



Walking as a Mode of Transport

Literature Review

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Executive summary

This report reviews recent literature on walking from a planning perspective to identify the current state of the art in the field. The work is intended to provide an input to the development of a research program hosted by Volvo Research and Educational Foundations (VREF) on the topic Walking as a mode of transport.

The search used the keywords 'walking' and 'pedestrian', combined with 'urban' and 'transport'. It was decided to remove three specific types of paper in order to make the final number of papers more manageable – those with a too strong focus on particular traffic safety factors, those too micro-scale in their outlook, and findings deemed difficult to transfer to other geographical contexts. The initial intention was to cover the literature over the last 10 years, though a recent review of reviews (Winters et al, 2017) provided good coverage of the period up to the end of 2016 and thus the literature review focused on papers published thenceforth.

The review showed a dominance of papers within the field of walkability (40 papers). However, other themes such as health (7), rights and justice (2), history (3), economic aspects (3) and covid-19 related papers (6) were also identified and discussed

Given the large number of papers on walkability (i.e. what factors influence the amount and quality of walking in urban areas and what needs to be done to enhance this), they were split into three sub-groups: Methods and models; Influencing factors and; Attractiveness/emotional response. There are a wide range of methods used in the various papers, both quantitative and qualitative. The specifics include a mix of quantitative and qualitative methods such as interviews, go-alongs, questionnaires, using existing travel survey data, street auditing procedures, use of new technologies such as mobile phone records and street imaging software such as street view. In terms of measures, intersection density, residential density and land use mix were the most used attributes for assessing walkability. Other factors which were shown to be important to walkability included safety and footpath continuity.

The amount of literature for the other themes were considerably smaller than for walkability. However, the overlap between e.g. health and walkability is considerable – much of the walkability literature often explicitly mentions health and wellbeing as potential beneficiaries of the work.

Based on the review, some overarching conclusions can be made.

- Better data collection and evaluation techniques are needed, where specific examples are longitudinal research studies and studies over larger geographic scales. One of the problems of walkability research is the often limited scale/geographic scope that is considered and the lack of more inclusive urban-wide applications.
- There are a number of papers published in the last couple of years which examine the effects of the Covid-19 pandemic on walking and active travel, with presumably many more to come. However, at this stage, it is difficult to draw sound conclusions from these due to the preliminary nature of the work and the continued uncertainty over the ultimate direction and effects of the pandemic.

- Whilst much of the walking literature comes from transport and health areas, there is a surprisingly wide range of studies from other areas – social development, history, computer science, to name a few. Comparing walking to other aspects of transport research it could be argued there are some differences in coverage of research – walking perhaps is over-represented in studies using qualitative and more social research techniques.
- Much of the walkability literature focuses on the things that can be done to an area in order to make it more walkable. However, few of those studies explicitly cite traffic as a key factor which reduces walkability nor suggest measures to significantly reduce (motorised) traffic flow and/or change traffic behaviour.

1. Introduction

This paper reviews recent literature on walking to identify the current state of the art in the field. The work is intended to provide an input to the development of VREF research on walking as part of their future cities research programme.

In 2001 the Volvo Research and Educational Foundations (VREF) launched its program Future Urban Transport – How to deal with the complexity of urban transport (FUT). Since then the program has functioned as an overarching framework for VREF initiatives such as Centers of Excellence (CoE), research programs and projects, events, publications and networking and other activities.

The vision of VREF is “Equitable access and sustainable transport in urban areas”, with the general mission to:

- Support the development of new knowledge relating to ideas and solutions that can contribute to equitable access and sustainable urban transport;
- Support the development of educational and outreach programs in the area of equitable access and sustainable urban transport;
- Contribute to the dissemination and implementation of research findings among university researchers, practitioners, decision-makers and other relevant stakeholders;
- Support demonstrative examples and change processes.

In December 2020, the VREF Board made a formal decision to initiate a VREF program for supporting research and education in the area of *Walking as a mode of transport*. The program started with an initial phase in 2021–2022 that consisted of both internal and external activities to strengthen the motivation and direction for the program, formulate concrete goals for the program, and develop the program’s “architecture”.

During the preparatory work and the initial phase, VREF has commissioned four preparatory studies carried out by leading scholars and experts in the field, as well as organized and led several workshops with researchers and other experts. This literature review acts as one of those preparatory studies.

This review is structured into three main sections: firstly an overview of the methods used to access the literature reviewed and the constraints used to limit the volume of literature; secondly a description of the main outcomes from the literature reviewed, split into a range of themes; finally a concluding section.

2. Methodology

The aim of this paper is to undertake a systematic review of academic literature to identify state of the art knowledge as a basis for informing the VREF future programme on walking as a mode of transport. The initial intention was to cover the literature over the last 10 years, though a recent review of reviews (Winters et al, 2017) provides good coverage of the period up to the end of 2016 and hence it is proposed to take the findings from this as a starting point and focus on later papers for the purpose of the current work. Winters et al (2017) covers active travel,

hence including cycling as well as walking, but it is possible to determine from the findings those that are particularly pertinent to walking. The focus of Winters et al (2017) is on policies to promote active travel, so any literature relevant to walking which falls outside of this remit in the period prior to 2017 will also be considered in the current review.

The current review searched three commonly used databases: Scopus, Web of Science and Transport Research International Documentation (TRID). The focus of the research was on walking as a means of transport in urban areas. The searches used the keywords 'walking' and 'pedestrian', combined with 'urban' and 'transport'. Each of the three searches returned many hundreds of hits, a lot of which could be quickly removed as the titles were obviously outside the scope of the research. Where titles were not clear enough to be sure about the contents, further examination of abstracts was undertaken. It was also decided to remove three specific types of paper in order to make the final number of papers more manageable. These were:

- Papers where the focus was on pedestrian safety, except where the focus was on how safety influences levels and quality of the walking experience. The searches threw up a lot of very specific papers which focussed on topics such as detailed design of crossing facilities, vehicle front end design etc.
- Papers which were very micro-scale in their outlook, for example, looking at features such as kerb height, placing of litter bins, etc.
- Papers which focussed entirely on one urban area or one part of an urban area, for example examining factors influencing walkability in one specific part of Berlin or Beijing. There were two reasons for excluding these papers, firstly that there were a very large number of them and secondly that the focus on one specific location raises considerations of transferability of findings. Where these papers did discuss issues of transferability in a way that increased their relevance to more generic understanding of factors influencing walkability those papers were included.

The work only considered papers in the English language – it is expected that this will have only a limited detrimental effect on the coverage of the relevant literature. Many papers submitted to non-English language journals may also have been submitted to English language journals, while if not, reference might still be made to their findings in other papers published in the English language. Where papers made reference to other papers not identified in the original searches and which were within the date constraints (i.e. post 2016) these additional papers were also considered in the review. In total, once duplications were removed, 63 papers were selected from Scopus, 14 papers from TRID and 26 from Web of Science. Two of the search engines used, Scopus and Web of Science, are broad in their coverage and it is expected that these would pick up papers from across a broad range of subject areas. TRID is rather more focussed on transport, though did also pick up a number on non-journal outputs, particularly from the TRB and WCTR conferences.

3. Key findings

Pre-2017 research

Winters et al (2017) in their review of reviews looked at 50 plus articles, but focussed on 17 which had undertaken substantial reviews of literature (ranging from 12 to 300 plus papers reviewed where walking was included in the review). They classified their findings into policies at 4 spatial scales – society, city, route and individuals. The studies reviewed provided a number of key insights which are worth repeating here as background to the later studies reviewed as part of the current study.

- A comprehensive package of measures across the different scales is likely to be more effective than individual measures. However, little hard knowledge exists about the effectiveness of different measures or the ideal mix of policies. This is compounded by the problems of transferability and the need for policies to be tailored to individual circumstances of a place and time.
- On the positive side, given there are many documented examples of cities which have achieved real changes in active travel (including walking) it seems unlikely that there are insurmountable problems for doing this anywhere.
- Safety is key, not just in absolute terms (one's likelihood of being involved in a crash on a given trip), but perhaps more importantly how safe (or dangerous) a location or a trip is perceived. Walking injury rates generally fall with increased levels of walking so success in increasing levels of walking could act as positive feedback.
- The likelihood of interventions being made to increase walking is related to the cost of the intervention, despite some studies suggesting investments in active travel are cost effective.
- There are a number of key limitations in existing research:
 - Better data collection and evaluation techniques are needed – specific examples are longitudinal research studies and studies over a larger scale.
 - Better evidence-based tools for planners are required.
 - More work is required on the equity distribution of interventions, with especial need for studies associated on sub-groups of the population who are least likely to engage in physical activity.
- Overall, comprehensive policy approaches operating at multiple levels are thought to be most effective.

2017 and beyond

The papers reviewed here derive mainly from journals in the transport and health areas, though also from a surprisingly wide range of journals from other areas, ranging from history through to computer science. A number of central themes are immediately apparent from the body of work – the most common by far of these is walkability (i.e. what factors influence the amount and quality of walking in urban areas and what needs to be done to enhance this), but there are significant numbers of papers which look at related areas to do with pedestrian and walking behaviours and health and wellbeing benefits from walking, satisfaction and rights and justice. There are also several papers which examine walking histories, tools economic impacts of walking and a few other more minor topics. Most recently there have been a growing number of

papers which have examined aspects of the covid-19 pandemic on walking and walking practices. Some of these themes match with gaps in research on walking as a transport mode as identified in a recent review by Heather Allen (Allen, 2021). For the other themes mentioned in that report there does not appear to be a body of peer reviewed research.

The following sections pick up on these themes and highlight some of the main findings for each.

Walkability

This section provides a brief summary of some of the key papers which have looked at walkability. Many of the excluded papers (see above) also consider this topic though for one very specific urban area. The focus here is on those papers which provide some generality and degree of transferability in their findings or novelty in their approach. These papers are very much interested in the practical questions around what do we (planners and others) need to do to our cities and urban areas to make them more walkable – to attract more people to walk and to improve the experience of those who do. The papers raise a number of key issues about the topic, specifically relating to transferability of approach and results and also issues of scale. Most difficult to deal with is transferability of results – what works in one place may not work or not work in the same way elsewhere. A number of the papers have explored how their findings (modelled or empirical) work in more than one area (for example Gagliani et al, 2021) which provides some pointers relating to transferability. Given the large number of papers on walkability, the discussion below splits them into 3 groups – Methods and Models; Influencing Factors and; Attractiveness/Emotional Response.

Table 1: Walkability: Methods and Models

Authors	Title	Approach	Key influences on walkability
Lopez-Lambas et al, 2021	The walking health: A route choice model to analyze the street factors enhancing active mobility	On street and online surveys. Respondents mapped routes over past day.	Attractiveness (e.g., green areas, amenities, tourist attractions, etc.) and accessibility (e.g., obstacles, pavement width). Change is thought to be easier in small/medium sized cities.
D'Orso and Migliore, 2020	A GIS-based method for evaluating the walkability of a pedestrian environment and prioritised investments	Developed a GIS based method to assess the walkability of the pedestrian environment. Developed decision support tool to help identify priorities for investment.	The problems that make the pedestrian environment in these areas unattractive, unsafe, and impassable are as follows: a poor cleaning of the sidewalks, the presence of architectural barriers, the presence of obstacles such as cars parked on the sidewalk, frequent interruptions of the pedestrian paths owing to the absence of sidewalks, poor drainage of rainwater, an abundance of depressions and holes owing to tree roots and poor sidewalk maintenance, poor lighting, and a lack of street furniture.
Yencha, 2019	Valuing walkability: New evidence from computer vision methods	Computer vision techniques, street level images and 60,000 house transactions.	Walkable space and pathway networks are valued by pedestrians. Generally access to local establishments is valued, but if no footways exist this relationship is broken.
Delso et al, 2019	Integrating pedestrian-habitat models and network kernel density	Develop concept of pedestrian habitat quality (taken from ecological studies) through measuring pedestrian habitat suitability in an urban street	Creates a priority map of streets for action in a case study area. Shows that the techniques developed are usable more generally in urban areas by planners and others and that the methods go beyond existing techniques which

	estimations to measure street pedestrian suitability	network and combining this with network kernel density estimations. The work combines the walkability macro-dimensions with the micro physical environmental factors relevant for pedestrians.	have tended to focus only on micro or macro environmental factors.
Figueroa Martinez et al, 2019	Walking through deprived neighbourhoods: Meanings and constructions behind the attributes of the built environment	Mixed qualitative techniques, including mobile interviews, researcher observation and mapping.	Perceptions of safety or danger are shaped by the presence of deterioration of buildings and public space, territorial demarcations, the features of the borders of public space and the urban form. Such awareness can induce change to pedestrian's trips.
Golan et al, 2019	Gendered walkability: Building a daytime walkability index for women	Uses a mixed methods approach to generate a women specific walkability index.	Shows that Walkscore does not reflect women's walkability needs and develops an alternative index with a particular focus on crime, homelessness and street/sidewalk cleanliness.
Wennberg et al, 2018	How older people as pedestrians perceive the outdoor environment-methodological issues derived from studies in two European countries	Mixed methods quantitative and qualitative methods used to assess how older adults perceive and use unfamiliar space. Cross-cultural study in two European countries.	Both the countries highlighted the importance of the immediate locality and neighbourhood to people in old age and the need for more-accessible neighbourhoods to enable people to go out more. Locality remains an important spatial reference in later life. Even with improvements in terms of barrier-free design, if people are fearful of traffic and crime then they will not go out. Key ingredients of a safe environment include the inclusive design of the built environment and simple measures for improvement, e.g. low kerbs and more benches. Reducing traffic volumes and speeds where there are pedestrians and clear separation of vulnerable road users (pedestrians, cyclists and mopeds)
Lefebvre-Ropars and Morency, 2018	Walkability: Which measure to choose, where to measure it, and how?	Four existing walkability measures are applied to Greater Montreal to assess how well they correlate with the outcomes of a pedestrian mode choice model short trips.	The 4 measures are assessed.
Sevtsuk et al, 2021	A big data approach to understanding pedestrian route choice preferences: Evidence from San Francisco	Pedestrian route choices are examined using data from smartphone applications. These are linked to the presence on the road of known factors from the literature which affect pedestrian choices. Alternative route choices were explored using Google Street View.	Whilst permitting a huge number of pedestrian trips to be included, the data does not provide any sense of trip purpose nor the characteristics of the pedestrians themselves. It does, however, permit analysis over a wide scale and range of sizes of urban areas.
Ma et al, 2021	Critical factors influencing the comfort evaluation for recreational walking in urban street environments	420 questionnaire responses with concurrently monitored micro-environmental conditions were analyzed to formulate a path model that portrayed the interrelationships between pedestrian comfort, and perceptual and objectively measured street built and micro-environmental characteristics.	Pedestrian comfort was shown to be directly related to satisfaction with the built environment, thermal sensation, perceived air quality and loudness.
Koo et al, 2021	How are Neighborhood and Street-Level	Uses Street View images to refine the ways in which walkable environments are measured and	Streetscale attributes of the built environment appear to have a larger effect on walking than neighbourhood scale attributes. The methods

	Walkability Factors Associated with Walking Behaviors? A Big Data Approach Using Street View Images	understood and how streetscapes are linked to walking.	developed provide practical guidance for planners on how to use streetscale factors to enhance walkability.
Nagata et al, 2021	Objective scoring of streetscape walkability related to leisure walking: Statistical modeling approach with semantic segmentation of Google Street View images	Uses an automated method to assess street walkability using semantic segmentation and statistical modeling on Google Street View images. Examines the relationship between leisure walking, micro-scale walkability, and multiple components of streetscape using GSV images and a deep learning approach.	Building segments of streetviews increase street walking while sky view do not, suggesting buildings provide a degree of comfort and interest.
Steinmetz-Wood et al, 2020	Moving to policy-amenable options for built environment research: The role of micro-scale neighborhood environment in promoting walking	Developed the Virtual Systematic Tool for Evaluating Pedestrian Streetscapes (Virtual-STEPS) to virtually audit the microscale environment of cities using Google Street View.	Whilst microscale neighbourhood features were associated with increase in leisure walking, this was not the case for utilitarian walking. Macroscale features were associated with increased odds of utilitarian walking.

The papers in Table 1 focus on the development of new approaches to understanding what makes a walkable urban area. Many of these new approaches seem to be trying to address some of the issues of transferability, though even here there are questions depending on whether data are available (travel surveys, street view etc) universally or in the same form. There are a wide range of methods used in the various papers, both quantitative and qualitative. Mixed methods approaches are common (for example Wennberg et al, 2018; Golan et al, 2019; Figueroa Martinez et al, 2019). The specifics include a mix of quantitative and qualitative methods such as interviews, go-alongs, questionnaires, using existing travel survey data, street auditing procedures, use of new technologies such as mobile phone records and street imaging software such as street view. A number of very recent papers have examined the potential for using more automated data collection and interpretation techniques – these have the advantages in allowing large samples to be constructed and also overcoming to some extent the limited scale problems which exist in many earlier studies. With these techniques a whole city can potentially be studied and issues to do with self-report bias can be reduced. Many of these studies use apps on mobile phones to provide data on activity, whilst some use automated assessments of street view images to rapidly interpret key aspects of different pedestrian environments (for example Sevstuk et al, 2021; Koo et al, 2021; Nagata et al, 2021; Steinmetz-Wood et al, 2020). Perhaps these types of studies represent one way forward, though it must be remembered that while they have access to large volumes of pedestrian trip data and walking environments, they provide little feel for the motivations behind such trips nor the actual feelings of the pedestrians about different aspects of their urban environments.

Such limitations point toward the need for some degree of mixed measures to be most effective.

There is another issue which arises from this literature which relates again to transferability. At one level there are tools such as WalkScore which provide a means of understanding something about the walkability of a local environment. So, for example, in the UK one can input a location to a website and the software will provide a score between 0 and 100 of how walkable the location is – essentially how easy it is to access places on foot, as well as a brief description of the place relating to walkability. However, whilst useful, this can be easily criticised as a one size fits all figure. Some of the walkability literature picks this up – for example Golan et al (2019) examine how well WalkScore fits for different groups of the population. They explore the applicability of WalkScore for women and conclude that it does not consider factors which are important to women about their walking environments and therefore fails that group of society. Important missing factors are crime, homelessness and street/sidewalk cleanliness. It is likely that generic measures such as WalkScore will not perform well for other groups such as the elderly or children. At the other end of the scale from WalkScore are studies which provide copious amounts of detail about the effects of a wide range of factors influencing walkability, often based on small areas or a single street or location, where it is difficult to believe they could be usefully transferred elsewhere. Maybe the balance lies somewhere in-between, but what is clear is that users of such results/tools need to be aware of their limitations. Some of the studies reviewed provide apparently conflicting outcomes – for example Koo et al (2021) shows that streetscale attributes of the built environment appear to have a larger effect on walking than neighbourhood scale attributes while Steinmetz-Wood et al (2020) show that macroscale attributes of urban environments have a bigger effect on levels of utilitarian walking than microscale attributes.

Table 2: Walkability: Influencing Factors

Authors	Title	Approach	Key influences on walkability
Cysek-Pawlak and Pabich, 2021	Walkability – the New Urbanism principle for urban regeneration	Aims to define walkability in the context of new urbanism. Uses statistical analysis of flows of people in a Polish town and a study of urban attributes influencing walkability in a French town.	Walkability needs to be analysed holistically – that is taking account of environmental, economic and social aspects.
Xiao et al, 2021	Multiscale Analysis of Urban Walkability and Pedestrian’s Destination Choice	Household travel survey	Compact design and high density contribute to levels of walking density, but decrease walking mobility. Mixed-land use does not help generate walking trips but creates destinations for walking and increases walking mobility. Important to consider how walkability is defined before determining factors which influence it.
Rahm et al, 2021	“In the evening, I don’t walk in the park”: The interplay between street lighting and greenery in perceived safety	Residents focus group discussions. Examiner relationship between greenery, street lighting, perceived safety and walking.	Quality of urban greenery and street lighting affects people’s choices to walk after dark. Entrapment due to greenery and darkness contributes to avoidance. Presence of other people has the opposite effect.
Kim and Hong, 2021	Differences in the influence of	Developed regression models linking pedestrian volume to	Microclimate variables have a bigger effect on pedestrian volume in residential compared to

	microclimate on pedestrian volume according to land-use	microclimates for different types of urban areas.	commercial areas. Adverse microclimate reduces pedestrian volume.
Zhang et al, 2020	Effects of green space on walking: Does size, shape and density matter?	Pedestrian activity data from the London Travel Demand Survey is compared to green space attributes of the urban environment.	Catchments around smaller parks have increased pedestrian activity as do retail areas close to parks. Park density is insignificant.
Cao et al, 2019	Using walk-along interviews to identify environmental factors influencing older adults' out-of-home behaviours in a high-rise, high-density neighbourhood	Qualitative study of 12 older adults out of home behaviours using qualitative walk-along interviews.	12 factors were shown to be important: access to facilities, pedestrian infrastructure (sidewalk quality, sheltered walkways, universal design, crossings, benches, and public toilets), aesthetics, traffic safety, safety from crime, wayfinding, familiarity, weather, social contact, high-rise, high-density, affordability), and maintenance and upgrading.
Su et al, 2019	Auditing street walkability and associated social inequalities for planning implications	Expert panel evaluation of indicators factors of walkability selected using word frequency in existing indicators classification frameworks.	The resulting framework for assessing walkability is shown to work based on the city of Hangzhou in China. Significant inequalities in street walkability are shown to exist in different parts of the city.
Soltani et al, 2018	The development and assessment of environmental features associated with walkability of Urban streets	The importance of macro and micro features of streets were assessed by urban science experts.	Safety of streets comes out as the top factors influencing walkability.
Jensen et al, 2017	Walkability, complete streets, and gender: Who benefits most?	Audits of a variety of streets pre and post-renovation.	Street renovations led to more people using the streets post-renovation. Walkability was related to gender proportions – female proportions doubled from less walkable to most walkable streets. More walkable streets are livelier and more gender balanced.
Hermann et al, 2017	The Missing Middle: Filling the Gap Between Walkability and Observed Walking Behavior	Use of survey data on pedestrian behaviour to assess the discrepancy that high walkability is not always linked to high levels of walking.	Reducing parking lots and setbacks and increasing street tree canopy cover can increase walking, especially in areas with high WalkScore and low walking rates.
Lindelöw et al, 2017	Satisfaction or compensation? The interaction between walking preferences and neighbourhood design.	Examines the interactions between preferences, neighbourhood design and walking.	Studies of walkability which fail to take account of preferences for residential choice will not consider differing demands for urban design characteristics and attributes.
Carlson et al, 2019	Impacts of Temporary Pedestrian Streetscape Improvements on Pedestrian and Vehicle Activity and	Two quick build infrastructure projects were evaluated. Video and in-person direct observations were conducted before and during implementation to assess the number of pedestrians and vehicles using the intersection and vehicle/driver behaviours.	Various positive pedestrian measures increased, whilst little negative change was experienced by vehicles. It is suggested that inexpensive quick build street projects have the capability to increase pedestrians, though the longer term effects still need to be evaluated.

	Community Perceptions	Resident and stakeholder attitudes towards the projects were captured through surveys and interviews.	
Nag et al, 2019	Assessment of relationships between user satisfaction, physical environment, and user behaviour in pedestrian infrastructure	Revealed preference data to assess pedestrian satisfaction and stated preference data to estimate changes in pedestrian behaviours as a result of infrastructure improvements.	Factors likely to influence pedestrian satisfaction are buffers, ease of walking, zebra crossings, footpath continuity, night time safety and location. Improving footpath continuity is shown to have the biggest effect in the likelihood of changing behaviour as a result of infrastructure improvement.
Gonzalez-Urango et al, 2020	Planning for Pedestrians with a Participatory Multicriteria Approach	Stakeholder and expert interviews to identify and rank factors determining criteria for pedestrian routes.	Factors related to improving mobility for pedestrians were broken down into 4 clusters - connectivity, urban function, route attributes and comfort.
Gaglioni et al, 2021	Urban services, pedestrian networks and behaviors to measure elderly accessibility	Identified characteristics of urban environments of relevance to the elderly. These were weighted using AHP. Development of a new measure of pedestrian accessibility.	Identification of areas within cities where levels of pedestrian accessibility were high or low as the basis for a planning tool. Accessibility was measured in relation to different activity types in the city.
Sun and Lau, 2021	Go-along with older people to public transport in high-density cities: Understanding the concerns and walking barriers through their lens	Mobile interviews with 72 older pedestrians to understand concerns, barriers and areas of improvement whilst walking towards public transport stops..	Narrow sidewalks with high pedestrian flows are challenging. Being bumped is a concern. Females are more concerned than males. Footbridges and underground areas are problematic due to often poor connectivity to the rest of the network. Other areas of improvement included pavement evenness, obstruction by store goods on the sidewalk, railings, seat and rest areas in the metro underground, street crossing on collector roads, and lack of traffic signal time.
Distefano et al, 2021	Neighbourhood walkability: Elderly's priorities	Surveys of 645 over 70 year olds to identify their concerns walking.	Older pedestrians with minor age related declines give strong importance to walkability and aggressive driving. Those with more major age related declines focus more on comfort issues in the urban environment.
Ma et al, 2021	Critical factors influencing the comfort evaluation for recreational walking in urban street environments	420 questionnaire responses with concurrently monitored micro-environmental conditions were analyzed to formulate a path model that portrayed the interrelationships between pedestrian comfort, and perceptual and objectively measured street built and micro-environmental characteristics.	Pedestrian comfort was shown to be directly related to satisfaction with the built environment, thermal sensation, perceived air quality and loudness.
Lee et al, 2021	Neighborhood Environments and Utilitarian Walking Among Older vs. Younger Rural Adults	Telephone interviews with 2000+ older and younger adults to determine factors which influence their use of the street for utilitarian walking.	Perceived presence of crosswalks and pedestrian signals was significantly related to utilitarian walking in all age groups. For older adults steep slopes were negatively associated with walking. For younger adults, traffic speed was negative, while significant destinations and access to public transportation were positive.
Fonseca et al, 2021	Built environment attributes and their influence on walkability	Review of recent studies on factors influencing walkability	Intersection density, residential density and land use mix were the most used attributes for assessing walkability, Attributes related to streetscape design and security were much less adopted in walkability assessments.

Cambra and Moura, 2020	How does walkability change relate to walking behavior change? Effects of a street improvement in pedestrian volumes and walking experience	Before/after study of the effects of a built environment improvement on walking volume and quality.	The results suggest that the scale of walkability change of environmental interventions is a significant factor in influencing walking behaviour. Smaller-scale interventions may be effective in improving the walking experience but not as effective in increasing walking activity.
McCormack et al, 2021	Evidence for urban design and public health policy and practice: Space syntax metrics and neighborhood walking	The study used space syntax methods to estimate associations between the space syntax measure of street integration and walkability (SSW) and neighborhood-specific leisure (LW) and transportation (TW) walking among 4422 Canadian adults.	Street integration and SSW were found to be positively associated with TW and LW participation in a usual week. A one-unit increase in SSW was associated with a 6-min increase in usual weekly minutes of TW. Street integration and SSW were also positively associated with TW participation in the last week. Higher street integration and walkability conceptualized using space syntax support neighborhood walking.

Table 2 identifies a range of studies which try to assess the factors influencing walkability of an environment. These use a variety of methods and approaches. There is a degree of overlap with the methods/models studies, the difference being that the focus of those in Table 1 appeared to be more on the development of methods (though in most cases results were also produced), whilst the studies in Table 2 appeared to be less about methodological development and more about the walkability outcomes.

The studies suggest a wide range of factors which are potentially important, though there is a lack of consistency of findings, perhaps in part related to the issues of transferability discussed above and also partly because many of the studies specifically set out to explore the effects of certain factors and did not choose to consider others. Some of the key suggestions are listed below:

- To get a clear idea of the importance of walkability and the factors which influence it studies needs to be holistic in their approach, considering economic, environmental and social aspects (Cysek-Pawlak and Pabich, 2021).
- Greenery and street lighting appear to be important, though in different ways. Rahm et al (2021) explore night time walking and identify the importance of good street lighting, but also some of the negative aspects of greenery as a result of a sense of entrapment, leading to avoidance. Others identify more positive aspects of greenery resulting from pleasantness of environment, shading etc (Zhang et al, 2020, Hermann et al, 2017). Kim and Hong (2021) also identify the negative effects on walking of adverse microclimates.
- Su et al, 2019 showed there were large inequalities in street walking infrastructure provision across different areas of cities. One might conclude that this is also likely to be true between cities – certainly there are cities which are well known for their walking friendliness. Jensen et al (2017) used a before and after approach to examine the effects of new walking infrastructure and showed that walkability is related to gender proportions on the streets – more walkable streets doubled the proportion of females using the street.
- Other factors which were shown to be important to walkability included safety (Soltani et al, 2018) and footpath continuity (Nag et al, 2019, Gonzalez-Urango et al, 2020).

Intersection density, residential density and land use mix were the most used attributes for assessing walkability (Fonseca et al, 2021).

- A number of studies considered specific problems related to older pedestrians – lack of provision of facilities (seating, toilets etc), issues relating to overcrowded pavements, slopes, existence of crossing facilities, aggressive driving (Sun and Lau, 2021, Distefano et al, 2021, Lee et al, 2021).
- Importantly, Cambra and Moura (2020) showed that scale of intervention changes is important – small scale changes can locally increase the experience of walking, but it takes larger scale changes to significantly increase levels of walking.

Table 3: Walkability: Attractiveness/Emotional Response

Authors	Title	Approach	Key influences on walkability
Gerike et al, 2021	Built environment determinants of pedestrian activities and their association in urban street design	Review and recommendations from European street designers through the MORE (Multimodal Optimisation of Roadspace in Europe) project	Urban designers appear able to meet movement requirements for pedestrians, rather less so planning environments to be pleasant and which meet rather less obvious human needs. Considers streets in terms of their movement and place functions.
Hillnutter, 2021	Stimulating urban walking environments – Can we measure the effect?	Observations of pedestrian head movements. What people look at is linked to their appreciation of their environment.	Urban spaces need to be at a human scale to be attractive to walking. They also need to be varied.
Resch, 2020	An interdisciplinary mixed-methods approach to analyzing urban spaces: The case of urban walkability and bikeability	Analysing emotions in different urban environments using physiological sensors, diary apps, chest mounted cameras and interviews.	Provision of a mood sensor for future planning purposes. Increase the transparency of planning.
Bornioli et al, 2019	Affective experiences of built environments and the promotion of urban walking	384 adults were exposed to virtual street scenes to evaluate their affective experience and intentions to walk in different kinds of environment.	Affective experiences are shown to influence walking intentions. Important factors are traffic, city busyness and poor aesthetics. Safety, comfort and sensory stimulation are essential to improve the walking experience.
Nag et al, 2019	Assessment of relationships between user satisfaction, physical environment, and user behaviour in pedestrian infrastructure	Revealed preference data to assess pedestrian satisfaction and stated preference data to estimate changes in pedestrian behaviours as a result of infrastructure improvements.	Factors likely to influence pedestrian satisfaction are buffers, ease of walking, zebra crossings, footpath continuity, night time safety and location. Improving footpath continuity is shown to have the biggest effect in the likelihood of changing behaviour as a result of infrastructure improvement.

These studies shown in Table 3 are closely related to those in Table 2, though focus a little more on human response to the walking environment. It is suggested that urban design seems to focus more on meeting movement requirements for pedestrians than on creating pleasant

environments (Gerike et al, 2021). Mood and emotional response to environments are important factors in walkability and should be considered more in planning (Resch, 2020). Variety in the walking environment and scale (ideal environments are designed at the human scale) are also important factors to increase attractiveness (Hillnhutter, 2021). Affective experiences are shown to be important – aesthetics, busyness of the environment, safety, comfort and sensory stimulation can all effect walkability and response to an environment (Bornioli et al, 2019). Buffers, ease of walking, zebra crossings, footpath continuity, night time safety and location are also important in this context (Nag et al, 2019).

One other study worth mentioning is Scorza et al (2021) which explored the role of participatory planning in designing walkable environments – involving people in the design of their local areas (albeit possibly as part of a wider more centralised planning approach for the whole urban area) improves buy-in to the end result.

Wellbeing and health

There is rather less literature here than for walkability (see Table 4 for summary), though the overlap between the two areas is considerable – much of the walkability literature often explicitly mentions health and wellbeing as potential beneficiaries of the work and even where non-explicit, given what is known about the health benefits of walking, the links are clearly there. One of the papers reviewed in this section is a review from 2017 (Garfinkel-Castro et al, 2017), covering the literature on the relationships between obesity and walking prior to this date. The key issues arising from this are that most studies to date are cross-sectional and lacking longitudinal elements and that direct causation between levels of walking and health is very hard to prove – a similar finding to Winters et al (2017). One of the few studies which does seem to make the direct link between health and active travel (including walking, but also cycling) is Zapata-Diomedes et al (2017) which examined the potential health benefits for the City of Brisbane in Australia if the city were able to achieve its stated active travel targets by the year 2026. Unusually the study also factored in potential negative impacts on health arising from greater levels of active travel, such as exposure to air pollution and safety impacts. Overall, the findings showed 33,000 health adjusted life-years (for a population of 860,000) were possible if the proposed changes in travel were achieved by 2026. These benefits largely came about due to lower risks of physical-inactivity related diseases in the population.

Table 4: Health and wellbeing.

Authors	Title	Approach	Key findings
Garfinkel-Castro et al, 2017	Obesity and the built environment at different urban scales: examining the literature	Literature review. Examines the influence on obesity of 4 different scales of urban environment from macro to micro.	Majority of studies to date are cross-sectional and lack a longitudinal component. More quasi-experimental and natural experiments would also help. Residential self-selection is also raised as a problem – do people who prefer to be physically active chose to leave in neighbourhoods which facilitate walking? Direct causal relationships between the built environment and obesity are difficult prove.
Zapata-Diomedes et al, 2017	A shift from motorised travel to active transport: What are the potential health gains for	Potential health gains for an Australian city (Brisbane) were estimated based on it achieving its stated active travel targets.	33,000 health-adjusted life years could be gained if the travel targets were achieved by 2026. This was mainly due to lower risks of physical inactivity-related diseases, with life course reductions in prevalence and mortality risk in the range of 1.5%-6.0%. Negative

	an Australian city?		effects from increased exposure to air pollution and safety risks were taken into account.
Wali and Frank, 2021	Neighborhood-level COVID-19 hospitalizations and mortality relationships with built environment, active and sedentary travel	This paper presents neighborhood level results linking census tract-level built environment and active/sedentary travel measures with COVID-19 hospitalization and mortality rates	Substantial variations in COVID-19 outcomes and built environment features were shown to exist across neighborhoods. More mixed land use and greater pedestrian-oriented street connectivity is correlated with lower COVID-19 hospitalization/fatality rates. Greater participation in sedentary travel correlates with higher COVID-19 hospitalization and mortality whereas the reverse is true for greater participation in active travel. COVID-19 hospitalizations strongly mediate the relationships between built environment, active travel, and COVID-19 survival.
Tsai et al, 2021	Types and spatial contexts of neighborhood greenery matter in associations with weight status in women across 28 US communities	This study examined associations between weight status and neighborhood greenery that capture ecosystem services most relevant to weight status across 28 U.S. communities.	Associations between greenery and overweight/obesity varied by type and spatial context of greenery, and climate. The findings add to a growing body of evidence that greenery design in urban planning can support public health.
Anciaes et al, 2019	Perceptions of road traffic conditions along with their reported impacts on walking are associated with wellbeing	This study looked at the associations between road traffic conditions, walking, and positive mental wellbeing in four urban neighbourhoods in England bisected by busy roads. Sequential models were fitted, examining the associations between objective and perceived traffic conditions (volume and speed); between perceived traffic conditions and the ability to walk locally and use busy roads; and between the perceptions of traffic conditions, ability to walk locally and use busy roads, and wellbeing.	Perception of traffic volume and speed depends on traffic composition and speed, not just on the day but relating to historical conditions too. Those who saw traffic volume as heavy and speed as fast were more likely to describe traffic as a barrier to walking. Those participants classed as having the worst combination of perceptions of road traffic conditions, and the reported impacts of them on their walking, had on average, significantly lower wellbeing
Forjuoh et al, 2017	Determinants of Walking among Middle-Aged and Older Overweight and Obese Adults: Sociodemographic, Health, and Built Environmental Factors	The association between selected sociodemographic, health, and built environmental factors and walking behaviors of middle-aged and older overweight/obese adults was examined.	The perception that there are lots of distracted drivers on cell phones was related to reduced walking, whilst the perception that the sidewalks provide a good coverage was linked to increased walking. Those with higher education levels were more likely to walk the recommended amount per week. Hence tailored campaigns and provision of appropriate infrastructure and behavioural enforcement are recommended. Safety from traffic and crime are the biggest influencers of walking.
Calvert et al, 2019	When urban environments meet pedestrian's thoughts: implications for pedestrian affect	Walkalong and indoor qualitative interviews with pedestrians to explore their experience of motor traffic and their experiences of walking more generally.	Walking in cities provides time for thinking, including problem-solving, personal reflection, daydreaming and creative thinking. Well-designed pedestrian environments should be unobtrusive with minimal intrusive elements such as motor traffic. Walking and the ability to think while walking contributes to wellbeing.

Wali and Frank (2021) also showed health benefits in terms of reduced serious Covid-19 outcomes for those living in environments which were more supportive of walking and negative

health outcomes associated with greater use of sedentary travel modes, though it is not clear whether the benefits arise from greater fitness or lower levels of exposure to Covid-19 while walking compared to, say, public transport.

Other studies made links between aspects of the physical environment and health gains. Tsai et al (2021) examined the link between greenery and obesity and concluded that careful design of greenery in built environments can increase participation in active travel according to background climate conditions, while Anciaes et al (2019) showed a linked between traffic volumes and speed, level of walking and wellbeing. Forjuoh et al (2017) linked traffic and environmental features (in particular safety and crime and appropriate sidewalk provision) with likelihood of walking amongst middle aged and overweight/obese adults.

Satisfaction, rights and justice

Very few papers in this category, though again some overlap with those papers on walkability, especially in relation to satisfaction issues. Two papers are highlighted in Table 5 (Middleton et al, 2018 and Chan et al, 2021), both qualitative in their approach and bringing perspectives on walking from a UK city and a Chinese city. Both papers examine some of the other values, aside from the usual focus on environmental and health benefits, that walking brings and how those values might be used to help promote walking in the future. Perhaps most importantly Chan et al (2017) show that how we think of walking and value walking is not static, rather it is ever changing according to mood, lifestage, time, experiences etc. This raises some fundamental considerations for design of environments which cater for pedestrians and which encourage more people to walk, as the people who will use those environments are complex and varied. Equally, the environments themselves are not static, changing all the time with varying levels of use by pedestrians and other road users, light levels, weather and many other factors.

Table 5: Satisfaction, rights and justice

Authors	Title	Approach	Key findings
Middleton, 2018	The socialities of everyday urban walking and the 'right to the city'	In depth interviews and diary data to understand the nature of social interactions on foot.	The paper goes beyond the usual focus of promoting walking relating to carbon reduction, health, the built environment and safety, but also to consider the significance of pedestrian encounters on how walking is engaged with, understood and most effectively promoted.
Chan et al, 2021	People and their walking environments: An exploratory study of meanings, place and times	Qualitative analysis of the life stories of 20 residents of a Chinese city, using walk-alongs and sedentary interviews.	Three themes emerged from analysis of the respondent narratives - meanings, timescapes and place. The respondents place some value on health, but more on how walking helped them to retain harmony between their mind, body and environment. The narratives also talked extensively about obstructions to walking arising from construction sites and unregulated commercial activities on the pavements (interestingly much less concerning obstructions arising from traffic). Temporality is highly significant in the way the built environment affects walking. The built environment is continually changing which shapes people's walking practices in complex ways. Design for pedestrians often overlooks the changes in a pedestrian's bodily capacity and emotional state over different timescales.

Walking histories

A number of papers give interesting longer term perspectives on walking - Table 6 shows summaries of 3 papers which fit into this topic. One highlights that not all countries appear to follow the same long term patterns in terms of levels of pedestrian activity. Specifically this examines the case of Chile (though also it is implied a number of other South American countries too) where despite increasing motorisation, high levels of walking persist in urban areas. Examination of various data sources suggest various reasons for this relating to culture and uses of road space, geography of the walking network and demographic characteristics. It remains to be seen whether walking will continue to persist into the future or whether other changes will lead to a longer term decline. Such a decline is examined in the other two papers, which look particularly at long term histories of walking in the UK, looking back over more than 150 years and using a variety of data sources (mainly government sources and various types of personal testimonies). The rather bleak conclusions focus on how modern planning decisions mostly concern provision for motorised traffic and have increasingly led to walking for utilitarian reasons being a marginalised or forgotten activity. It suggests that the planning system typically tends to look on pedestrians as something which gets in the way or slows down the flow of traffic, rather than as an entity in their own right. It is suggested that radical change is required both to the planning system and planning tools used and also to the way in which pedestrians are viewed - walking in urban areas should become the default activity.

Table 6: Walking histories

Authors	Title	Approach	Key findings
Pooley, 2021	Walking spaces: Changing pedestrian practices in Britain since c. 1850	Uses personal testimonies and government reports to examine how spaces for travel have changed over time and how this has affected pedestrian mobility.	In the 19 th century walking in urban spaces was not usually pleasant, but there was a lot of it – enough to dominate the space. In the twentieth century and forward into the current one planning decisions have made walking appear harder and riskier. Motorised travel is now the norm and pedestrians have been marginalised – radical change is required to reverse this.
Hermann-Lunecke et al, 2020	Persistence of walking in Chile: lessons for urban sustainability	Various data sources – literature review, qualitative case study materials, results of O-D surveys in Chile’s main cities, safety data and reports on transport from other Latin American countries.	Walking in Chile has remained a majority transport mode despite the increasing domination of urban space by cars and associated infrastructure – a concept described as ‘persistent walking’. Reasons suggested include: low incomes; urban form and layout of Chilean cities with well-connected networks favouring pedestrian movement; relatively high density urban areas; inner city urban renewal leading to ageing population and small household sizes, leading to greater demand for flat style accommodation; intense use of streets for markets, fairs etc.
Pooley et al, 2021	Introduction: historical perspectives on pedestrians and the city	This is an introduction to 4 separate chapters of the journal which explore histories (using different kinds of sources) of walking at different periods in 4 countries. The article provides an overview.	The paper makes some interesting points, such as the invisibility of pedestrians in the planning system especially once the focus of urban transport planning became planning for the motor car. At this point pedestrians just became something which got in the way of the smooth flow of the cars and attempts were made to corral them and restrict their access to the road. The article also examines the neglect of walking for utilitarian reasons in academic literature (4 papers in 20 years in the Journal of Transport History have been published where walking was the focus). Finally, walking is often portrayed as potentially risky, especially for women, leading to an impression that travel on foot is unusual and dangerous.

Economic impacts of walking

The three studies cited in Table 7, although different in approach and scale, all add to the evidence for positive economic benefits (identified in Winters et al, 2017) from appropriate provision for walking and show a positive link between perceived quality of the walking environment and residential property values.

Table 7: Walking and economy

Authors	Title	Approach	Key findings
Botes and Zanni, 2021	Trees, ground vegetation, sidewalks, cycleways: users’ preferences and economic values for different elements of an urban street—a case study in Taipei	An investigation of the economic values of a variety of streetscape elements using a discrete choice experiment.	Monetary values are developed for various types of greenery and infrastructure elements for streets. The results highlight the importance of urban vegetation for pedestrians, though it is noted that the study is small scale.
Lucchesi et al, 2021	Are people willing to pay more to live in a	The increase in real estate values	Results show that prices of residential properties are positively impacted by perceived walkability.

	walking environment? A multigroup analysis of the impact of walkability on real estate values and their moderation effects in two Global South cities	associated with walkability is tested using multigroup models in 2 Brazilian cities where economic constraints limit mobility choices.	Perceptions of walkability are influenced by infrastructure provision, particularly sidewalk quality and crossing opportunities, but also perceptions of personal safety. It is suggested that the real estate premium could be a justification and means for greater investment in walking, if not by cash strapped highway authorities then by private investors seeking to maximise profits on residential developments.
Miranda et al, 2021	Desirable streets: Using deviations in pedestrian trajectories to measure the value of the built environment	Pedestrian paths taken from GPS data are used to construct a desirability index of streets. Actual paths are compared with shortest paths to get a sense of willingness to deviate from the shortest path. Computer vision techniques are used to obtain a measure of the desirability of streets.	Desirable streets provide access to parks, have better infrastructure. They don't follow straight paths, are enclosed with simple facades and provide diversity of establishment types.

The effects of the Covid-19 pandemic

There are a number of papers published in the last couple of years which examine the effects of the Covid-19 pandemic on walking and active travel, with presumably many more to come.

These are shown in Table 8, though it is difficult to draw sound conclusions from these due to the preliminary nature of the work and the continued uncertainty over the ultimate direction and effects of the pandemic. Early in the pandemic many urban areas were considering ways in which they could help their residents to move around safely in order to undertake fundamental tasks, especially given the decline in shared transport, most notably public transport due to worries over possible transmission in enclosed spaces. Walking and cycling were seen by many as perfect solutions, especially with (temporary) declines in car traffic due to lockdowns and work-at-home rules. Many of the studies presented in Table 5 strive to develop complex mathematical algorithms and applications which might be used to help people safely walk about urban areas, either by reducing encounters or by providing opportunity for appropriate social distancing.

Table 8: Walking and responses to the Covid-19 pandemic

Authors	Title	Approach	Key findings
Mishra et al, 2021	Application-Based COVID-19 Micro-Mobility Solution for Safe and Smart Navigation in Pandemics	Development of an application based system to provide routing guidance to pedestrians and cyclists to help them stay away from Covid-19 hotspots in a city. The application was developed based on use of Google Map mobility data in Delhi.	Safer routes are proposed for individual trips, though the downside appears to be that these are on average 8-12% longer than the routes which would be more naturally chosen.
Mohamma di et al, 2021	Developing levels of pedestrian physical distancing during a pandemic	The study developed pedestrian physical distancing indicators to quantitatively evaluate	A virtual walkway environment was used to simulate pedestrian walking and demonstrate the proposed distancing approach. Changes in relative risk were calculated according to different walking scenarios.

		different levels of physical distancing. It also developed a mathematical process to estimate the relative risk of viral transmission between pedestrians under different pedestrian walking conditions.	
Mello, 2020	One-Way Pedestrian Traffic Is a Means of Reducing Personal Encounters in Epidemics	Aims to minimise contact and frequency of encounters between pedestrians by development of certain behavioural rules. Theoretical study.	Study shows that if one-way movement and walking-only rules are imposed on bidirectional tracks shared by walkers (80%) and runners (20%), the number of people encountering each other per minute is reduced to one-seventh of its original value and the number of encounters per 100 m is reduced to one-sixth of its original value. If one-way movement is imposed on a walking-only walkway, or sidewalks, for example, the number of encounters is reduced to one-fifth of its original value.
Barbarossa, 2020	The Post Pandemic City: Challenges and Opportunities for a Non-Motorized Urban Environment. An Overview of Italian Cases	Examination of mobility programmes and analysis of official documentation set up by 10 Italian cities as a response to the pandemic.	A very consistent awareness is documented amongst planners and decision-makers of the need to rethink urban spaces and mobility – a green revolution to reduce emissions and enhance walking and cycling. There is some evidence that the Covid-19 pandemic sped up the implementation of some previously considered pro-walking and cycling policies, though not in all cities.
Rhoads et al, 2021	A sustainable strategy for Open Streets in (post) pandemic cities	An examination of pedestrian networks in terms of sidewalk availability in 10 cities on three continents.	The cities examined show an uneven distribution of space between pedestrians and automobile users. Very little work exists on planning of sidewalk networks compared to roadways. Without further changes, the implementation of social distancing rules will further fragment the sidewalk networks.
Wali and Frank, 2021	Neighborhood-level COVID-19 hospitalizations and mortality relationships with built environment, active and sedentary travel	This paper presents neighborhood level results linking census tract-level built environment and active/sedentary travel measures with COVID-19 hospitalization and mortality rates	Substantial variations in COVID-19 outcomes and built environment features were shown to exist across neighborhoods. More mixed land use and greater pedestrian-oriented street connectivity is correlated with lower COVID-19 hospitalization/fatality rates. Greater participation in sedentary travel correlates with higher COVID-19 hospitalization and mortality whereas the reverse is true for greater participation in active travel. COVID-19 hospitalizations strongly mediate the relationships between built environment, active travel, and COVID-19 survival.

The papers by Barbarossa (2020) and Rhoads (2021) take a different approach, documenting how cities have started to make more fundamental changes to mobility in favour of non-motorised modes as a result of the pandemic (or at least spurred on by the pandemic) and envisaging different, perhaps fairer, mobility opportunities in the future. The work raises the question of the permanence of many of the changes and also whether things which have by necessity been implemented very quickly in response to the pandemic are necessarily the best solutions, especially in a post pandemic world – there is already in some countries evidence of pandemic implementations being removed as lockdowns were relaxed (Mishra et al (2021) touch upon the challenges of planning effectively for pedestrian movement in a rapidly changing policy environment).

4. Conclusions

The following bullet points are some personal reflections on key messages arising from the review.

- The limitations of existing research as expressed by Winters et al (2017) still appear to be largely true, despite a large number of published studies on walking over the intervening period.
- Whilst much of the walking literature comes from transport and health areas, there is a surprisingly wide range of studies from other areas – social development, history, computer science, to name a few. Comparing walking to other aspects of transport research it could be argued there are some differences in coverage of research – walking perhaps is over-represented in studies using qualitative and more social research techniques. While there is some focus on mathematical and econometric modelling approaches in walking research, these appear less dominant than in other areas of transport. Walking is clearly an area which interests a diverse range of researchers. It is also noticeable that there is considerable effort being placed on development of methods. Inevitably, perhaps, given the focus of this work on papers in the English language, much of the literature still comes predominantly from a small range of regions – Europe, North America and Australia. However, reassuringly, there are significant studies and research capacity elsewhere too – Asia (Singapore, China, Hong Kong, India) and South America (Chile, Brazil), reflecting something of the diverse walking experiences around the world.
- Much of the walkability literature focuses on the things that can be done to an area in order to make it more walkable. However, few of those studies explicitly cite traffic as a key factor which reduces walkability nor suggest measures to significantly reduce traffic flow and/or change traffic behaviour. This seems counterintuitive and it is hard to know if this reflects a reluctance to mention such a possibility or if such change is perceived as improper or impossible or a step too far and thus not worth considering. Indeed, in many cases the methodological approaches used did not allow for such outcomes and there seems to be little research which explicitly looks towards the provision of new planning approaches and new tools to support those approaches. A move away from planning which essentially in transport terms supports the status quo and rarely provides the opportunity to consider radical opportunities towards planning of urban areas walking is considered the norm and default mode rather than an aberration.
- One of the problems of walkability research is the often limited scale considered and the lack of more inclusive urban wide application. While many city centre locations are making large strides towards walking friendly environments, much of the suburbs are ignored and still essentially remain arteries for motor vehicle movements, despite being the areas where people live and spend most of their time. There is some indication in some of the research that more inclusive wide-scale data collection methods are being considered, making use of new technologies to mine data sources such as street view images and mobile phone data (e.g. Sevstuk et al, 2021; Koo et al, 2021; Nagata et al,

2021; Steinmetz-Wood et al, 2020), as well as more inclusive modelling techniques (Goel et al, 2018). There is also some recognition of the laudable state of walking provision in our urban areas and the need for more radical change (see Pooley, 2021).

- Health (not just in relation to covid-19) remains an important area of research in relation to walking given the well documented health benefits. There is some evidence that studies are starting to consider longitudinal aspects of the research (see for example Zapata-Diomedes et al, 2017), though this clearly needs to go further as suggested by Winters et al (2017).
- The emergence of the Covid-19 pandemic has the potential to accelerate change, but it is not clear if this will be permanent. Given the continuing uncertainty of how the pandemic will pan out it is very unclear if the initial responses in relation to provision for walking will continue or there will be further changes of direction. As this is being written many European countries seem to be heading for a new wave of rapidly rising cases and a new, possibly more transferable variant has appeared. One thing seems clear is that the rapid changes being experienced have the potential to lead to considerable rewriting of research and policy and perhaps as a result new opportunities for reconsidering transport more generally in our urban areas.
- The most recent research reviewed here does not easily fit into the same 4 spatial scales identified by Winters et al (2017) in their review. This is not to say that the newer research is not relevant to those scales (indeed some of the studies could fit into one or more of the scales), rather that a lot of the research reviewed here seems to cross one or more of the scales.
- Research on walking has long appeared to be outside of mainstream transport research, however, there is evidence here and from previous reviews that there is a healthy interest in the topic from academics from a wide range of backgrounds. It is difficult to know whether, given this, the lack of interest from within transport is a problem or not. It may partly arise from walking not simply being one thing – walking for transport, leisure walking, walking the dog, walking up hills, walking around supermarkets etc – it means different things to different people and in different contexts and as such doesn't fit neatly into a box. It may also be partly to do with power relationships, being the poor relation in transport terms and existence (or not) of appropriate champions.

5. References

Note that this list includes the selected studies from the searches, not all of which are described in the above text.

Alawadi, K., Khanal, A., Doudin, A., Abdelghani, R. (2021) Revisiting transit-oriented development: Alleys as critical walking infrastructure. *Transport Policy*, 100, pp. 187-202.

Alsaleh, R., Sayed, T., Zaki, M.H. (2018) Assessing the effect of pedestrians' use of cell phones on their walking behavior: A study based on automated video analysis. *Transportation Research Record*, 2672 (35), pp. 46-57.

Anciaes, PR; Stockton, J; Ortegon, A; and Scholes, S (2019) Perceptions of road traffic conditions along with their reported impacts on walking are associated with wellbeing. *Travel Behaviour and Society*, Vol 15, pp.88-101.

Appolloni, L., Corazza, M.V., D'Alessandro, D. (2019) The pleasure of walking: An innovative methodology to assess appropriate walkable performance in urban areas to support transport planning. *Sustainability (Switzerland)*, 11(12).

Arranz-Lopez, A; Mejia-Macias, LM and Soria-Lara, JA (2021) Combining walking accessibility measures to map spatial inequalities. *Journal of Maps*, 17 (1) , pp.84-93.

Barbarossa, L. (2020) The post pandemic city: Challenges and opportunities for a non-motorized urban environment. An overview of Italian cases. *Sustainability (Switzerland)*, 12 (17).

Barber, Lachlan B (2020) Governing uneven mobilities: Walking and hierarchized circulation in Hong Kong. *Journal of Transport Geography*, Volume: 82.

Bhowmick, D., Winter, S., Stevenson, M., Vortisch, P. (2021) Exploring the viability of walk-sharing in outdoor urban spaces. *Computers, Environment and Urban Systems*, 88.

Bornioli, A., Parkhurst, G., Morgan, P.L. (2019) Affective experiences of built environments and the promotion of urban walking. *Transportation Research Part A: Policy and Practice*, 123, pp. 200-215.

Botes, C.M., Zanni, A.M. (2021) Trees, ground vegetation, sidewalks, cycleways: users' preferences and economic values for different elements of an urban street—a case study in Taipei. *Environmental Economics and Policy Studies*, 23 (1), pp. 145-171.

Cambra, P and Moura, F (2020) How does walkability change relate to walking behavior change? Effects of a street improvement in pedestrian volumes and walking experience. *Journal of Transport and Health*, Vol 16.

Calvert, T., Jain, J., Chatterjee, K. (2019) When urban environments meet pedestrian's thoughts: implications for pedestrian affect. *Mobilities*, 14 (5), pp. 545-560.

Cao, Y., Heng, C.K., Fung, J.C. (2019) Using walk-along interviews to identify environmental factors influencing older adults' out-of-home behaviors in a high-rise, high-density neighbourhood. *International Journal of Environmental Research and Public Health*, 16 (21).

Carlson, Jordan A; Grimes, Amanda; Green, Maggie; Morefield, Thomas; Steel, Chelsea; Reddy, Ashleigh; Bejarano, Carolina; Shook, Robin P; Moore, Tiffany; Steele, Laura; Campbell, Karen; Rogers, Eric (2019) Impacts of Temporary Pedestrian Streetscape Improvements on Pedestrian and Vehicle Activity and Community Perceptions. *Journal of Transport & Health*, Volume 15, Issue 0.

Chan, E.T.H., Li, T.E., Schwanen, T., Banister, D. (2020) People and their walking environments: An exploratory study of meanings, place and times. *International Journal of Sustainable Transportation*, pp. 1-12.

Cui, JQ (2021) Building three-dimensional pedestrian networks in cities. *Underground Space*, Volume 6, Issue 2, Page 217-224.

Cysek-Pawlak, M.M., Pabich, M. (2020) Walkability—the New Urbanism principle for urban regeneration. *Journal of Urbanism*.

Delclòs-Alió, X., Rodríguez, D.A., Medina, C., Miranda, J.J., Ávila-Palencia, I., Targa, F., Moran, M.R., Sarmiento, O.L., Quistberg, D.A. (2021) Walking for transportation in large Latin American cities: walking-only trips and total walking events and their sociodemographic correlates. *Transport Reviews*.

Dédélé, A., Miškinytė, A. (2021) Promoting sustainable mobility: A perspective from car and public transport users. *International Journal of Environmental Research and Public Health*, 18 (9).

Delso, J., Martín, B., Ortega, E., Van De Weghe, N. (2019) Integrating pedestrian-habitat models and network kernel density estimations to measure street pedestrian suitability. *Sustainable Cities and Society*, 51.

D'Orso, G., Migliore, M. (2020) A GIS-based method for evaluating the walkability of a pedestrian environment and prioritised investments. *Journal of Transport Geography*, 82.

De Siqueira, G., Adeel, A., Pasha, P., Al Balushi, A., Shah, S.A.R. (2021) Sustainable transportation and policy development: A study for impact analysis of mobility patterns and neighborhood assessment of walking behaviour. *Sustainability (Switzerland)*, 13 (4), pp. 1-18.

De Siqueira, G., Al Balushi, A. (2020) Co-designing the pedestrian revolution in Muscat. *City, Territory and Architecture*, 7 (1).

Distefano, N; Pulvirenti, G and Leonardi, S (2021) Neighbourhood walkability: Elderly's priorities. *Research in Transportation Business and Management* Vol. 40.

Dörrzapf, Linda; Kovács-Györi, Anna; Resch, Bernd; Zeile, Peter (2019) Defining and assessing walkability: a concept for an integrated approach using surveys, biosensors and geospatial analysis. *Urban Development Issues*, Volume 62, Issue: 1, pp 5-15.

Duim, Etienne; Lebrão, Maria Lucia; Antunes, José Leopoldo (2017) Walking Speed of Older People and Pedestrian Crossing Time. *Journal of Transport & Health*, Volume 5, pp 70-76.

Emanuel, M. (2021) Challenging the system: Pedestrian sovereignty in the early systemisation of city traffic in Stockholm, ca. 1945-1955. *Journal of Transport History*, 42 (2), pp. 247-276.

Erath, Alexander; van Eggermond, Michael A B; Ordóñez, Sergio A; Axhausen, Kay W (2017) Introducing the Pedestrian Accessibility Tool: Walkability Analysis for a Geographic Information System. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2661, 2017, pp. 51-61.

Ferrer, S., Ruiz, T. (2018) The impact of the built environment on the decision to walk for short trips: Evidence from two Spanish cities. *Transport Policy*, 67, pp. 111-120.

Figueroa Martínez, C., Hodgson, F., Mullen, C., Timms, P. (2019) Walking through deprived neighbourhoods: Meanings and constructions behind the attributes of the built environment. *Travel Behaviour and Society*, 16, pp. 171-181.

Fonseca, F., Conticelli, E., Papageorgiou, G., Ribeiro, P., Jabbari, M., Tondelli, S., Ramos, R. (2021) Levels and characteristics of utilitarian walking in the central areas of the cities of Bologna and Porto. *Sustainability (Switzerland)*, 13 (6).

Fonseca, F, Ribeiro, PJG, Conticelli, Jabbari, M, Papageorgiou, G, Tondelli, S,, and Ramos, RAR (2021) Built environment attributes and their influence on walkability. *International Journal of Sustainable Transportation*, Early Access.

Forjuoh, SN; Ory, MG; Won, J; Towne Jr., SD; Wang, S; and Lee, C (2017) Determinants of Walking among Middle-Aged and Older Overweight and Obese Adults: Sociodemographic, Health, and Built Environmental Factors. | *Journal of Obesity*.
<https://doi.org/10.1155/2017/9565430>.

Gaglione, Federica; Cottrill, Caitlin; Gargiulo, Carmela (2021) Urban services, pedestrian networks and behaviors to measure elderly accessibility. *Transportation Research Part D*, Volume 90.

Garfinkel-Castro, A., Kim, K., Hamidi, S., Ewing, R. (2017) Obesity and the built environment at different urban scales: Examining the literature. *Nutrition Reviews*, 75, pp. 51-61.

Gerike, R., Koszowski, C., Schröter, B., Buehler, R., Schepers, P., Weber, J., Wittwer, R., Jones, P. (2021) Built environment determinants of pedestrian activities and their consideration in urban street design. *Sustainability (Switzerland)*, 13 (16).

Goel, R., Garcia, L.M.T., Goodman, A., Johnson, R., Aldred, R., Murugesan, M., Brage, S., Bhalla, K., Woodcock, J. (2018) Estimating city-level travel patterns using street imagery: A case study of using Google Street View in Britain. *PLoS ONE*, 13 (5).

Golan, Y., Henderson, J., Lee, N., Weverka, A. (2019) Gendered walkability: Building a daytime walkability index for women. *Journal of Transport and Land Use*, 12 (1), pp. 501-526.

Gonzalez-Urango, Hannia; Inturri, Giuseppe; Le Pira, Michela; García-Melón, Mónica (2020) Planning for Pedestrians with a Participatory Multicriteria Approach. *Journal of Urban Planning and Development*, Volume 146, Issue 3.

Graham, H., De Bell, S., Flemming, K., Sowden, A., White, P., Wright, K. (2020) Older people's experiences of everyday travel in the urban environment: A thematic synthesis of qualitative studies in the United Kingdom. *Ageing and Society*, 40 (4), pp. 842-868.

Herrmann, Thomas; Boisjoly, Geneviève; Ross, Nancy A; El-Geneidy, Ahmed (2017) The Missing Middle: Filling the Gap Between Walkability and Observed Walking Behavior. *Transportation Research Record: Journal of the Transportation Research Board*, 2661, pp 103-110.

Herrmann-Lunecke, Marie Geraldine; Mora, Rodrigo; Sagaris, Lake (2020) Persistence of walking in Chile: lessons for urban sustainability. *Transport Reviews*, Volume 40, Issue 2, pp 135-159.

Hillnhütter, H. (2021) Stimulating urban walking environments – Can we measure the effect? *Environment and Planning B: Urban Analytics and City Science*.

Ignaccolo, M; Inturri, G; Giuffrida, N; Le Pira, M; Torrisi, V; Calabro, G (2020) A step towards walkable environments: spatial analysis of pedestrian compatibility in an urban context. *European Transport-Transporti Europei*, Vol 76 (1).

Jensen, W.A., Stump, T.K., Brown, B.B., Werner, C.M., Smith, K.R. (2017) Walkability, complete streets, and gender: Who benefits most? *Health and Place*, 48, pp. 80-89.

Kim, H., Hong, S. (2021) Differences in the influence of microclimate on pedestrian volume according to land-use. *Land*, 10 (1), art. no. 37, pp. 1-18.

Koo, BW; Guhathakurt, S and Botchwey, N (2021) How are Neighborhood and Street-Level Walkability Factors Associated with Walking Behaviors? A Big Data Approach Using Street View Images. *Environment and Behaviour*, 1-31.

Koohsari, M.J., Shibata, A., Ishii, K., Kurosawa, S., Yasunaga, A., Hanibuchi, T., Nakaya, T., Mavoia, S., McCormack, G.R., Oka, K. (2020) Built environment correlates of objectively-measured sedentary behaviours in densely-populated areas. *Health and Place*, 66.

Kowalewski, M and Bartłomiejski, R (2020) Is it research or just walking? Framing walking research methods as "non-scientific". *Geoforum*, Vol 114, pp.59-65.

Lee, JS (2020) Urban Form, Children's Active Travel to/from School, and Travel related Physical Activity. *International Review for Spatial Planning and Sustainable Development*, Vol 8 (1), pp.21-38.

Lee, S; Koschinsky, J and Talen, E (2018) Planning tools for walkable neighbourhoods: zoning, land use and urban form. *Journal of Architecture and Planning Research*, Vol 35 (1), pp.69-88.

Lee, Won Do; Ectors, Wim; Bellemans, Tom; Kochan, Bruno; Janssens, Davy; Wets, Geert; Choi, Keechoo; Joh, Chang-Hyeon (2018) Investigating pedestrian walkability using a multitude of Seoul data sources. *Transportmetrica B: Transport Dynamics*, Volume 6, Issue 1, pp 54-73.

Lefebvre-Ropars, G., Morency, C. (2018) Walkability: Which measure to choose, where to measure it, and how? *Transportation Research Record*, 2672 (35), pp. 139-150.

Li, MY, Liu, JX, Lin, YF, Xiao, LZ, and Zhou, JP (2021) Revitalizing historic districts: Identifying built environment predictors for street vibrancy based on urban sensor data. *Cities*, Volume 117.

Li, X., Li, Y., Xia, B., Han, Y. (2021) Pathways between neighbourhood walkability and mental wellbeing: A case from Hankow, China. *Journal of Transport and Health*, 20.

Li, X., Santi, P., Courtney, T.K., Verma, S.K., Ratti, C. (2018) Investigating the association between streetscapes and human walking activities using Google Street View and human trajectory data *Transactions in GIS*, 22 (4), pp. 1029-1044.

Lindelöw, D., Svensson, Å., Brundell-Freij, K., Winslott Hiselius, L. (2017) Satisfaction or compensation? The interaction between walking preferences and neighbourhood design. *Transportation Research Part D: Transport and Environment*, 50, pp. 520-532.

Liu, Shiqin, Higgs, Carl, Arundel, Jonathan, Boeing, Geoff, Cerdera, Nicholas, Moctezuma, David, Cerin, Ester, Adlakha, Deepti, Lowe, Melanie and Giles-Corti, Billie (2021) A Generalized Framework for Measuring Pedestrian Accessibility around the World Using Open Data. *Geographical Analysis* May 2021 (Early Access).

Loo, BPY (2021) Walking towards a happy city. *Journal of Transport Geography* Vol 93.

Loor, I., Evans, J. (2021) Understanding the value and vulnerability of informal infrastructures: Footpaths in Quito. *Journal of Transport Geography*, 94.

López-Lambas, M.E., Sánchez, J.M., Alonso, A. (2021) The walking health: A route choice model to analyze the street factors enhancing active mobility. *Journal of Transport and Health*, 22.

Lyons, G (2020) Walking as a service - Does it have legs? *Transportation Research A, Policy and Practice*, Vol 137 , pp.271-284.

Ma, XT; Chau, CK and Lai, JHK (2021) Critical factors influencing the comfort evaluation for recreational walking in urban street environments. *Cities*, Vol 116.

McCormack, G.R., Koohsari, M.J., Turley, L., Nakaya, T., Shibata, A., Ishii, K., Yasunaga, A., Oka, K. (2021) Evidence for urban design and public health policy and practice: Space syntax metrics and neighborhood walking. *Health and Place*, 67.

Massingue, Suzanna Allen; Oviedo, Daniel (2021) Walkability and the Right to the city: A snapshot critique of pedestrian space in Maputo, Mozambique. *Research in Transportation Economics*, Volume 86.

Mello, B.A. (2020) One-Way Pedestrian Traffic Is a Means of Reducing Personal Encounters in Epidemics. *Frontiers in Physics*, 8.

Middleton, J. (2018) The socialities of everyday urban walking and the 'right to the city'. *Urban Studies*, 55(2), pp. 296-315.

Mishra, S., Singh, N., Bhattacharya, D. (2021) Application-based covid-19 micro-mobility solution for safe and smart navigation in pandemics. *ISPRS International Journal of Geo-Information*, 10 (8).

Mohammadi, A., Chowdhury, M.T.U., Yang, S., Park, P.Y. (2021) Developing levels of pedestrian physical distancing during a pandemic. *Safety Science*, 134.

Nag, Dipanjan; Goswami, Arkopal Kishore; Gupta, Ankit; Sen, Joy (2020) Assessing urban sidewalk networks based on three constructs: a synthesis of pedestrian level of service literature. *Transport Reviews*, Volume: 40, Issue: 2, pp 204-240.

Nag, Dipanjan; Bhaduri, Eeshan; Kumar, Gujjar Pankaj; Goswami, Arkopal K (2019) Assessment of relationships between user satisfaction, physical environment, and user behaviour in pedestrian infrastructure. *Transportation Research Procedia*, Volume 48, Issue 0, pp 2343-2363.

Nagata, S; Nakaya, T; Hanibuchi, T; Amagasa, S; Kikuchi, H; and Inoue, S (2020) Objective scoring of streetscape walkability related to leisure walking: Statistical modeling approach with semantic segmentation of Google Street View images. *Health and Place*, Vol 66.

Opach, T., Navarra, C., Rød, J.K., Neset, T.-S. (2021) Pedestrian routing and perspectives: Wayfinder's route down the lane—come on with the rain. *ISPRS International Journal of Geo-Information*, 10 (6).

Papageorgiou, G., Ioannou, A., Maimaris, A., Ness, A. (2021) A strategic approach for implementing a smart pedestrian network (SPN) system. *Open Computer Science*, 11(1), pp. 208-217.

Pooley, C. (2021) Walking spaces: Changing pedestrian practices in Britain since c. 1850. *Journal of Transport History*, 42 (2), pp. 227-246.

Pooley, C; Emanuel, M; Männistö-Funk, T; Norton, P (2021) Introduction: historical perspectives on pedestrians and the city. *Urban History*, Vol 48 (2) , pp.204-210.

Rahm, J., Sternudd, C., Johansson, M. (2021) "In the evening, I don't walk in the park": The interplay between street lighting and greenery in perceived safety. *Urban Design International*, 26(1), pp. 42-52.

Resch, B., Puetz, I., Bluemke, M., Kyriakou, K., Miksch, J. (2020) An interdisciplinary mixed-methods approach to analyzing urban spaces: The case of urban walkability and bikeability. *International Journal of Environmental Research and Public Health*, 17 (19), pp. 1-20.

Rhoads, D; Sole-Ribalta, A; Marta C. González; Borge-Holthoefer, J (2021) A sustainable strategy for Open Streets in (post)pandemic cities. *Communications Physics*, Vol 4 (1).

Rišová, K. (2020) Walkability research: concept, methods and a critical review of post-socialist studies. *Geografický Casopis*, 72 (3), pp. 219-242.

Salazar Miranda, A., Fan, Z., Duarte, F., Ratti, C. (2021) Desirable streets: Using deviations in pedestrian trajectories to measure the value of the built environment. *Computers, Environment and Urban Systems*, 86.

Santilli, D; D'Apuzzo, M; Evangelisti, Azzurra; Nicolosi, V (2021) Towards Sustainability: New Tools for Planning Urban Pedestrian Mobility. *Sustainability*, Vol 13 (16).

Scorza, F., Fortunato, G., Carbone, R., Murgante, B., Pontrandolfi, P. (2021) Increasing urban walkability through citizens' participation processes. *Sustainability (Switzerland)*, 13 (11).

Seles, E., Afacan, Y. (2019) Exploring the relationship between health and walkability. *Open House International*, 44 (1), pp. 44-52.

Sevtsuk, A; Basu, R; Kalvo, R (2021) A big data approach to understanding pedestrian route choice preferences: Evidence from San Francisco *Travel Behaviour and Society* 25(2021) 41-51

Sidaway, J.D. (2021) Psychogeography: Walking through strategy, nature and narrative. *Progress in Human Geography*.

Soltani, A., Hosseinpour, M., Zare, P. (2018) The development and assessment of environmental features associated with walkability of Urban streets. *Theoretical and Empirical Researches in Urban Management*, 13 (1), pp. 22-36.

Steinmetz-Wood, M; El-Geneidy, A and Ross, NA (2020) Moving to policy-amenable options for built environment research: The role of micro-scale neighborhood environment in promoting walking. *Health and Place*, Vol 66.

Su, S., Pi, J., Xie, H., Cai, Z., Weng, M. (2017) Community deprivation, walkability, and public health: Highlighting the social inequalities in land use planning for health promotion. *Land Use Policy*, 67, pp. 315-326.

Su, S., Zhou, H., Xu, M., Ru, H., Wang, W., Weng, M. (2019) Auditing street walkability and associated social inequalities for planning implications. *Journal of Transport Geography*, 74, pp. 62-76.

Sun, Guibo; Lau, Cheuk Yin (2021) Go-along with older people to public transport in high-density cities: Understanding the concerns and walking barriers through their lens. *Journal of Transport & Health*, Volume 21.

Trichês Lucchesi, S., Larranaga, A.M., Bettella Cybis, H.B., Abreu e Silva, J.A.D., Arellana, J.A. (2021) Are people willing to pay more to live in a walking environment? A multigroup analysis of the impact of walkability on real estate values and their moderation effects in two Global South cities. *Research in Transportation Economics*, 86.

Tsai, WL, Nash, MS, Rosenbaum, DJ, Prince, SE, D'Aloisio, AA, Neale, AC, Sandler, DP, Buckley, TJ, and Jackson, LE (2021) Types and spatial contexts of neighborhood greenery matter in associations with weight status in women across 28 US communities. *Environmental Research*, Vol 199.

Wali, B and Frank, LD (2021) Neighborhood-level COVID-19 hospitalizations and mortality relationships with built environment, active and sedentary travel. *Health and Place*, Vol 71.

Wennberg, H., Phillips, J., Ståhl, A. (2018) How older people as pedestrians perceive the outdoor environment-methodological issues derived from studies in two European countries. *Ageing and Society*, 38 (12), pp. 2435-2467.

Winters, M., Buehler, R. and Götschi, T. (2017) Policies to Promote Active Travel: Evidence from Reviews of the Literature. *Curr Envir Health Rpt*, Vol 4, pp278-285,

Xiao, W., Wei, Y.D. (2021) Multiscale Analysis of Urban Walkability and Pedestrian's Destination Choice. *Journal of Urban Planning and Development*, 147 (1).

Yencha, C. (2019) Valuing walkability: New evidence from computer vision methods. *Transportation Research Part A: Policy and Practice*, 130, pp. 689-709.

Zapata-Diomedes, B., Knibbs, L.D., Ware, R.S., Heesch, K.C., Tainio, M., Woodcock, J., Veerman, J.L. (2017) A shift from motorised travel to active transport: What are the potential health gains for an Australian city? *PLoS ONE*, 12 (10).

Zhang, X., Melbourne, S., Sarkar, C., Chiaradia, A., Webster, C. (2020) Effects of green space on walking: Does size, shape and density matter? *Urban Studies*, 57 (16), pp. 3402-3420.

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