighbourhoods (i.e., somewhat walkable and very walkable neighbourhoods). Consistently, the mean score of all the perceived workplace neighbourhood built-environment attributes tended to be activity-supportive (e.g., 3 out of 4 for crime safety and 2.9 out of 4 for land use mix access).

There were no differences in the characteristics with the only exception of organisation size between the overall sample and the Walk Score® subsample, irrespective of samples for physically-active and sedentary behaviours. The subsample for which Walk Score® was available had a higher proportion of

participants working in smaller workplaces, compared with the overall sample.

Table 3.3 Characteristics of participants and workplace neighbourhood built-environment attributes

Characteristics	Overall sample for physical activity (n = 2,261)		Walk Score® subsample for physical activity (n = 1,224)		Overall sample for sedentary behaviour (n = 2,141)		Walk Score® subsample for sedentary behaviour (n = 1,164)		p[a]
Gender, % men	48.3%		49.9%		48.0%		50.2%		ns
Age group, %									ns
20-29 years	23.4%		20.8%		23.5%		20.9%		
30-39 years	25.6%		24.1%		24.9%		23.9%		
40-49 years	25.6%		27.5%		25.7%		27.5%		
50-59 years	25.5%		27.7%		25.8%		27.7%		
Married, %	44.4%		47.3%		44.5%		47.6%		ns
Have tertiary education, %	85.9%		86.2%		86.0%		86.4%		ns
Annual income ≥ 4,000,000 yen, %	48.5%		50.9%		48.5%		51.0%		ns
Have a driving licence, %	89.2%		89.8%		89.7%		90.2%		ns
Organisation size, %									0.001
Small (≤ 29 workers)	24.0%		29.9%		23.9%		29.6%		
Medium (30-99 workers)	14.3%		13.6%		14.5%		13.7%		
Large (≥ 100 workers)	58.5%		53.8%		58.5%		53.9%		
Missing	3.2%		2.7%		3.2%		2.7%		
Working hours per week, mean (SD)	8.9	(2.1)	9.0	(2.2)	8.9	(2.0)	9.0	(2.0)	ns
Perceived environment attributes, mean (SD)									
Land use mix diversity	3.0	(0.9)	3.1	(0.9)	3.0	(0.9)	3.0	(0.9)	ns
Land use mix access	2.9	(0.6)	2.9	(0.6)	2.9	(0.6)	2.9	(0.6)	ns
Street connectivity	2.8	(0.7)	2.8	(0.7)	2.8	(0.7)	2.8	(0.7)	ns
Walking and cycling facilities	2.5	(0.7)	2.5	(0.7)	2.5	(0.7)	2.5	(0.7)	ns

Note: SD, standard deviation; ns, non-significant

[a] Difference across subsample categories was tested using x^2 for categorical variables and t-tests for continuous variables.

[b] Measures of domain-specific behaviours were for workdays. [c] Measures of domain-specific behaviours were for workdays and non-workdays.

Table 3.3 Characteristics of participants and workplace neighbourhood built-environment attributes (continued)

Characteristics	Overall sample for physical activity (n = 2,261)		Walk Score® subsample for physical activity (n = 1,224)		Overall sample for sedentary behaviour (n = 2,141)		Walk Score® subsample for sedentary behaviour (n = 1,164)		p[a]
Perceived environment attributes, mean (SD)									
Aesthetics	2.3	(0.7)	2.3	(0.7)	2.3	(0.7)	2.3	(0.7)	ns
Crime safety	3.0	(0.5)	3.0	(0.5)	3.0	(0.5)	3.0	(0.5)	ns
Walk Score®, mean (SD)									ns
Car-dependent (0-69)		-	32.2%		-		32.4%		
Somewhat walkable (70-89)		-	33.5%		-		33.3%		
Very walkable (90-100)		-	34.3%		-		34.3%		
Physical activity (minutes/day), mean (SD)[b]									
Any work-related	16.4%		18.1%		-		-		ns
Work-related	42.3	(70.7)	37.5	(54.9)	-			-	ns
Any transport	59.6%		60.9%		-		-		ns
Transport	34.4	(32.9)	33.7	(26.4)	-			-	ns
Any leisure-time	35.3%		37.3%		-		-		ns
Leisure-time	31.8	(39.1)	31.2	(33.6)	-			-	ns
Sedentary behaviour (minutes/day), mean (SD)									
At work[c]		-		-	382.6	(153.1)	382.2	(153.2)	ns
Car use[c]		-		-	23.7	(45.5)	23.1	(40.9)	ns
Public transport use[c]		-		-	28.0	(44.5)	26.5	(43.8)	ns
Television viewing[b]		-		-	111.3	(95.9)	114.3	(98.7)	ns
Internet use[b]		-		-	94.8	(90.9)	93.8	(90.1)	ns
Other leisure[b]		-		-	40.7	(52.1)	40.8	(50.2)	ns

Note: SD, standard deviation; ns, non-significant

[a] Difference across subsample categories was tested using x^2 for categorical variables and t-tests for continuous variables.

[b] Measures of domain-specific behaviours were for workdays. [c] Measures of domain-specific behaviours were for workdays and non-workdays.

3.3 Correlations between perceived workplace neighbourhood built-environment attributes and Walk Score®

As shown in Table 3.4, all perceived workplace neighbourhood built-environment attributes were positively correlated with Walk Score® - the strongest correlation was found for land use mix access (rho = 0.48), and the weakest correlation was found for aesthetics (rho = 0.10). The strongest (rho = 0.50 for land use mix access) and the weakest (rho = 0.12 for aesthetics) correlations were consistently observed whilst using the sample size for overall sample (n = 2,141) and Walk Score® subsample (n = 1,164) for sedentary behaviour.

All the perceived workplace neighbourhood built-environment attributes were positively correlated with each other, suggesting all of them were indeed proxy indicators of being activity-supportive or walkable. Amongst the environmental perceptions, the strongest correlation was found in land use mix diversity and access whilst the weakest correlation was found in aesthetics and crime safety.

Table 3.4 Spearman's correlations of workplace neighbourhood built-environment attribute

	a	b	c	d	e	f	g
a. Land use mix diversity	1.00						
b. Land use mix access	0.52	1.00					
c. Street connectivity	0.30	0.48	1.00				
d. Walking and cycling facilities	0.24	0.31	0.32	1.00			
e. Aesthetics	0.20	0.17	0.17	0.47	1.00		
f. Crime safety	0.25	0.45	0.29	0.24	0.09	1.00	
g. Walk Score®	0.36	0.48	0.30	0.22	0.10	0.26	1.00

Note: All the correlations were significant ($p < 0.001$)
The sample size for the correlations between perceived workplace neighbourhood built-environment attributes was 2,261 and that for the correlations between Walk Score® and perceived attributes was 1,224.

3.4 Workplace neighbourhood built-environment attributes and work-related physical activity and sedentary behaviour at work

The associations of workplace neighbourhood built-environment attribute with time spent on work-related physically-active behaviours were shown in Table 3.5. In unadjusted models, better-perceived workplace neighbourhood built-environment attributes, indicated by land use mix access and crime safety, were less likely to engage in any work-related physical activity. After adjusting for all potential covariates, the results showed only those working in neighbourhoods with high crime safety were less likely to participate in any work-related physical activity (OR = 0.83; 95% CI 0.74, 0.93) (part A). However, whilst investigating those reported physically-active minutes, no evidence was found in the associations of all perceived workplace neighbourhood built-environment attributes, including crime safety, with

work-related physical activity minutes (part B). The coefficients ranged from -7.16 (for land use mix access) to 5.75 (for land use mix diversity) without an observed tendency of potential associations between these variables investigated.

In terms of Walk Score®, unadjusted models showed that people working in car-dependent neighbourhoods were more likely to participate in any work-related physical activity, compared with those who work in somewhat walkable neighbourhoods. By contrast, there was no evidence in such association for the participation of physical activity after adjusting for all covariates (part A). Amongst people engaging in any physical activity, those who worked in car-dependent (β = -21.73, 95% CI -39.71, -3.74) and very walkable (β = -20.12, 95% CI -39.20, -1.03) neighbourhoods were both found to spend shorter minutes being physically-active in their workplace than those who working in somewhat walkable neighbourhoods (part B). Although the significant association between neighbourhoods being very walkable and physically-active minutes was not observed in the unadjusted model (marginally; β = -17.76, 95% CI -36.23, 0.70), the direction observed was consistently between the unadjusted and adjusted models. The marginal and relatively changeable associations observed may be attributable to a small number of the sample in the subgroup (n = 70).

Table 3.5 Associations of workplace neighbourhood built-environment attributes with (A) daily participation (none vs any) and (B) engagement in minutes of work-related physical activity

Workplace neighbourhood environment	Unadjusted			Adjusted [a]		
	OR	(95% CI)	p	OR	(95% CI)	p
(A) Daily participation of work-related physical activity (none vs any)						
Perceived measures (n = 2,261)						
Land use mix diversity	0.99	(0.89 , 1.11)	0.90	1.02	(0.90 , 1.14)	0.78
Land use mix access	**0.89**	**(0.80 , 1.00)**	**0.049**	0.93	(0.83 , 1.05)	0.24
Street connectivity	1.05	(0.94 , 1.18)	0.38	1.09	(0.97 , 1.22)	0.15
Walking and cycling facilities	0.97	(0.87 , 1.09)	0.66	1.01	(0.90 , 1.13)	0.93
Aesthetics	1.06	(0.95 , 1.19)	0.27	1.11	(0.99 , 1.24)	0.081
Crime safety	**0.82**	**(0.73 , 0.92)**	**<0.001**	**0.83**	**(0.74 , 0.93)**	**0.001**
Walk Score® (n = 1,224)						
Car-dependent (0-69, n=394)	**1.48**	**(1.04 , 2.12)**	**0.031**	1.42	(0.99 , 2.04)	0.058
Somewhat walkable (70-89, n=410)	Ref			Ref		
Very walkable (90-100, n=420)	1.06	(0.73 , 1.54)	0.75	1.09	(0.75 , 1.59)	0.65
	β	(95% CI)	p	β	(95% CI)	p
(B) Engagement in minutes of work-related physical activity						
Perceived measures (n = 371)						
Land use mix diversity	6.16	(-1.58 , 13.91)	0.12	5.75	(-2.27 , 13.77)	0.16
Land use mix access	-7.11	(-14.46 , 0.23)	0.058	-7.16	(-14.66 , 0.33)	0.061
Street connectivity	-7.07	(-15.04 , 0.90)	0.082	-6.52	(-14.62 , 1.58)	0.11
Walking and cycling facilities	-3.41	(-10.61 , 3.79)	0.35	-4.05	(-11.48 , 3.37)	0.28
Aesthetics	2.04	(-5.55 , 9.62)	0.60	2.01	(-5.92 , 9.95)	0.62
Crime safety	-2.79	(-9.87 , 4.29)	0.44	-2.91	(-10.11 , 4.28)	0.43
Walk Score® (n = 221)						
Car-dependent (0-69, n=86)	**-20.44**	**(-38.05 , -2.82)**	**0.023**	**-21.73**	**(-39.71 , -3.74)**	**0.018**
Somewhat walkable (70-89, n=65)	Ref			Ref		
Very walkable (90-100, n=70)	-17.76	(-36.23 , 0.70)	0.059	**-20.12**	**(-39.20 , -1.03)**	**0.039**

OR: odds ratio relative to participants with none work-related physical activity and the workplaces located in somewhat walkable neighbourhoods; β: unstandardised regression coefficient (minutes/day) corresponding to 1 standard deviation increment in perceived attributes and relative to the workplaces located in somewhat walkable neighbourhoods; CI: confidence interval; Ref: reference group

[a] Models were adjusted for gender, age group, marital status, educational level, individual annual income, work hours per week, and organisation size.

Note: Figures highlighted in bold indicate statistically significant findings ($p < 0.05$).

Table 3.6 presents the associations of workplace neighbourhood built-environment attributes with workplace sitting time. In the unadjusted models, five out of the six perceived workplace neighbourhood built-environment attributes (land use mix diversity and access, street connectivity, walking and cycling facilities, and crime safety) investigated were significantly associated with sitting minutes at work. Overall, workplace neighbourhoods perceived to have higher levels of walkability attributes tended to have participants who spent longer time sitting at work. After adjusting for all covariates, sitting minutes at work remained positively associated with those built-environment attributes, except for walking and cycling facilities. One SD increment in land use mix diversity, land use mix access, street connectivity, and crime safety was associated with 7.60, 15.25, 9.73, and 15.26 more minutes of daily sitting time at work, respectively. Covariate-adjusted associations were not significant for perceived aesthetics, and any categories of Walk Score®.

Table 3.6 Associations of workplace neighbourhood built-environment attributes with daily sedentary time at work

Workplace neighbourhood environment	Unadjusted			Adjusted [a]		
	β	(95% CI)	p	β	(95% CI)	p
Perceived measures (n=2,141)						
Land use mix diversity	**7.16**	**(0.41 , 13.91)**	**0.037**	**7.60**	**(1.10 , 14.11)**	**0.022**
Land use mix access	**17.45**	**(10.99 , 23.91)**	**<0.001**	**15.25**	**(8.99 , 21.50)**	**<0.001**
Street connectivity	**10.82**	**(4.25 , 17.39)**	**0.001**	**9.73**	**(3.42 , 16.03)**	**0.003**
Walking and cycling facilities	**7.96**	**(1.37 , 14.55)**	**0.018**	4.83	(-1.53 , 11.19)	0.14
Aesthetics	-3.49	(-10.01 , 3.02)	0.29	-2.13	(-8.40 , 4.14)	0.51
Crime safety	**17.86**	**(11.42 , 24.30)**	**<0.001**	**15.26**	**(9.04 , 21.47)**	**<0.001**
Walk Score® (n=1,164)						
Car-dependent (0-69, n=377)	-5.91	(-27.59 , 15.77)	0.59	-3.58	(-24.22 , 17.05)	0.73
Somewhat walkable (70-89, n=388)	Ref			Ref		
Very walkable (90-100, n=399)	**24.51**	**(3.14 , 45.89)**	**0.025**	19.37	(-1.03 , 39.76)	0.063

β: unstandardised regression coefficient (minutes/day) corresponding to 1 standard deviation increment in perceived attributes and relative to the workplaces located in somewhat walkable neighbourhoods; CI: confidence interval; Ref: reference group

[a] Models were adjusted for gender, age group, marital status, educational level, individual annual income, work hours per week, and organisation size.

Note: Figures highlighted in bold indicate statistically significant findings ($p < 0.05$).

3.5 Workplace neighbourhood built-environment attributes and transport-related physical activity and sitting in cars and public transport

The associations of workplace neighbourhood built-environment attribute with time spent on transport-related physically-active behaviours were shown in Table 3.7. All the perceived workplace neighbourhood built-environment attributes were positively associated with participation in any transport-related physical activity after adjusting for all covariates including driving licence. The odds ratios of any participation in transport-related physical activity (both walking and cycling behaviours without the separate intensity of physical activity) ranged from 1.15 (95% CI 1.05, 1.26, for aesthetics) to 1.60 (95% CI 1.45, 1.76, for land use mix access) (part A). By contrast, people perceiving two workplace neighbourhood built-environment attributes to be more activity-supportive – higher street connectivity (β = -2.87; 95% CI -4.71, -1.04) and crime safety (β = -2.15; 95% CI -3.90, -0.39) – were associated with fewer minutes being physically-active for transport purposes amongst those reported any physical activity in the transport domain (part B).

Similar associations with the participation of any transport-related physical activity were also observed in Walk Score®. Compared with the people working in

somewhat walkable neighbourhoods, those who worked in car-dependent neighbourhoods were lower likely (OR = 0.68; 95% CI 0.51, 0.91) whilst those in very walkable neighbourhoods were higher likely to participate in transport-related physical activity (OR = 1.67; 95% CI 1.23, 2.29) (part A). Whilst investigating those reported physically-active minutes, no associations with physical activity minutes for transport were found in the Walk Score® category (part B).

Table 3.7 Associations of workplace neighbourhood built-environment attributes with (A) daily participation (none vs any) and (B) engagement in minutes of transport-related physical activity

Workplace neighbourhood environment	Unadjusted			Adjusted [a]		
	OR	(95% CI)	p	OR	(95% CI)	p
(A) Daily participation of transport-related physical activity (none vs any)						
Perceived measures (n = 2,261)						
Land use mix diversity	**1.42**	**(1.30 , 1.56)**	**<0.001**	**1.35**	**(1.23 , 1.48)**	**<0.001**
Land use mix access	**1.77**	**(1.61 , 1.94)**	**<0.001**	**1.60**	**(1.45 , 1.76)**	**<0.001**
Street connectivity	**1.37**	**(1.26 , 1.50)**	**<0.001**	**1.33**	**(1.21 , 1.46)**	**<0.001**
Walking and cycling facilities	**1.44**	**(1.32 , 1.57)**	**<0.001**	**1.33**	**(1.22 , 1.46)**	**<0.001**
Aesthetics	**1.16**	**(1.07 , 1.27)**	**0.001**	**1.15**	**(1.05 , 1.26)**	**0.002**
Crime safety	**1.34**	**(1.23 , 1.46)**	**<0.001**	**1.26**	**(1.15 , 1.38)**	**<0.001**
Walk Score® (n = 1,224)						
Car-dependent (0-69, n=394)	**0.58**	**(0.44 , 0.77)**	**<0.001**	**0.68**	**(0.51 , 0.91)**	**0.010**
Somewhat walkable (70-89, n=410)	Ref			Ref		
Very walkable (90-100, n=420)	**2.07**	**(1.54 , 2.79)**	**<0.001**	**1.67**	**(1.23 , 2.29)**	**<0.001**
	β	(95% CI)	p	β	(95% CI)	p
(B) Engagement in minutes of work-related physical activity						
Perceived measures (n = 1,348)						
Land use mix diversity	-0.85	(-2.82 , 1.12)	0.40	-0.87	(-2.86 , 1.12)	0.39
Land use mix access	-1.42	(-3.29 , 0.45)	0.14	-1.56	(-3.48 , 0.37)	0.11
Street connectivity	**-2.82**	**(-4.64 , -1.01)**	**0.002**	**-2.87**	**(-4.71 , -1.04)**	**0.002**
Walking and cycling facilities	-0.73	(-2.60 , 1.14)	0.44	-1.02	(-2.91 , 0.87)	0.29
Aesthetics	0.96	(-0.82 , 2.73)	0.29	0.89	(-0.91 , 2.69)	0.33
Crime safety	**-2.17**	**(-3.90 , -0.44)**	**0.014**	**-2.15**	**(-3.90 , -0.39)**	**0.017**
Walk Score® (n = 745)						
Car-dependent (0-69, n=183)	-3.17	(-8.23 , 1.88)	0.22	-3.32	(-8.38 , 1.74)	0.20
Somewhat walkable (70-89, n=245)	Ref			Ref		
Very walkable (90-100, n=317)	-0.14	(-4.55 , 4.26)	0.95	0.04	(-4.36 , 4.45)	0.99

OR: odds ratio relative to participants with none work-related physical activity and the workplaces located in somewhat walkable neighbourhoods; β: unstandardised regression coefficient (minutes/day) corresponding to 1 standard deviation increment in perceived attributes and relative to the workplaces located in somewhat walkable neighbourhoods; CI: confidence interval; Ref: reference group

[a] Models were adjusted for gender, age group, marital status, educational level, individual annual income, driving licence, work hours per week, and organisation size.

Note: Figures highlighted in bold indicate statistically significant findings ($p < 0.05$).

Table 3.8 presents the associations of workplace neighbourhood built-environment attributes with time spent driving cars and using public transport. In the unadjusted modes, all the perceived workplace neighbourhood built-environment attributes studied were negatively associated with time spent driving cars. After adjusting for all covariates, including the possession of driving licence, these associations were largely attenuated but still statistically significant. The associations were strongest for land use mix access (β = -7.43; 95% CI -9.23, -5.64) whilst weakest for aesthetics (β = -1.91; 95% CI -3.67, -0.15). By contrast, compared with people working in somewhat walkable neighbourhoods, those who worked in very walkable neighbourhoods were associated with less time spent using cars (β = -7.33; 95% CI -12.46, -2.21) (part A).

Four out of six perceived workplace neighbourhood built-environment attributes (i.e., land use mix diversity, land use mix access, walking and cycling facilities, and aesthetics) were associated with higher minutes spent on public transport use. After adjusting for all covariates, all of them were largely attenuated. Only better-perceived land use mix access (β = 4.11; 95% CI 2.18, 6.03) and walking and cycling facilities (β = 3.06; 95% CI 1.16, 4.97) were significantly associated with higher minutes in daily sitting time of public transport use (part B). After adjusting for all covariates, no associations with public transport use were found in the Walk Score® category.

Table 3.8 Associations of workplace neighbourhood built-environment attributes with daily sedentary time whilst sitting in (A) cars and (B) public transports

Workplace neighbourhood built attributes	Unadjusted			Adjusted [a]		
	β	(95% CI)	p	β	(95% CI)	p
(A) Sitting in cars						
Perceived measures (n=2,141)						
Land use mix diversity	**-7.75**	**(-9.72 , -5.77)**	**<0.001**	**-5.14**	**(-6.97 , -3.31)**	**<0.001**
Land use mix access	**-11.95**	**(-13.82 , -10.09)**	**<0.001**	**-7.43**	**(-9.23 , -5.64)**	**<0.001**
Street connectivity	**-4.99**	**(-6.93 , -3.04)**	**<0.001**	**-3.20**	**(-4.99 , -1.42)**	**<0.001**
Walking and cycling facilities	**-6.06**	**(-8.00 , -4.12)**	**<0.001**	**-3.31**	**(-5.10 , -1.51)**	**<0.001**
Aesthetics	**-2.43**	**(-4.36 , -0.49)**	**0.014**	**-1.91**	**(-3.67 , -0.15)**	**0.033**
Crime safety	**-5.81**	**(-7.72 , -3.91)**	**<0.001**	**-3.44**	**(-5.21 , -1.68)**	**<0.001**
Walk Score® (n=1,164)						
Car-dependent (0-69, n=377)	**9.95**	**(4.31 , 15.58)**	**0.001**	3.56	(-1.60 , 8.72)	0.18
Somewhat walkable (70-89, n=388)	Ref			Ref		
Very walkable (90-100, n=399)	**-14.44**	**(-20.00 , -8.89)**	**<0.001**	**-7.33**	**(-12.46 , -2.21)**	**0.005**
(B) Sitting in Public transports						
Perceived measures (n=2,141)						
Land use mix diversity	**2.69**	**(0.73 , 4.65)**	**0.007**	1.35	(-0.60 , 3.31)	0.17
Land use mix access	**5.81**	**(3.94 , 7.69)**	**<0.001**	**4.11**	**(2.18 , 6.03)**	**<0.001**
Street connectivity	1.79	(-0.12 , 3.71)	0.066	0.99	(-0.90 , 2.88)	0.31
Walking and cycling facilities	**4.72**	**(2.81 , 6.63)**	**<0.001**	**3.06**	**(1.16 , 4.97)**	**0.002**
Aesthetics	**2.46**	**(0.56 , 4.35)**	**0.011**	1.84	(-0.03 , 3.70)	0.054
Crime safety	1.06	(-0.82 , 2.95)	0.27	0.06	(-1.82 , 1.93)	0.95
Walk Score® (n=1,164)						
Car-dependent (0-69, n=377)	**-8.35**	**(-14.52 , -2.17)**	**0.008**	-5.82	(-11.99 , 0.35)	0.065
Somewhat walkable (70-89, n=388)	Ref			Ref		
Very walkable (90-100, n=399)	5.34	(-0.75 , 11.43)	0.085	2.73	(-3.39 , 8.86)	0.381

β: unstandardised regression coefficient (minutes/day) corresponding to 1 standard deviation increment in perceived attributes and relative to the workplaces located in somewhat walkable neighbourhoods; CI: confidence interval; Ref: reference group

[a] Models were adjusted for gender, age group, marital status, educational level, individual annual income, driving licence, work hours per week, and organisation size.

Note: Figures highlighted in bold indicate statistically significant findings ($p < 0.05$).

3.6 Workplace neighbourhood built-environment attributes and leisure-time physical activity and sedentary behaviours

The associations of workplace neighbourhood built-environment attribute with time spent on leisure-time physically-active behaviours were shown in Table 3.9. In the unadjusted models, all the perceived workplace neighbourhood built-environment attributes, with the only exception of walking and cycling facilities, were positively associated with the participation of leisure-time physical activity. These associations were consistent and stable after adjusting for all covariates (including driving licence). No associations with the participation of leisure-time physical activity were found in Walk Score®.

Whilst investigating people who engaged in any leisure-time physical activity, no statistical evidence for any of the perceived neighbourhood built-environment attributes and objectively-measured neighbourhood walkability (Table 3.9).

Table 3.9 Associations of workplace neighbourhood built-environment attributes with (A) daily participation (none vs any) and (B) engagement in minutes of leisure-time physical activity

Workplace neighbourhood environment	Unadjusted OR	(95% CI)	p	Adjusted [a] OR	(95% CI)	p
(A) Daily participation of leisure-time physical activity (none vs any)						
Perceived measures (n = 2,261)						
Land use mix diversity	**1.18**	**(1.08 , 1.29)**	**<0.001**	**1.19**	**(1.08 , 1.31)**	**<0.001**
Land use mix access	**1.15**	**(1.06 , 1.26)**	**0.001**	**1.20**	**(1.09 , 1.31)**	**<0.001**
Street connectivity	**1.24**	**(1.14 , 1.36)**	**<0.001**	**1.26**	**(1.15 , 1.38)**	**<0.001**
Walking and cycling facilities	1.08	(0.99 , 1.18)	0.088	1.09	(0.99 , 1.19)	0.064
Aesthetics	**1.21**	**(1.11 , 1.32)**	**<0.001**	**1.22**	**(1.11 , 1.33)**	**<0.001**
Crime safety	**1.16**	**(1.07 , 1.27)**	**0.001**	**1.18**	**(1.08 , 1.29)**	**<0.001**
Walk Score® (n = 1,224)						
Car-dependent (0-69, n=394)	1.11	(0.83 , 1.48)	0.47	1.12	(0.83 , 1.50)	0.47
Somewhat walkable (70-89, n=410)	Ref		Ref	Ref		Ref
Very walkable (90-100, n=420)	1.08	(0.81 , 1.43)	0.60	1.05	(0.78 , 1.41)	0.76
	β	(95% CI)	p	β	(95% CI)	p
(B) Engagement in minutes of leisure-time physical activity						
Perceived measures (n = 799)						
Land use mix diversity	-0.62	(-3.47 , 2.23)	0.67	-0.83	(-3.70 , 2.04)	0.57
Land use mix access	-2.65	(-5.40 , 0.92)	0.058	-2.14	(-4.96 , 0.67)	0.14
Street connectivity	-2.50	(-5.27 , 0.27)	0.077	-1.94	(-4.75 , 0.87)	0.18
Walking and cycling facilities	-2.36	(-5.20 , 0.47)	0.10	-2.32	(-5.20 , 0.55)	0.11
Aesthetics	0.46	(-2.31 , 3.23)	0.74	0.50	(-2.29 , 3.30)	0.72
Crime safety	-2.42	(-5.12 , 0.28)	0.079	-1.88	(-4.62 , 0.85)	0.18
Walk Score® (n = 456)						
Car-dependent (0-69, n=151)	-0.88	(-8.54 , 6.79)	0.82	-2.47	(-10.25 , 5.31)	0.53
Somewhat walkable (70-89, n=147)	Ref			Ref		Ref
Very walkable (90-100, n=158)	1.52	(-6.06 , 9.11)	0.69	1.29	(-6.49 , 9.07)	0.74

OR: odds ratio relative to participants with none work-related physical activity and the workplaces located in somewhat walkable neighbourhoods; β: unstandardised regression coefficient (minutes/day) corresponding to 1 standard deviation increment in perceived attributes and relative to the workplaces located in somewhat walkable neighbourhoods; CI: confidence interval; Ref: reference group

[a] Models were adjusted for gender, age group, marital status, educational level, individual annual income, driving licence, work hours per week, and organisation size.

Note: Figures highlighted in bold indicate statistically significant findings ($p < 0.05$).

Table 3.10 presents the associations of workplace neighbourhood built-environment attributes with time spent being leisure, including television viewing, internet use, and others. In the unadjusted models for television viewing, four out of the six perceived workplace neighbourhood built-environment attributes studied were associated with longer minutes spent watching television. The same four attributes were still positively associated with television viewing – one SD increment in land use mix diversity, land use mix access, street connectivity, and crime safety was associated with 6.58, 4.99, 4.50, and 5.04 more minutes of daily sitting time in television viewing, respectively. By contrast, Walk Score® was not associated with television viewing minutes (part A).

Amongst the perceived workplace neighbourhood built-environment attributes, two attributes were associated with time spent on internet use. After adjusting for all covariates, the two attributes were still associated with time spent using the internet. Less level in aesthetics (β = -5.16; 95% CI -8.98, -1.34) and better crime safety (β = 6.49; 95% CI 2.66, 10.33) were associated with more time in internet use. Additionally, no associations of street connectivity with internet use was found before adjustment of any covariates (β = 3.71; 95% CI -0.20, 7.62); after adjusting for the covariates, better-perceived street connectivity was associated with higher time spent

using the internet (β = 4.52; 95% CI 0.65, 8.39) (part B). No associations were found in Walk Score® and minutes in internet use.

For other leisure-time sedentary behaviours, only land use mix access (β = 2.70; 95% CI 0.40, 5.01) and street connectivity (β = 2.63; 95% CI 0.37, 4.89) was found to be positively associated with time spent on other sedentary behaviours. Walk Score® was not associated with other leisure-time sedentary behaviours.

Table 3.10 Associations of workplace neighbourhood built-environment attributes with daily sedentary time whilst (A) television viewing, (B) internet use, and (C) other leisure

Workplace neighbourhood environment	Unadjusted β	(95% CI)	p	Adjusted [a] β	(95% CI)	p
(A) Television viewing						
Perceived measures (n=2,141)						
Land use mix diversity	**6.80**	**(2.58 , 11.02)**	**0.002**	**6.58**	**(2.38 , 10.78)**	**0.002**
Land use mix access	**6.61**	**(2.55 , 10.67)**	**0.001**	**4.99**	**(0.84 , 9.13)**	**0.019**
Street connectivity	**6.07**	**(1.95 , 10.18)**	**0.004**	**4.50**	**(0.43 , 8.57)**	**0.030**
Walking and cycling facilities	0.10	(-4.03 , 4.23)	0.96	1.17	(-2.95 , 5.28)	0.58
Aesthetics	-1.13	(-5.21 , 2.95)	0.59	-1.03	(-5.06 , 2.99)	0.62
Crime safety	**6.64**	**(2.59 , 10.69)**	**0.001**	**5.04**	**(1.00 , 9.07)**	**0.014**
Walk Score® (n=1,164)						
Car-dependent (0-69, n=377)	-2.61	(-16.6 , 11.40)	0.72	-0.50	(-14.42 , 13.41)	0.94
Somewhat walkable (70-89, n=388)	Ref			Ref		
Very walkable (90-100, n=399)	7.73	(-6.07 , 21.54)	0.27	6.71	(-7.10 , 20.53)	0.34
(B) Internet use						
Perceived measures (n=2,141)						
Land use mix diversity	2.62	(-1.39 , 6.63)	0.20	2.71	(-1.29 , 6.71)	0.19
Land use mix access	3.86	(0.00 , 7.72)	0.050	3.81	(-0.14 , 7.76)	0.059
Street connectivity	3.71	(-0.20 , 7.62)	0.063	**4.52**	**(0.65 , 8.39)**	**0.022**
Walking and cycling facilities	-2.83	(-6.75 , 1.09)	0.16	-3.14	(-7.06 , 0.77)	0.12
Aesthetics	**-6.48**	**(-10.34 , -2.62)**	**0.001**	**-5.16**	**(-8.98 , -1.34)**	**0.008**
Crime safety	**6.25**	**(2.41 , 10.09)**	**0.001**	**6.49**	**(2.66 , 10.33)**	**0.001**
Walk Score® (n=1,164)						
Car-dependent (0-69, n=377)	-5.48	(-18.27 , 7.30)	0.40	-2.96	(-15.58 , 9.66)	0.65
Somewhat walkable (70-89, n=388)	Ref			Ref		
Very walkable (90-100, n=399)	-5.61	(-18.21 , 7.00)	0.38	-10.08	(-22.61 , 2.45)	0.12
(C) Other leisure						
Perceived measures (n=2,141)						
Land use mix diversity	**2.57**	**(0.27 , 4.86)**	**0.029**	2.08	(-0.26 , 4.42)	0.081
Land use mix access	**3.48**	**(1.27 , 5.69)**	**0.002**	**2.70**	**(0.40 , 5.01)**	**0.022**
Street connectivity	**2.98**	**(0.74 , 5.22)**	**0.009**	**2.63**	**(0.37 , 4.89)**	**0.023**
Walking and cycling facilities	0.90	(-1.35 , 3.14)	0.43	0.63	(-1.66 , 2.92)	0.59
Aesthetics	0.22	(-2.00 , 2.43)	0.85	0.25	(-1.98 , 2.49)	0.82
Crime safety	**2.34**	**(0.14 , 4.54)**	**0.038**	1.77	(-0.47 , 4.02)	0.12
Walk Score® (n=1,164)						
Car-dependent (0-69, n=377)	**-7.96**	**(-15.08 , -0.85)**	**0.028**	-6.02	(-13.22 , 1.18)	0.10
Somewhat walkable (70-89, n=388)	Ref			Ref		
Very walkable (90-100, n=399)	-4.13	(-11.15 , 2.88)	0.25	-6.74	(-13.88 , 0.41)	0.065

β: unstandardised regression coefficient (minutes/day) corresponding to 1 standard deviation increment in perceived attributes and relative to the workplaces located in somewhat walkable neighbourhoods; CI: confidence interval; Ref: reference group

[a] Models were adjusted for gender, age group, marital status, educational level, individual annual income, driving licence, work hours per week, and organisation size.

Note: Figures highlighted in bold indicate statistically significant findings ($p < 0.05$).

Chapter 4. Comprehensive Discussion and Conclusions

4.1 Introduction

This final chapter summarises the main findings from this thesis (Section 4.2), compares the findings with those reported in previous research, as well as outlines possible explanations for the associations of workplace neighbourhood built-environment attributes with physically-active and sedentary behaviours observed in Japanese workers (Sectionb4.3), and discusses the strengths and limitations of this study (Sections 4.4 and 4.5). The final two sections (Sections 4.6 and 4.7) discuss the implications of the findings for both future relevant research and policies to tackle the emerging health priorities in Japan with an environmental approach.

4.2 Summary of main findings

This study investigated the associations of both perceptions of workplace neighbourhood built-environment attributes and one composite objectively-measured neighbourhood walkability with physically-active and sedentary behaviours across three domains amongst desk-based workers in Japan.

Desk-based workers spend the majority of their working hours being sedentary, around 6 hours and 20 minutes per workday on average, and have limited

opportunities for physically-active behaviours in the workplace neighbourhood. Their perceptions of workplace neighbourhood built-environment attributes were positively correlated with the objectively-measured neighbourhood walkability.

Overall, perceptions of activity-supportive workplace neighbourhood built-environment attributes were the most associated with transport-related behaviours. All the better-perceived built-environment attributes in the workplace neighbourhoods were associated with higher odds of participating in any (versus none) physical activity for transport (i.e., walking and cycling) and less time spent sitting in cars. Activity-supportive perceptions of built-environment attributes in the workplace neighbourhoods were also found to be associated with longer time spent sitting at work and for leisure and being physically-active for leisure.

The associations for the transport domain in environmental perceptions were consistently observed in the objectively-measured neighbourhood walkability; by contrast, the objectively-measured neighbourhood walkability showed dissimilar associations with physically-active and sedentary behaviours for the work and leisure domains.

4.3 Comparison with previous findings and potential explanations

4.3.1 Study participants

The study participants paid attention to the desk-based workers who spend the majority of their working hours being sedentary with less physically-active. On average, our participants spend 6.3 hours sitting at work per workday. Previous studies into office workers showed a large variance in sedentary behaviour during work hours over samples. For example, a study into university office workers from Spain reported 4.8 hours per day,[8] whilst studies into university office workers from China reported median sitting at work of 7.0 hours per workday[11] and into office workers (clerical and professional occupation) from Australia showed the accelerometer-based sedentary time of 11.3 hours per workday.[10] The categories of occupation were relatively complex in the participants recruited in this thesis, compared with previous relevant studies. Most of them were company employees; other occupations predominantly involved sitting such as civil servants, the self-employed, and the professional were also included. The larger variance in the nature of occupations may result in averaged sedentary time amongst the participants of this thesis. Although the sedentary time at work was different between studies, our thesis and all the previous relevant studies found that workplace sitting behaviours

occupied the majority of work hours in desk-based workers,[8, 10-12] along with less time in physical activity.[4, 11]

4.3.2 Correlations between perceived and objectively-measured neighbourhood built-environment attributes

Positive correlations were observed between perceptions of workplace neighbourhood built-environment attributes and Walk Score®. The strongest correlation with Walk Score® was found in land use mix access (rho = 0.48); these findings are correspondence with the measures of Walk Score®. Walk Score® mainly assess the level of access to local destinations over diversities.[117] By contrast, those that were not considered in Walk Score® (i.e., walking and cycling facilities, aesthetics, and crime safety) were less correlated with Walk Score®.

The low to moderate correlations (ranged from 0.10 to 0.48) between perceived attributes and objectively-measured neighbourhood walkability highlighted the need to investigate both measures; the findings from both environmental perceptions and objective neighbourhood walkability could provide additional information and offset the shortages of each measure. Additionally, the positive associations observed between them supported that these perceived attributes studied actually measured the

concept of walkability to some extent.

4.3.3 Workplace neighbourhood built-environment attributes and physically-active and sedentary behaviours in the work domain

Contrary to our expectation, perceptions of workplace neighbourhoods to be more supportive of walking were generally associated with less likely to participate in physical activity but with higher sitting time at work. We found that a better perception of crime safety that supportive of walking was associated with less likely to participate in work-related physical activity. A previous study from the US showed that perceived crime safety surrounding the workplace was associated with higher levels of work-related physical activity.[64] The previous study assessed the crime safety during the day but not at night; however, higher levels of crime safety during the day may encourage workers to participate in work-related physical activities (e.g., errands for work purposes) whilst the concept of crime safety at night may capture other meanings. Workplace neighbourhoods with more people and lights at night may reflect that many people worked late with long work hours in the neighbourhoods. The desk-based workers may contribute their long work hours to workplace sitting, rather than physical activity at work.

In terms of workplace sedentary behaviour, greater walkability indicated by perceptions of higher land use mix diversity and access, street connectivity, and crime safety was associated with longer sitting time at work. The potential explanation underlying the association is that workplaces in high walkable areas such as urban centres with better access to destinations and connected streets tend to have occupation types involving longer workplace sitting time with less physical activity at work. Alternatively, this may be attributable to the time saved from travelling from the workplace to and from different destinations with connected streets in the workplace neighbourhood during work breaks. Workers may spend some time outside their workplace (e.g., for errands, lunch breaks). It is possible that such breaks can be shorter in more walkable workplace neighbourhoods, which can lead to longer sitting time at work. A previous study from Japan also found that living in more walkable residential neighbourhoods was associated with longer indoor sitting time e.g., television viewing, potentially due to reduced time spent in commuting and for errands.[124] Our findings may be particular to the Asian work environment and workplace culture. Further research needs to check whether the same relationships are observed in non-Asian contexts, where workplace culture may be different.

Compared with people working in somewhat walkable neighbourhoods, those who worked in less (i.e., car-dependent) or more (very walkable) walkable

neighbourhoods were both associated with fewer physical activity minutes for work purposes. The underlying explanations of the inconsistent findings were unclear. A previous study showed that Walk Score® was not associated with physical activity while at work but positively associated with physical activity around the workplace.[83] Another recent study showed that Walk Score® was positively associated with the percentage of active minutes while at work.[31] These different associations may be attributable to the measure of physical activity at work – it may be the case that the walkable workplace neighbourhoods can help to increase time spent in the workplace neighbourhood but will not influence what takes place inside of the workplace. Future research should examine the urban-rural differences in walkability levels and their work-related physical activity.

No statistically significant associations of Walk Score® with sedentary time at work were found. Walk Score® was moderately correlated with land use mix access (rho = 0.50) and with land use mix diversity (rho = 0.38). Although a positive association was found for perceived access to diverse destinations around the workplace and sitting at work, the association for a similar objective measure was not significant. These findings suggest that there is a discrepancy between perceived access to destinations and objectively measured availability of destinations. It is possible that participants may have limited knowledge of their workplace

neighbourhoods (e.g., between the workplace and nearby public transit stops), while Walk Score® is derived using all destinations surrounding the workplace. Such mismatch between perception and reality is known to exist for measures related to land use.[125] However, if our interpretation for perceived environmental measures is correct (i.e., workplaces where workers spend longer time sitting tend to be located at walkable neighbourhoods), we could expect similarly positive associations for Walk Score®. Future studies need to explore this inconsistency to understand mechanisms through which built-environment attributes are related to workplace sitting time.

4.3.4 Workplace neighbourhood built-environment attributes and physically-active and sedentary behaviours in the transport domain

Better-perceived workplace neighbourhood built-environment attributes were associated with more odds of participation in transport-related physical activity and public transport use as well as less time in car use. Consistent with the results of this thesis, several previous studies into active travel found that workplace neighbourhoods with a variety of destinations[62, 64, 82] and route infrastructures[64, 70] were associated with higher levels of active travel including walking and cycling. These findings supported that activity-supportive neighbourhoods indeed provide more opportunities and make walking and cycling accessible modes amongst workers.

By contrast, whilst investigating the participants who engaged in any transport-related physical activity, street connectivity and crime safety were found to be associated with lower minutes in transport-related physical activity. It has been suggested that connected streets were positively associated with more time in active travel,[38, 82] inconsistent with the results of this thesis. A possible explanation may be these workers may engage in active commuting regularly and the highly connected streets can increase the flexibility in changing routes between home and workplace whilst facing traffic issues (e.g., car accidents or a traffic jam) and thereby save more travel time. Similar to the results of this thesis, a previous study showed an unexpectedly negative association between perceived safety from crime in the workplace neighbourhood and time spent on active transport.[82] However, the underlying explanations were still unclear, further research should improve the measurement and confirm the associations observed.

This study found that more walkable workplace neighbourhoods were associated with less sitting time in cars, consistent with previous study findings[76, 126]. We also found such workplace neighbourhoods to be conducive to longer sitting time in public transport. These findings suggest that activity-supportive workplace neighbourhoods would discourage longer car use and promote public transport use, implying the use of combining active modes of travel such as walking and cycling. Integrating the

findings of sitting at work and sitting for transport, we could argue that those who work in activity-supportive workplace neighbourhoods may sit longer at work. However, their longer workplace sitting may be mitigated by a shorter amount of car use. Given that Japanese workers spent on average about 1 hour and 20 minutes commuting per day[127], non-car commuting is likely to involve a considerable amount of standing and walking, which may be a reason for longer sitting at work amongst those who work in walkable neighbourhoods. Future research needs to examine whether and to what extent sitting behaviours while commuting and at work may compensate each other.

A study from the UK also suggested that better perceived commuting environments, including routes and aesthetics between home and workplace was associated with commuting by public transport.[80] Furthermore, studies focusing on driving reported that adults who perceived their workplace neighbourhoods to have restricted access to car parking [76] and better access to public transport [44] were less likely to use cars for commuting to work. These results suggest that workers generally commute to work using public transport, which incorporates walking or cycling, rather than using cars alone, if there are activity-supportive built-environment attributes around their workplaces.[85]

The results showed generally consistent associations between perceived attributes and Walk Score®. People who worked in more-walkable workplace neighbourhoods were more likely to report participation in transport-related physical activities and less time driving cars. However, the associations were not found for the sedentary time in public transport. A lack of association between more-walkable workplace neighbourhoods and public transport use observed may be attributable to no available and/or accessible public transport stations in workers' home neighbourhoods.[68] Unlike public transport accessibility, people should possess a parking space in the home neighbourhood (less than two kilometres from home) prior to the purchase of a car according to Japanese law.[128] It was difficult for workers to adopt using public transport between home and workplace if there were no relevant facilities to access in their home neighbourhoods, although there were diverse destinations including public transport stations in the workplace neighbourhoods.

4.3.5 Workplace neighbourhood built-environment attributes and physically-active and sedentary behaviours in the leisure domain

Compared with sitting at work and for transport, the leisure domains of sedentary behaviour was not be expected to be strongly related to environmental attributes around the workplace. The weaker associations may be attributable to the sedentary

behaviours in leisure time may more likely be related to the venue beyond the workplace neighbourhood. Future research should investigate the potential compensation effect of different domains of behaviours, taking the neighbourhood environmental changes into account. Additionally, similar to previous studies on the residential neighbourhood,[129, 130] the results did not show statistical evidence for the association of Walk Score® with leisure-time sedentary behaviour. The lack of association between Walk Score® and sitting in leisure time may be attributable to the nature of Walk Score®,[131] as many destinations considered in Walk Score® are not leisure-specific. Furthermore, with the few recreational destinations (e.g., parks) considered in the Walk Score®, the quality, which is associated with leisure-time activities,[23] is not assessed. A comprehensive index comprising more aspects of diverse neighbourhood built-environment attributes measured objectively could identify other aspects of the environment.

The results showed that people who perceived workplace neighbourhoods to be activity-supported, indicated by land use mix diversity and access, street connectivity, aesthetics, and crime safety, were more likely to participate in leisure-time physical activity. In keeping with the results, a previous study conducted in the US found that living in workplace neighbourhoods with the better-perceived presence of some certain destinations such as healthy restaurants and recreational facilities were

positively associated with workers' leisure-time physical activity.[64] However, an earlier study from Japan found that there were no associations between the objectively-measured number of leisure-oriented destinations such as parks and sports facilities with physically-active behaviours for leisure purposes.[32] The differences in these results may be attributable to the inconsistency between perceptions and objective measures of the presence of different destinations. People need to be aware of the presence of leisure facilities and may consequently increase the likelihood of engaging in leisure-time physical activity by approaching them outside work hours.

There were two potential explanations for the associations of workplace neighbourhood built-environment attributes with leisure-time physical activity observed. First, perceptions of diverse destinations, connected streets, aesthetics, and crime safety near the workplaces may increase the intention in workers to participate in physical activity for leisure purposes when out of work such as before or after work and during work breaks, as well as increase the likelihood to access to leisure facilities for leisure-time physical activity. Second, people working in more-walkable neighbourhoods were found to spend long minutes in the workplace sitting with less physical activity and thus may aim to do more physical activity outside work hours (e.g., during their leisure time) for compensating for the lack of physical activity at work.[132] A previous study showed some evidence of the compensation effect in

leisure-time physical activity.[132] Future studies should examine whether the compensation effect of sedentary behaviour undertaken within and outside work hours.

By contrast, the results also showed that workplace neighbourhoods with some attributes supportive walking were associated with leisure-time sedentary behaviours. For example, land use diversity, land use access, street connectivity, and crime safety were all associated with longer time watching television, which amongst the most common sedentary behaviour during leisure. The underlying mechanism is still unclear due to there being no previous studies into workplace neighbourhood and leisure-time behaviours. However, it has been suggested that the time spent by people commuting to or from work and producing daily work-related errands may be reduced in the residential neighbourhoods with higher levels of walkability, and thereby provide them with more time to input into leisure activities such as television viewing and internet use.[124] Alternatively, this may be attributable to an automatic process of the behavioural norm. People who work in the more-walkable neighbourhoods tend to spend longer workplace sitting time may automatically replicate the habitual behavioural types.[133]

No associations were observed between perceptions of workplace neighbourhood

built environment and physically-active minutes for leisure. The results showed that aesthetics presented its influence in the leisure domain the most, amongst the three domains studied. The level of aesthetics was not only associated with the participation in leisure-time physical activity but also associated with internet use and other leisure behaviours. It suggests that compared with the work and transport domains, leisure-time physical activity needs higher motivation and tendency. Therefore, those who participated in leisure-time physical activity may have stronger motivation to approach the facilities or venues for leisure, even these relevant resources are less accessible (e.g., longer distances and less convenient).

Similar to previous studies on the residential neighbourhood,[129, 130] the results did not show statistical evidence for the association of Walk Score® with leisure-time physically-active and sedentary behaviours. The lack of association of Walk Score® with leisure-time behaviours may be attributable to the nature of Walk Score®,[131] as many destinations considered in Walk Score® are not leisure-specific. Additionally, with the few recreational destinations (e.g., parks) considered in the Walk Score®, the quality, which is associated with leisure-time activities,[23] is not assessed.

4.4 Strengths

A recent review has synthesised findings on the associations of workplace neighbourhood built-environment attributes with workers' physically-active and sedentary behaviours.[33, 34] The majority of previous studies of workplace neighbourhood built-environment attributes examined physical activity but not sedentary behaviour. Furthermore, the studies on sedentary behaviour and workplace neighbourhoods examined sitting in cars rather than sitting at work.

This thesis is the first systematic investigation into the associations of workplace neighbourhood built-environment attributes, including individual walking-supportive indicators and overall neighbourhood walkability, with physically-active and sedentary behaviours. The thesis included the first systematic review identifying potential associations varied by domain-specific physically-active and sedentary behaviours and provided comprehensively empirical evidence across the domains from Japanese workers. The national data recruiting desk-based workers were collected across the 47 prefectures in Japan. The questionnaires for assessing environmental perceptions in workplace neighbourhoods were used in the thesis after examining the internal consistency and test-retest reliability using a subsample of the participants. Both of them showed acceptable reliability. The only attribute (i.e.,

traffic safety) was excluded of which showed low internal consistency.

All analyses have taken into account the potential confounding factors, in response to different contexts. For example, we further adjusted for the possession of driving licence for the transport and leisure domain, as behaviours in these domains may largely depend on whether they can use a car freely. Furthermore, the variables regarding behaviours have taken into account the contexts and hypotheses behind them. The average time spent on workdays was adopted for the work-related and transport-related behaviours whilst the average time spent on the whole regular week was adopted for the leisure-time behaviours.

Analyses presented in the thesis put the public issue in a wider context by examining both perceived built-environment attributes and objectively-measured neighbourhood walkability as well as exploring three different domains of behaviours. It provides a unique opportunity to provide an insight into further relevant studies, particularly those in the Asian context with long work hours and a high-dense population in the neighbourhoods. Findings show that different built-environment attributes are associated with behaviours differently by the domain.

4.5 Limitations

4.5.1 Generalisability of research findings

The non-representative sample of participants, due to the nature of the internet recruitment strategy and self-selection of participants,[134, 135] may limit the generalisability. However, the participants were randomly selected to be equally distributed across gender- and age groups; these approaches may reduce the sample bias to some extent. Furthermore, there were no differences in the sociodemographic characteristics over the four subsamples used in the thesis, suggesting no marked sample bias in the inclusion of valid responses. However, Walk Score® of participants' workplace was not available to 45% of the sample, mainly due to participants being unable to recall the 7-digit postcode of their workplace. Although participants without Walk Score® did not differ from those with Walk Score® in terms of their mean sitting time and environmental perceptions, the results for Walk Score® may be biased if missing of Walk Score® occurred in a non-random manner.

4.5.2 Measurements for study variables

The ANEWS environmental-perceptions instrument was specifically developed for assessing built-environment attributes of residential neighbourhoods rather than

workplace neighbourhoods, some attributes may not apply to be used in the workplace-neighbourhood context. However, we found that the subscales had acceptable test-retest reliability and internal consistency (except for the traffic safety subscale, which was excluded). The reported measures of investigated behaviours over domains and covariates may be subject to recall bias. Additionally, sitting for transport takes place not only within but also beyond workplace neighbourhoods. Unlike sitting at work, there was no strict correspondence between where behaviours took place and where environmental attributes were measured. However, strong and consistent associations of sitting time in cars with workplace neighbourhood environmental attributes were observed (both for perceived attributes and Walk Score®). This suggests that environmental attributes around the workplace may be strong determinants of car use.

4.5.3 Potential unobserved covariates

This study may be limited by a lack of comprehensive work-related information, such as job type (management, professional, clerical), workplace policies (e.g., encouraging standing breaks), and workplace indoor settings (e.g., availability of height-adjustable workstations), which may confound the relationships examined. There may be some inconsistencies in the effect of home and workplace

neighbourhoods on active behaviours,[32, 64] but we could not distinguish if there are overlaps between home and workplace neighbourhoods as we did not assess the home locations. Some participants may have worked from home. However, this is expected to have a minimal impact on the findings, given that only 7.4% of workers worked from home in 2019 in Japan.[136] The distance from home to the workplace may affect workers' transport behaviours;[34] however, we did not consider the variable while investigating the associations between workplace neighbourhood built attributes and workers' behaviours for which data were not available. Research has shown that both the volume and patterns of sitting are related to health.[137] Further studies should consider measuring bouts of sitting behaviour to better understand whether workplace neighbourhood environments are associated with sitting patterns.

4.5.4 Limit the causal associations

As this thesis was conducted based on cross-sectional data, causal associations cannot be inferred directly. Associations of workplace neighbourhood built-environment attribute with physically-active and sedentary behaviours identified in the analyses may be reverse relationships. However, the aim of this thesis was to investigate their associations and explore the possible determinants of physically-active and sedentary behaviours for developing further environmental

approaches, rather than determine the one-way causal relationships. Longitudinal studies, such as workplace relocation studies, are required to examine the causal associations.

4.6 Future research

4.6.1 Conducting more research on workplace neighbourhood built-environment attributes and sedentary behaviour

Most of the previous studies examined the associations of the workplace neighbourhood built-environment attributes with workers' physical activity, rather than their sedentary behaviour. This thesis is the first systematic investigation in the associations of workplace neighbourhood with sitting at work and leisure-time sedentary. Given that the increased proportion of workers in desk-based occupations[138] which need to spend a high proportion of time sitting in the workplace settings,[10, 11] more attention is needed to be paid to investigate into the neighbourhood built-environment correlates of sedentary behaviour rather than physically-active behaviour under the workplace context. A recent review showed that relevant studies on workplace environmental correlate and sedentary behaviour mostly focused on the workplace interior environment e.g., workstations;[33] however, the systematic review

of this thesis suggest that some specific destination-related attributes surrounding workplaces i.e., car parking were associated with sitting behaviours, particularly for the transport domain, amongst workers. To develop effective approaches to improving workers' general health through reducing sitting time and potentially increased physically-active behaviour as the decreased sitting may be replaced by physical activity, more studies on workplace neighbourhood built-environment attributes and sedentary behaviour, particularly the domains which were most likely to be affected (e.g., at work and for transport), are needed.

4.6.2 Improving measurement and diversity of workplace neighbourhood built-environment attributes

A large number of previous studies assessed the perceptions of workplace neighbourhood built-environment attributes; however, perceptions of the attributes of workplace neighbourhoods investigated could vary markedly between individuals, regardless of the objective environmental attributes that keep the same in one specific workplace neighbourhood. The results from this thesis also showed that there were differences in the perceived and objectively-measured walking-supportive attributes. Furthermore, amongst the reviewed relevant studies, all of them identified the shortest commuting route between workplace and home,[47, 52, 53] irrespective of workers'

transport modes. In practice, the shortest commuting route between the two locations may not actually represent the routes taken by the individuals. Additionally, the commuting route may change over periods. Future studies included both perceived and objective measures of the workplace neighbourhood built-environment attributes and monitoring the actual daily commuting routes (e.g., wearable devices with global positioning system) for workers is encouraged to identify and clarify their associations with physically-active and sedentary behaviours.

The variety of public open spaces in the workplace neighbourhood without considering the quality of such attributes in some of the reviewed studies from the thesis. However, previous studies have shown that the quality of built-environment attributes, including destinations such as parks, may be crucial to impact individuals' physically-active behaviours.[139, 140] Therefore, future studies should consider the overall quality or the level of maintenance of the attributes investigated for behaviours whilst identifying their associations. In this thesis, we included not only the availability but also the quality of walking/cycling infrastructures. However, it will be further improved if studies measured and examined this variable separately. Research on diverse varieties of public open space or other activity-supportive attributes around the workplace setting and multiple measures for accessibility (e.g., the number of public transport stops as well as the frequency/schedule of public transport) may

provide deeper insights that will be useful to develop effective strategies to promoting workers' physically-active behaviour and reducing sedentary behaviour.

4.6.3 Developing a framework to define the potentially influential regions for built-environment attributes under the workplace setting for physically-active and sedentary behaviours

Many of the reviewed studies from this thesis did not define the locations or areas of the built-environment attributes investigated with a clear definition of boundary. For example, some of them used ambiguous terms (e.g., at or around the workplace) to measure the workplace neighbourhood without taking into account the differences in perceptions between individuals.[42, 56, 141] By contrast, this thesis specifically defined the workplace neighbourhood as around 10-15 minutes by walk from the workplace. Providing a specific and solid boundary could somewhat limit the differences between individuals' understanding of neighbourhood in the workplace context. Furthermore, it can specifically divide the interior and neighbourhood contexts of workplaces. The main rationale for distinguishing the two contexts is its implications for where responsibility for improvements lies, namely land/property owners or governments.

Within the neighbourhood context of workplaces, re-examining the potentially influential regions of the workplace is important as it may be smaller than the regions frequently identified e.g., 400- and 800-m for both radius or network buffers in research around residences,[89] because limited free time[32] and less autonomy over their behavioural decisions[142] and/or flexibility to change physical motions for workers during work hours. Considering the difference in the nature of the workplace and home contexts, identifying the influential buffers of the workplace neighbourhood amongst the desk-based workers is needed.

Some other studies reviewed in this thesis combined interior facilities and workplace social policies[56, 57, 66] whilst assessing neighbourhood built-environment attributes. These additional measures other than built-environment attributes within the variable investigated may contribute to stronger associations observed. Future studies are encouraged to specify the potentially influential region of the workplace with explicit definitions and a focus on neighbourhood built attributes made by human beings when examining their associations with physical activity or sedentary behaviours.

4.6.4 Enhancing the correspondence between where neighbourhoods and behaviours are assessed

Overall, the previous studies reviewed in this thesis did not precisely designate 'where' the physically-active or sedentary behaviours occurred; by contrast, the built-environment attributes assessed surrounding the workplace only. The disparity between the variables investigated may lead to a misinterpretation of workplace neighbourhood built-environment attributes due to the contribution of physically-active or sedentary behaviours in non-work contexts to the total amount of the behaviours. A study investigating the compensation effect found that workers who spent higher levels of light-intensity physical activity during work hours did less amount of physical activity during hours off work.[132] Therefore, distinguishing the location where the behaviours occurred and the behaviours examined in different contexts, particularly with data for different intensities, could inform detailed information to examine whether the behaviours over domains indeed compensated each other. In this thesis, we specified the sitting behaviour for the work domain; however, the other subdomains of sedentary behaviour were difficult to identify the venue, even though we specify the purposes. For example, internet use can occur in the workplace, at home, or on the commuting from workplace to work. For ascertaining the associations of the workplace neighbourhood on physically-active

and/or sedentary behaviours that occur during at work or commuting, further studies with advanced monitors and assessments that could identify specific venues (e.g., global positioning system) as well as behaviours over time (e.g., accelerometer) are suggested to involve when identifying the domain of behaviours based on their reported purposes.

4.6.5 Considering possible confounding factors

When considering the workplace built-environment correlates of physically-active and/or sedentary behaviours, some potential covariates should be examined in future relevant research. Some geographic attributes attached to locations may act an essential role when individuals decide to select where to live and work.[143] The so-called self-selection of the residence and workplace may be the modifiers of the associations of built-environment attributes with physically-active and sedentary behaviours. The ecological model illustrates that there may be an accumulative effect across different levels of factors. The characteristics across levels such as individual motivations, lifestyle preferences, social supports from supervisors/colleagues, interior workplace facilities, and workplace health promotion programs, may all contribute to the associations of workplace built-environment attributes with workers' physically-active and sedentary behaviours to some extent.[65] However, few of the

studies reviewed considered factors such as the preference of the workplace whilst examining the associations investigated. Relevant studies accounting for these additional possible confounding factors will provide further evidence for independently examining the associations of built-environment attributes with physically-active and/or sedentary behaviours.

4.6.6 Implementing studies in diverse settings with prospective designs

Previous research into possible built-environment attributes in workplace neighbourhoods and both physically-active and sedentary behaviours have been mostly carried out in Western countries such as the US and the UK. An increased number of relevant studies from non-Western countries should be conducted, as behaviour patterns and neighbourhood built environments vary by country or location. For example, marked differences were observed in the prevalence of active travel i.e., walking and cycling for commuting purposes across locations.[144] The low prevalence of physically-active travel in many Western countries leads to the majority of the studies investigated focused to aim to promote active travelling to or from work (a sort of transport-related physical activity) but less into the other domains. However, studies giving weight to the other domains of behaviours, both physically-active and sedentary behaviours, may have greater contributed to increasing the total amount of

physical activity as well as reducing the overall time of sedentary behaviour, particularly in those countries/areas where characterised a high prevalence of active travel to work. This thesis provided empirical evidence from Japan, a representatively contemporary country in Asia, where has a high prevalence of incorporating walking or cycling during their commutes.

Future research using prospective or (quasi-)experimental designs, instead of cross-sectional designs that have been already largely used in the existing research, to assess any changes in workplace neighbourhood built-environment attributes impact physically-active and sedentary behaviours and establish the causal relationships.

4.7 Policy implications

Findings from this thesis have implications to support and inform the potential environmental strategies in Japan, as well as other countries experiencing rapid development and urbanisation. The following sections discuss the improvement of social policies to improve workers' health using environmental approaches.

4.7.1 Designing mixed-use neighbourhoods with increasing individuals' perceptions

The findings from this thesis, including the systematic review, reinforce the case for urban design and planning policies on designing mixed-use neighbourhoods where there are opportunities to live closer to workplaces and have access to a higher density of shops, services, and recreational facilities. The large-scale urban design approaches can be beneficial to higher time spent using walking and cycling during transport and less time spent driving cars. However, the thesis results suggest that environmental changes designed to enhance physically-active and sedentary behaviours may be less effective if efforts are not put into promote individuals' perceptions of the environment of their workplace. Even though in the areas with less supportive of walking, there is the potential to overcome environmental barriers through increasing a positive view or perception of the available of existing neighbourhood built-environment attributes. Public mass media campaigns to announce opportunities in the neighbourhoods for physically active may be helpful to raise people's awareness and shape their perceptions of surrounding environments.[145, 146]

Meanwhile, locating attractive landscapes or attributes in the mixed-use neighbourhoods may contribute to more physical activity in workers' leisure time (see Section 4.8). It is suggested to take into account the quality and maintenance whilst

designing a mixed-use neighbourhood, with the collaborations from the local government and community organisations to improve the level of aesthetics in general in the neighbourhood. However, it is also found the workplace neighbourhoods supported walking was associated with longer time spent being sedentary in workers' leisure time (see Section 4.9). These attractive attributes in the neighbourhoods should further aim to leave people going outdoors standing or being physically-active, instead of sitting.

4.7.2 Identifying subpopulations who are likely to misperceive relevant built-environment attributes

A previous study reported that there were mismatches of built environment and perceptions of environment.[125] Previous investigations into the mismatch between perceived and objectively-measured built environments showed that the mismatches may be attributable to limited exposure to the surrounding environments.[147] Therefore, workers who were inactive may not fully understand of their workplace neighbourhood built environments and likely to misperceive the environment attributes surrounding their workplaces.

To understand the subpopulations (e.g., populations in specific gender, age group, or socioeconomic status) and examine the level or type of multiple factors may contribute to mismatched perceptions is needed to further research and interventions on the design of built environment on behaviours in workers.

4.8 Conclusions

The findings from this thesis in the Asian context extend those of previous studies investigating the role of workplace neighbourhoods in transport-related sedentary behaviour. Desk-based workers who perceived aspects of their workplace neighbourhood as more-walkable reported higher amounts of time sitting at work and being physically-active and using public transport for commuting, as well as lower amounts of time driving cars across workdays. The leisure-time physically-active and sedentary behaviours outside of work were both associated with walkable perceptions around their workplaces. This suggests that neighbourhoods supportive of walking (e.g., urban centres) tend to have workplaces where workers spend long hours sitting and easy access to public transport, and implement active travel. The findings point to potential untapped opportunities outside of the workplace for desk-based workers to reduce and interrupt workplace sitting time whilst increasing active travel adoption. Workplace interventions to reduce sitting time for work and transport and increase

physically-active time for transport purposes may consider using such neighbourhood opportunities to improve their effectiveness. Further research into workplace neighbourhood built-environments and physically-active and sedentary behaviours for leisure is required to investigate the underlying mechanism. Different strategies may need to be implemented to reduce workers' sedentary time. For those working in neighbourhoods supportive of walking (e.g., urban centres), workers may be encouraged to take advantage of opportunities outside of the workplace to reduce and interrupt workplace sitting time. For those working in less walkable neighbourhoods, workplace interventions to support active modes of transport (e.g., facilities for cyclists, incentives for public transport use) may help reduce sitting in cars.

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Appendix

Appendix Table 1 Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies

Criteria	Yes	No	Other (CD, NR, NA)
1. Was the research question or objective in this paper clearly stated?			
2. Was the study population clearly specified and defined?			
3. Was the participation rate of eligible persons at least 50%?			
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?			
5. Was a sample size justification, power description, or variance and effect estimates provided?			
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?			
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?			
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?			
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?			
10. Was the exposure(s) assessed more than once over time?			
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?			
12. Were the outcome assessors blinded to the exposure status of participants?			
13. Was loss to follow-up after baseline 20% or less?			
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?			

*CD, cannot determine; NA, not applicable; NR, not reported

Source: https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools

Appendix Table 2 The English-translated items of the Japanese sedentary behaviour questionnaire

In the last week (seven days), on how many hours and minutes do you do the domain-specific sedentary behaviour listed below on workdays and non-workdays, respectively? Please select all applicable behaviours and provide the total time of the day for each. If the amount of time you spend sitting varies from day to day, please provide the average time per day.

	Workdays	Non-workdays
Being transported to and from a place by car	Total time of the day _____hours _____minutes	Total time of the day _____hours _____minutes
Using public transport	Total time of the day _____hours _____minutes	Total time of the day _____hours _____minutes
At work	Total time of the day _____hours _____minutes	Total time of the day _____hours _____minutes
Watching television, videos, and DVDs	Total time of the day _____hours _____minutes	Total time of the day _____hours _____minutes
Using a computer, cell phone, or tablet PC outside of working hours	Total time of the day _____hours _____minutes	Total time of the day _____hours _____minutes
In leisure time (excluding watching television, videos, and DVDs)	Total time of the day _____hours _____minutes	Total time of the day _____hours _____minutes

Appendix Table 3 The English-translated items of the modified Abbreviated Neighborhood Environment Walkability Scale Japanese version for workplace neighbourhood built-environment attributes

A. Land use mix diversity: About how long would it take to get from your workplace to the nearest businesses or facilities listed below if you walked to them? Please select the answer that best applies to you.

	1-5 min	6-10 min	11-20 min	21-30 min	31+ min	don't know
1) convenience/grocery store						
2) supermarket						
3) laundry/dry cleaners						
4) clothing store						
5) post office						
6) library						
7) book store						
8) fast food restaurant (e.g., hamburger, beef bowl, and stand-up-eating noodle stalls)						
9) coffee place						
10) bank						
11) non-fast food restaurant						
12) pharmacy/drug store						
13) salon/barber shop						
14) bus or train stop						
15) park						
16) gym or fitness facility						

B. Land use mix access: Please select the answer that best applies to your workplace neighbourhood (within a 10- to 15-minute walk from your workplace).

	strongly disagree	somewhat disagree	somewhat agree	strongly agree
1)Stores are within easy walking distance of my workplace.				
2)Parking is difficult in the shopping areas around my workplace.				
3)There are many places (stores, post offices, and public facilities) to go within easy walking distance of my workplace.				
4)It is easy to walk to a transit stop (bus, train) from my workplace.				
5)The streets in my workplace neighbourhood are hilly, making my workplace neighbourhood difficult to walk in. (reversely coded)				
6)There are major freeways, railway lines, or rivers to walking in my workplace neighbourhood that make it hard to get from place to place. (reversely coded)				

Appendix Table 3 The English-translated items of the modified Abbreviated Neighborhood Environment Walkability Scale Japanese version for workplace neighbourhood built-environment attributes (continued)

C. Street connectivity: Please select the answer that best applies to your workplace neighbourhood (within a 10- to 15-minute walk from your workplace).

	strongly disagree	somewhat disagree	somewhat agree	strongly agree
1)The streets in my workplace neighbourhood do not have many cul-de-sacs.				
2)The distance between intersections in my workplace neighbourhood is usually short (100 meters or less).				
3)There are many alternative routes for getting from place to place in my workplace neighbourhood. (I don't have to go the same way every time.)				

D. Availability and quality of walking/cycling infrastructures: Please select the answer that best applies to your workplace neighbourhood (within a 10- to 15-minute walk from your workplace).

	strongly disagree	somewhat disagree	somewhat agree	strongly agree
1)There are sidewalks on most of the streets in my workplace neighbourhood.				
2)Sidewalks are separated from the road/traffic in my workplace neighbourhood by guardrails and steps.				
3)Sidewalks are separated from the road/traffic in my workplace neighbourhood by parked cars.				
4)There is a grass/dirt strip that separates the streets from the sidewalks in my workplace neighbourhood.				

Appendix Table 3 The English-translated items of the modified Abbreviated Neighborhood Environment Walkability Scale Japanese version for workplace neighbourhood built-environment attributes (continued)

E. Aesthetics: Please select the answer that best applies to your workplace neighbourhood (within a 10- to 15-minute walk from your workplace).

	strongly disagree	somewhat disagree	somewhat agree	strongly agree
1)There are trees along the streets in my workplace neighbourhood.				
2)There are many interesting things to look at while walking in my workplace neighbourhood.				
3)There are many attractive natural sights in my workplace neighbourhood.				
4)There are attractive buildings/homes in my workplace neighbourhood.				

F. Crime safety: Please select the answer that best applies to your workplace neighbourhood (within a 10- to 15-minute walk from your workplace).

	strongly disagree	somewhat disagree	somewhat agree	strongly agree
1) My workplace neighbourhood streets are well lit at night.				
2) Walkers and bikers on the streets in my workplace neighbourhood can be easily seen by people in their homes.				
3) There is a high crime rate in my workplace neighbourhood. (reversely coded)				
4) The crime rate in my workplace neighbourhood makes it unsafe to go on walks during the day. (reversely coded)				
5) The crime rate in my workplace neighbourhood makes it unsafe to go on walks at night. (reversely coded)				

Source: http://www.tmu-ph.ac/news/data/ANEWS_Jpn_ver3.pdf