Journal of Transport & Health 5 (2017) 97–112

Contents lists available at ScienceDirect

Journal of Transport & Health

journal homepage: www.elsevier.com/locate/jth

A new assessment model to evaluate the microscale sidewalk design factors at the neighbourhood level

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ARTICLE INFO

Available online 10 October 2016

Keywords:
Sidewalk assessment
Neighbourhood-level
Microscale factors
Residents' involvement

ABSTRACT

To date, several assessment tools have been developed to evaluate the pedestrian environments and sidewalks at the street and neighbourhood level. While the existing tools that assess sidewalks at the street level consider the microscale sidewalk factors, the assessment tools at the neighbourhood level neglected the importance of microlevel factors for the assessment purpose. In addition, the important role of residents in neighbourhoods in the examination and review procedure of neighbourhood facilities is overlooked. In contrast with previous assessment methods that considered macro and mesoscale factors for assessment purpose, this research has developed an assessment method to evaluate the neighbourhood sidewalks using the microscale factors. This tool has been developed in the form of a questionnaire to assess the sidewalk conditions within the neighbourhoods. The proposed tool has been tested in three neighbourhoods within Johor Bahru District in Malaysia. Most sidewalk factors in these surveys showed moderate to high reliability. The results of using the proposed tool indicate that the tool is capable of identifying the drawbacks of neighbourhood sidewalks. In addition, this tool allows the residents to convey their needs to city planners and ask for improving existing sidewalks. Lastly, the tool appears ready to be used by urban planners and researchers.

1. Introduction

The advantages of walking, such as low cost and availability to all people, make it the most preferred and common form of physical activity (Badland and Schofield, 2005; De Cambra, 2012; Giles-Corti and Donovan, 2002; Giles-Corti and Donovan, 2003; Guo, 2009). Sidewalks are the main channels for walking, which is considered to be important for encouraging people to be physically active and for forming a healthy community (Mirzayi, 2010; Sung et al., 2015). In addition, they are vital factors for increasing transport-related walking and sustainable transportation (Mendoza et al., 2012; Saito et al., 2013; Taboada, 2015).

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http://dx.doi.org/10.1016/j.jth.2016.08.012
2214-1405/

There is a growing effort to assess pedestrian environments and sidewalks at different levels (Asadi-Shekari et al., 2014; Cerin et al., 2011; Clifton et al., 2007; Galanis and Eliou, 2012; Millington et al., 2009; Williams et al., 2005). Various assessment tools have aimed to increase awareness about sidewalk conditions among local policy makers, prioritise investments, and finally upgrade the walking facilities of communities. Neighbourhoods and street segments are the main areas explored by the proposed tools. While the majority of existing assessment tools evaluate sidewalks at the street level, a limited number of instruments examine sidewalks at the neighbourhood level. In addition, the existing tools developed to assess the sidewalks at the neighbourhood level tend to evaluate the overall condition of the microscale sidewalk factors. The microscale factors must be assessed to capture the detailed and multiple dimensions of the physical condition of the sidewalk.

Neighbourhoods are an important part of city developments. People with different characteristics live together and each group has its own needs. To convey neighbourhood issues to city planners and authorities, residents must be involved in the review and examination process (Kansas City Walkability Plan, 2014). In most part of the cities, the condition of the pedestrian environments and sidewalks is not satisfactory because the perception of the pedestrian is overlooked, and sidewalks are built based on engineering considerations (Lee et al., 2009). In addition, when it comes to assessment, majority of the pedestrian environment assessment tools rely on the judgment of auditors, and this might lead to neglect of the perception of people who use the sidewalks and its facilities on a day-to-day basis.

Recognising the need for an applicable, consistent, and efficient tool to collect information and assess the sidewalks at the neighbourhood level, this study developed and tested a new sidewalk assessment tool at the neighbourhood level (neighbourhood's sidewalk assessment tool (NSAT)). To conduct this effort, the study is structured as follows. The following section reviews the existing pedestrian and sidewalk assessment tools. The model development is then presented. To test the applicability and reliability of the tool, three neighbourhoods have been selected within Malaysia, and the assessment results and reliability condition of the tool follow. The final section concludes with a discussion of the contribution of this research, the implications, limitations, and future directions of the research.

2. Review of existing assessment tools

Sidewalk assessment is an integral component of pedestrian environment assessment tools, such as walkability assessment and pedestrian level of service (PLOS). While walkability assessment tools attract the attention of researchers in the fields of public health and social science, PLOS methods are widely encouraged in urban and transportation planning models. The walkability assessment tools aim to assess whether the physical environment features are linked to the levels of different forms of physical activity, particularly walking (Albers et al., 2010; San Francisco Department of Public Health, 2008). A list and summary of the most prominent walkability assessment tools are presented in Table 1. PLOS methods are developed to assess the overall quality of service, street furnishing, and infrastructure for pedestrian use (Asadi-Shekari et al., 2014). Although the existing tools (walkability assessment tools and PLOS methods) were used to measure the same concept, a variety of techniques and factors were used for this purpose. Each has its own advantages and drawbacks for sidewalk assessment. The various approaches of the tools for assessing the sidewalks are discussed in the following sections.

2.1. Sidewalk assessment in walkability assessment tools

2.1.1. Audits

Walkability assessment tools are developed in different forms, such as audits (Brownson et al., 2003; Clifton et al., 2007; Emery et al., 1998; Evenson, 2009; Pikora et al., 2000; Troped and Cromley, 2005), questionnaires (Kihl et al., 2005; Saelens et al., 2003), checklists (Hoehner, 2011), and inventories (Boarnet et al., 2006). Audits are the most common form of walkability assessment tools, which are conducted by trained auditors. Walkability audit tools are used for keeping detailed records and assessing of pedestrian environments such as sidewalks, calming devices, crossing aids at intersections, and other design features relating to the pedestrian (Moniruzzaman and Paez, 2012). With regard to sidewalk assessment, the developed audits have used various approaches and techniques. Path environment audit tool (PEAT) (Troped et al., 2006) used a multiple number of sidewalk design factors for assessing pedestrian environments. Moreover, this tool considered a few issues regarding disability, and assessed the accessibility of some facilities, such as drinking fountains and benches, for wheelchair users. This tool can be improved by considering more types of disabilities, such as hearing and visual impairments. In addition, some important characteristics of sidewalks, such as safety from crime are not assessed in this tool, including some items regarding active and passive surveillance, such as CCTVs, active frontages, and windows into the sidewalk assessment, which can help ensure that the sidewalk is sufficiently visible to all people.

Walking suitability assessment form (WSAF), which was developed by Emery et al. (2003), assessed very limited number of sidewalk design factors, such as presence and continuity of the sidewalks, material, surface condition, and sidewalk width. This tool does not consider assessing the facilities for people's convenience, such as seating areas and benches, drinking fountains, and trash receptacles. Furthermore, items related to disability issues (e.g. tactile pavement and accessible drinking fountains) are neglected in this audit tool. Systematic pedestrian and cycling environmental scan (SPACES) (Pikora et al., 2002) and pedestrian environment data scan (PEDS) (Clifton et al., 2007) considered several sidewalk design factors, such as path material, path condition, slope, and path obstructions. While the SPACES assess whether the sidewalk

Table 1
Summary of prior walkability assessment tools.

Tool name	Authors	Field	Sidewalk indicators
Path Environment Audit Tool (PEAT)	Troped et al. (2006)	Health	(1) Availability of seating areas and benches along trail segment, (2) Availability of wheelchair accessible benches and seating areas, (3) Availability of bollards on the segments, (4) Availability of wheelchair accessible bollards (wheelchair can safely pass by the gate or bollard), (5) Availability of drinking fountains, (6) Function of drinking fountains, (7) Cleanliness of drinking fountains, (8) Availability of wheelchair-accessible drinking fountains, (9) Availability of toilets along the sidewalk, (10) Function of existing toilets along the sidewalks, (11) Cleanliness of existing toilets, (12) Availability of wheelchair-accessible toilets, (13) Slope of the segment, (14) Path condition (under repair), (15) Availability of pedestrian signal, (16) Availability of signage, (17) Availability of lighting
Walking Suitability Assessment Form (WSAF)	Emery et al. (2003)	Health	(1) Material, (2) Surface Condition, (3) Sidewalk Width, (4) Necessity of installation of pedestrian signals at busy intersection, (5) Availability of curb ramps, (6) Availability of adequate lighting
PIN3 Neighbourhood Audit Instrument	Evenson et al. (2009)	Health	(1) Availability of trees shading the walking area, (2) Availability of public lighting
Irvine Minnesota Inventory (I-M)	Boarnet et al. (2006)	Planning	(1) Number of seating areas, (2) Number of trees, (3) Sidewalk shaded by trees, (4) Number of visible driveways on the segment, (5) Steepness of the segment, (6) Availability of pedestrian signal, (7) Availability of lighting on the segment
Analytic Audit Tool	Brownson et al. (2003)	Health	(1) Availability of comfort features (shade trees, benches, or other types of amenities), (2) Availability of path obstructions (trees, trash receptacles), (3) Availability/visibility of service amenities in the segment (trash receptacles), (4) Presence of street amenities (trash receptacles), (5) Availability/visibility of destinations in the segments (driveways), (6) Sidewalk width, (7) Number of benches
Neighbourhood Environment Walkability Survey (NEWS)	Saelens et al. (2003)	Health	(1) Availability of trees along the streets in the neighbourhood, (2) Shade from trees to cover the sidewalks in the neighbourhood, (3) Availability of pedestrian signals at crosswalks in the neighbourhood, (4) Availability of trees along the streets in the neighbourhoods
Livable communities	Kihl et al. (2005)	Planning	(1) Availability of safe and inviting benches and seating areas, (2) Availability of shades from trees to cover the sidewalks, (3) Sidewalk maintenance, (4) Sufficiency of sidewalk width (a minimum width of 4 feet), (5) Availability of traffic signals located at pedestrian crossings, (6) Adequacy of time provided by traffic signals for pedestrians to cross the street without feeling rushed, (7) Availability of push-to-walk buttons at signal poles, (8) Availability of street signs with legible letters, (9) Readability of signs at night, (10) Clearness of directions provided by signs, (11) Adequacy of lighting at night
Twin Cities Walking Survey	Forsyth et al. (2009)	Health, planning	(1) Shades from trees to cover the sidewalks in the neighbourhood, (2) Availability of pedestrian signals at crosswalks in the neighbourhood
Pedestrian Environment Data Scan (PEDS)	Clifton et al. (2007)	Planning	(1) Availability of street amenities (benches), (2) Number of trees shading the walking area, (3) Availability of medium-/high-volume driveways, (4) Path material, (5) Sidewalk width, (6) Availability of crossing aids (pedestrian signal, signage), (7) Obstruction of path (signs), (8) Overall cleanliness of sidewalk, (9) Roadway/path lighting
Systematic Pedestrian and Cycling Environmental Scan (SPACES)	Pikora et al. (2002)	Health	(1) Availability of path obstructions (trees, sign poles), (2) Number of verge trees, (3) Average height of trees, (4) Driveway crossovers, (5) Path material, (6) Path surface condition, (7) Cleanliness: (can you see any litter, rubbish, graffiti, broken glass, discarded items?), (8) Availability of lighting
Microscale Audit of Pedestrian Streetscapes (MAPS)	Brownson et al. (2003)	Health	(1) Availability of street amenities (benches and seating area, drinking fountain), (2) Presence of path obstruction (trees), (3) Number of trees within 5 feet of either side of the sidewalk, (4) The order of planting the trees, (5) Coverage of trees along the sidewalk (percentage), (6) Number of driveways on the segments, (7) The degree of steepest cross slope, (8) Sidewalk width, (9) Availability of signal (pedestrian signal)

can be observed from windows and verandas to conduct surveillance of the sidewalk, the majority of audit tools did not consider this factor. In addition, these tools overlooked the items related to disability issues. Although these tools considered some microscale design factors, they are not sufficient for an inclusive assessment.

Microscale audit of pedestrian streetscapes (MAPS) (Brownson et al., 2003) devoted a section to sidewalk assessment. Although this section consisted of nine questions regarding sidewalk design factors, assessing many sidewalk facilities, such as drinking fountains, benches, and tactile pavement for people with disability, is overlooked. Furthermore, the surveillance of sidewalks is not assessed by this tool. PIN3 neighbourhood audit instrument (Evenson et al., 2009) assessed the presence of sidewalks, path condition, material and surface, public lighting, and trees casting shade along the sidewalks. This tool considered few numbers of microscale design factors, as well as items regarding assessment for people with disability; thus it is not sufficient for a comprehensive assessment. The section of the sidewalk assessment of the Irvine Minnesota inventory (I–M) (Boarnet et al., 2006) considered seven questions regarding assessing the presence of continuous sidewalk, path condition and maintenance, protection from weather conditions, and buffering. Although, several items related to sidewalk design have been considered, many sidewalk facilities and amenities are absent in this tool, such as drinking fountains, trash receptacles, and bollards. Moreover, this tool lacks items regarding assessing the disability issues, such as elevators next to skybridges and tactile pavement.

Analytic audit tool (Brownson et al., 2003) measured very limited number of factors regarding presence, location, and continuity of sidewalks, path condition and levelness, sidewalk width, and obstructions in sidewalks. This tool also neglects to consider sufficient number of microscale sidewalk design factors for an inclusive assessment. In addition to the noted drawbacks of existing audit tools regarding sidewalk assessment, walkability audit tools are expensive and time consuming (McMillan et al., 2010; Rundle et al., 2011). Furthermore, the audits are criticised because of their reliability and result consistency (Clifton et al., 2007).

In general, audits suffer from numerous drawbacks. First, the reliability of the audit items may depend on the auditors' interpretation. For example, an auditor might interpret the item 'obstruction to pedestrian movement' (e.g. sign poles and trees) subjectively and report his/her perception of whether sign poles or trees are obstacles to him/her rather than merely reporting their availability on the sidewalk (Cerin et al., 2011). Second, the audit is a time-dependent procedure, which means that the results may vary on a day-to-day or week-to-week basis (Kelly et al., 2007). For instance, the number of path obstructions or shades from trees may depend on the time of day or season of the year. It is also suggested that, to produce an adaptive survey for assessing the facilities for people with disability, trained auditors who have been involved in and working with disabled people should perform the audit (Rahim and Samad, 2010).

2.1.2. Questionnaires

Questionnaires are another important data collection instrument. Using a questionnaire is a practical approach for capturing and assessing people's perception (Batista e Silva et al., 2013). When it comes to physical activity and walkability assessment, several studies used questionnaires for assessing whether the neighbourhood environment characteristics are related to the levels of physical activity and walking, as well as the liveability of the community (Kihl et al., 2005; Saelens et al., 2003). The most widely used instrument in the form of questionnaire is the neighbourhood environment walkability survey (NEWS) developed by Saelens et al. (2003), which considered some items regarding sidewalk assessment. This tool asks people to describe their walking environment regarding sidewalk presence and maintenance, lighting, surveillance and cleanliness, as well as the separation of pedestrian from vehicles (buffering). However, this instrument neglects to consider issues related to disability as well as assessment of some sidewalk amenities, such as drinking fountains, tactile pavements, toilets, and elevators.

Liveable communities (Kihl et al., 2005) focuses on aged people. This tool included some items regarding assessing the presence and maintenance of sidewalks, visibility of curb cuts, sidewalk obstructions, regulations regarding snow removal from sidewalk, sidewalk width, presence of non-pedestrians that makes walking difficult such as bicyclists, and skateboarders, presence and function of traffic signals, and sidewalk amenities. Twin cities walking survey (Forsyth et al., 2009) followed the same idea of liveable communities; however, this tool considers less sidewalk design factors, such as sidewalk presence and maintenance, and separation of pedestrian from vehicles (buffering).

2.2. Sidewalk assessment in pedestrian level of service (PLOS) methods

Pedestrian level of service (PLOS) methods are widely used by urban and transportation researchers. With regard to sidewalk assessment, these tools used multiple design factors for assessment purpose (Table 2). Several PLOS methods considered assessing the sidewalk presence and continuity (e.g., Landis et al., 2001). Examining the path characteristics factors, such as slope, sidewalk width, material, and surface condition was considered by numerous studies (e.g., Asadi-Shekari et al., 2012, 2014; Christopoulou and Pitsiava-Latinopoulou, 2012; Dowling, 2008; Kang et al., 2013). The existing PLOS tools considered a limited number of sidewalk amenities, such as benches, trees, lighting, and drinking fountains. Very limited number of PLOS methods considered an acceptable number of sidewalk amenities (e.g., Asadi-Shekari et al., 2012, 2014). Some tools also considered to identify and assess the items that create buffer between pedestrian and vehicle flow, such as landscape and trees, bollards, and parking on the street (e.g., Asadi-Shekari et al., 2014; Kang et al., 2013; Landis et al., 2001). Items concerning disability issues are overlooked by the majority of PLOS tools; some items like wheelchair accessible drinking fountains, accessible toilets, elevators next to skybridge, and tactile pavement are relevant to people's impairments and limitations. A limited number of PLOS methods included some items regarding disability issues (e.g., Asadi-Shekari et al., 2012, 2014; Christopoulou and Pitsiava-Latinopoulou, 2012). Some tools consider assessing the presence of signage and signals which are other important facilities for warning the pedestrian of upcoming vehicles and guiding them to their destinations (e.g., Asadi-Shekari et al., 2012, 2014).

Based on Asadi-Shekari et al. (2014) the missing part of existing PLOS methods is the lack of reliable measures for data collection and assessing the streets for pedestrians with various disabilities; thus, the existing methods are not sufficient for

Table 2
Summary of prior PLOS tools.

Authors	Sidewalk indicators
Jaskiewicz (2000)	(1) Buffer, (2) Shade Trees
Landis et al. (2001)	Lateral separation elements: (1) Width of outside lane, (2) Width of shoulder or bike lane, (3) On-street parking effect coefficient, (4) Percentage of segment with on-street parking, (5) Buffer area barrier coefficient, (6) Buffer width, (7) Sidewalk presence coefficient, (8) Width of sidewalk
Dowling (2008)	(1) Sidewalk width, (2) Shoulder width, (3) On-street parking, (4) Barrier, (5) Buffer width
Asadi-Shekari et al. (2012)	(1) Buffer and barriers (curb and furnishing zone), (2) Land scape and trees, (3) Facilities (fire hydrants), (4) Furniture (trash receptacles), (5) Footpath pavement, (6) Sidewalk on both sides, (7) Width of footpath, (8) Driveway, (9) Lighting, (10) Signage, (11) Bollard, (12) Curb ramp, (13) Wheelchair accessible drinking fountain, (14) Tactile pavement (guiding), (15) Tactile pavement (warning), (16) Ramp, (17) Grade, (18) Signal, (19) Bench and seating area, (20) Drinking fountain, (21) Slope
Christopoulou and Pitsiava-Latinopoulou (2012)	(1) Total sidewalk width, (2) Free height (without obstacles), (3) Guide for the blind, (4) Pavement condition of sidewalk, (5) Ramps, (6) Trees and plants
Kang et al. (2013)	(1) Plants or trees, (2) Visual damage of sidewalk surface, (3) Barrier separation of sidewalk from motor-vehicle traffic, (4) Decorated sidewalk surface, (5) Sidewalk width
Asadi-Shekari et al. (2014)	(1) Buffer and barriers (curb and furnishing zone), (2) Land scape and trees, (3) Facilities (fire hydrants), (4) Furniture (trash receptacles), (5) Footpath pavement, (6) Sidewalk on both sides, (7) Width of footpath, (8) Driveway, (9) Lighting, (10) Signage, (11) Bollard, (12) Curb ramp, (13) Wheelchair-accessible drinking fountain, (14) Tactile pavement (guiding), (15) Tactile pavement (warning), (16) Ramp, (17) Grade, (18) Signal, (19) Bench and seating area, (20) Drinking fountain, (21) Slope

universal usage, especially the proposed PLOS models, which assumed pedestrians without disability (Dowling, 2008). Although, the majority of existing PLOS methods consider pedestrian indicators from the macroscale view (Jaskiewicz, 2000; Muraleetharan et al., 2005; Petritsch et al., 2005), De Cambra (2012) and Southworth (2005) acknowledged that microdesign qualities of pedestrian condition are more important for identification of the quality of walking environment. As a result, most existing PLOS methods cover a narrow range of indicators and pedestrian requirements and may not be applicable to all situations.

Using macro and microdesign factors are two fundamental approaches in the assessment of pedestrian environment. The macroscale design factors are density, diversity, design, destination accessibility, and distance to transit (Kim et al., 2014). These factors are mostly evaluated in certain boundaries like neighbourhoods. The microscale design factors are path quality and sidewalk amenities. These factors are commonly assessed at street level (Pikora et al., 2002; Troped et al., 2006). Despite the progress in developing pedestrian environment assessment tools, few walkability and PLOS studies assessed microscale environmental factors at neighbourhood level; instead, they mostly assessed macro/mesoscale factors. The neglect of microscale design factors has been a fundamental oversight, which can result in inaccurate results.

Consequently, this study develops a tool in form of questionnaire. Using questionnaire is a pragmatic approach to capture the public perception toward their environment (Batista e Silva et al., 2013), and helped this study to assess the overall view of the residents toward their neighbourhood sidewalks. This study introduced an analytical point system, which is simple and produced desired outcomes, to evaluate the neighbourhood sidewalks. While the existing tools do not consider intermediate condition for the responses, the NSAT takes it into consideration as well. The existing tools do not consider sufficient number of sidewalk facilities; thus, the proposed tool aims to remedy this shortage by utilising the widest range of sidewalk design factors. Concerning accessibility of the sidewalk factors for people with disability, this tool assessed the factors to examine whether they are accessible to people with disability, which is not considered in the majority of existing walkability and PLOS tools. For instance, the space between bollards were assessed to determine the passability of the bollards to wheelchair users' movement. This study also assessed microscale design factors at neighbourhood level, which was rarely done before. The details of the methods and materials used in this study are discussed in the following sections.

3. Tool development objectives

Sidewalk assessment is an integral component of walkability assessment tools and pedestrian level of service methods. The walkability assessment tools aim to objectively assess the physical environment as a whole and provide reliable information about the pedestrian environment in particular. The outputs of these tools might lead to identifying and eliminating the barriers to convenient walking opportunities within the streets and neighbourhoods. While these attempts contributed to shape well the reliable audits for assessing the pedestrian environments and sidewalks, few studies have developed objective and systematic tools in the form of a questionnaire to assess the sidewalks at the neighbourhood level. Although the progress in developing of microscale assessment tools has continued, few walkability studies in the form of questionnaires included microscale sidewalk factors; instead, they primarily focused on macro/mesoscale factors. However, related studies to the pedestrian environment assessment suggest that microscale factors play a vital role in walkability, and eliminating them may lead to inaccurate results in empirical studies. Lastly, a limited number of tools in the form of

Table 3
Selected sidewalk design factor specifications and design considerations

Factor	Specification	Design consideration
Seating areas	1) Provide convenience for pedestrian (County of Brant, 2013; Galanis and Eliou, 2011; Kihl et al., 2005) 2) Create a buffer between pedestrian and vehicles (Asadi-Shekari et al., 2013, 2014; City of Boston, 2013)	a) The benches must be accessible for people with disability (Troped et al., 2006) b) The benches and seating areas should not obstruct the path of travel (Alberta Transportation and Utilities, 1996) c) Design of benches and seating areas should be beautiful and proper (City of Boston, 2013) d) The benches should be located in a safe distance (Asadi-Shekari et al., 2013, 2014; City of Boston, 2013)
Bollards	1) Separate pedestrian from vehicle traffic (Van Cauwenberg et al., 2012)	a) The space between bollards should be sufficient for easy passage of wheelchair users (Centre for Excellence in Universal Design, 2014) b) The bollards should not obstruct the path of travel for pedestrian (City of Boston, 2013) c) The shape, height, and colour of bollard should be appropriate (City of Boston, 2013)
Drinking Fountains	1) Impact the accessibility and attractiveness of the walking environment (De Cambra, 2012; Sarkar, 2003)	a) Provide shorter/smaller size drinking fountains to serve wheelchair users and children (ADA, 2010; Centre for Excellence in Universal Design, 2014; City of Toronto, 2004; Stark et al., 2007)
Landscape and Trees	1) Create pleasant street environment (Lee et al., 2009; U.S. Department of Transportation, 2002) 2) Create buffer between pedestrian and vehicles (Landis et al., 2001; MacNeil, 2012; Samarasekara et al., 2013; Southworth, 2005; Todorova et al., 2004) 3) Help to deter crime (Cui et al., 2012; Hernandez, 2013; Kihl et al., 2005)	a) The trees should cast shade for pedestrian (Kihl et al., 2005; Otak, 2003) b) Separate pedestrian from vehicles (U.S. Department of Transportation, 2002; UNC Highway Safety Research Center, 2000; University of North Carolina, H.S.R.C., 2004) c) Remove any obstruction on sidewalk caused by trees (Boisseau, 1999; Centre for Excellence in Universal Design, 2014; County of Brant, 2013; Otak, 2003; Troped and Cromley, 2005; Venter et al., 2002) d) Provide attractive design for landscape along the sidewalk (Otak, 2003; Southworth, 2005)
Toilets	1) Pedestrian convenience	a) The toilets should be clean b) Equip the toilets with accessible facilities (Austrailian Government, 2013; City of Toronto, 2004)
Trash Receptacles	1) Impact the visual appeal and cleanliness of the sidewalk (Kansas City Walkability Plan, 2014)	a) The trash receptacles should not obstruct the path of travel for pedestrian (The City of Calgary, 2010; U.S. Department of Transportation, 2002) b) Trash receptacles must be well maintained (cleanliness and function)
Elevators next to skybridges	1) Make the elevators accessible for people with disability	a) Using the elevators for people with disability should be easy* b) Elevators must be well maintained (Cleanliness and function)
Driveways	1) Increasing the risk of conflicts between pedestrian and vehicles (Otak, 2003)	a) The pedestrian should be alerted of upcoming driveways (signs, audible signals, mirrors, and special paving) (Otak, 2003) b) The slope of the driveways should be appropriate for usage of wheelchair users (Otak, 2003)
Slope	1) Allow to maintain pedestrian movement without extra force (Akiyama and Kim, 2005)	a) The minimum slope should be considered for sidewalks to be usable for people with disability
Material/Surface	1) Allow to maintain pedestrian movement (Centre for Excellence in Universal Design, 2014; City of Minneapolis, 2009)	a) The surface should be even and slip resistant (Austrailian Government, 2013; City of Minneapolis, 2009; City of Ottawa, 2009; Kihl et al., 2005; Southworth, 2005) b) The material used should be suitable for people with disability (Austrailian Government, 2013; CEN/CENELEC, 2002; Centre for Excellence in Universal Design, 2014; City of Minneapolis, 2009; City of Toronto, 2004; Deichmann et al., 2004; Ferreira and Sanches, 2007; Oxley and Britain, 2002; Stark et al., 2007; U.S. Department of Transportation, 2002, 2004) c) The surface of the sidewalks should not have holes and cracks
Effective Sidewalk Width	1) Impact comfort and enjoyment of walking (Krambeck, 2006)	a) Provide sufficiently wide and clear sidewalk (Azemati et al., 2011; Cervero, 2002; City of Boston, 2013; Kim et al., 2011; Krambeck, 2006; Lin and Chang, 2010; Rodríguez and Joo, 2004; Samarasekara et al., 2013)
Signals	1) Impact safety and accessibility of the sidewalk (Boisseau, 1999)	a) Provide audible and flashing crossing signals (Boisseau, 1999; Centre for Excellence in Universal Design, 2014).
Signage	1) Warn and guide the pedestrian (Otak, 2003)	a) Provide simple, understandable, and visible signs (Rickert and Reeves, 1998)

Table 3 (*continued*)

Factor	Specification	Design consideration
Tactile Pavement	1) Provide accessibility for people with disability (Alberta Transportation and Utilities, 1996)	a) The tactile pavements should be appropriately raised and coloured (Preiser, 2007) b) Provide sufficient tactile pavements at intersections, driveways, etc. (Deichmann et al., 2004; Fearnley et al., 2011; Hanson, 2004; Monteiro and Campos, 2012; Oxley and Britain, 2002; Rickert and Reeves, 1998)
Ramps	1) Help to transition between elevations (ISO/IEC, 2001)	a) Provide appropriate slope for ramps (ISO/IEC, 2001) b) Provide ramps where any level change exists on sidewalks (ISO/IEC, 2001)
Curb Ramps	1) Provide accessibility for people with disability	a) The design of the ramp should be suitable to serve people with disability (Otak, 2003).
Cleanliness	1) Make the sidewalks more attractive, comfortable, and aesthetic (De Cambra, 2012; Galanis and Eliou, 2011; Handy and Clifton, 2001; Krambeck, 2006; Suminski et al., 2005)	a) Remove litter, graffiti or broken facilities along the sidewalks (Krambeck, 2006)
Lighting	2) Enhance crime and traffic safety (Crews and Zavotka, 2006; Haans and de Kort, 2012; Painter, 1996)	a) Provide adequate pedestrian lighting along the sidewalk (Crews and Zavotka, 2006)

questionnaires assess the microscale sidewalk factors. To fill this gap, this study develops a new tool using the microscale factors for assessing the sidewalks at the neighbourhood level. Based on Andréa D. Livi and Clifton (2004), the proposed tool is classified as a community-based survey, which encourages on-the-ground improvements and do not have any questions about walking behaviour. This type of tool is interested in perceptions of walkability. The questions regarding the perception of community members are a convenient way to draw actual walkability conditions instead of potentially time-consuming and costly windshield surveys. Moreover, they provide an opportunity for the communities to involve the public in the planning process. The residents can perceive subtle differences of the neighbourhoods, which may result from the shared governance and geographical proximity of the areas. This ability of respondents to recognise the differences can provide strong support for the validity of the subscale constructs (Saelens et al., 2003). The proposed tool is capable of giving an overall awareness of the neighbourhoods' sidewalk conditions to the city planners. The outcomes of this tool may assist in the direction and priorities of investments.

4. Materials and method

4.1. Factor selection

This study used a wide range of sidewalk design factors to consider people with different needs and abilities. The pedestrian environment assessment tools (audits and questionnaires) and sidewalk design guidelines were reviewed to identify relevant factors for inclusion in a first attempt to generate an assessment tool for examining whether the condition of the sidewalks is suitable for unhindered walking. Based on the review, 18 items were determined: seating areas, bollards, drinking fountains, landscape and trees, toilets, trash receptacles, elevators next to skybridges, driveways, slope, material/surface, effective width of the sidewalks, curb ramps, ramps, tactile pavement, signage, signals, lighting, and cleanliness. Table 3 presents the selected sidewalk design factors, as well as their contribution in the different aspects of walking such as safety, accessibility, attractiveness, and convenience. The rightmost column shows the design considerations for each sidewalk design factor, which helped this study to assess the selected factors. The design considerations were adopted by reviewing various sidewalk design guidelines, accessible design standards, universal design handbooks, and scientific articles on pedestrian issues. These factors are evaluated in the three neighbourhoods of Johor Bahru District in Malaysia.

4.2. Method

This study proposes a new tool to assess the sidewalk factors using the residents' judgment toward their neighbourhood's sidewalks. This tool is developed in the form of two questionnaires. The first one evaluates the importance of each sidewalk facility for the residents of the neighbourhoods. With regard to the measurement scale, this research used a five-point Likert scale. The five-point Likert scale used in this step of research ranged from 1 (least important) to 5 (extremely important). The outputs of this questionnaire are used to generate the relative weight for each sidewalk indicator. This step has been taken because the identified factors do not have the same impacts on the overall condition of the sidewalks. In addition, some sidewalk design factors may have very different perceived importance to society, depending on the people's physical condition and characteristics, such as ethnicity, age, and gender.

The second questionnaire attempts to assess the selected factors using the residents' perception toward their neighbourhoods' sidewalk conditions. Each sidewalk design factor is evaluated by means of some statements that the residents should show their level of agreement (refer Table 4). Survey items were developed from an extensive literature review and

Table 4
Assessment items of the sidewalk factors

Factor 1: Seating areas	Factor 7: Elevators next to skybridges	Factor 13: Signage
Q_1: There are sufficient seating areas along the sidewalks in your neighbourhood. Q_2: The existing sidewalk benches in your neighbourhood are comfortable to use. Q_3: There is enough space for wheelchair users to sit alongside other people. Q_4: The sidewalk benches do not obstruct the continuous path of travel. Q_5: There is a safe distance from vehicles while I am seated on a sidewalk bench. Q_6: The sidewalk benches and seating areas are attractively designed.	Q_{28}: There are elevators/lifts next to skybridges along the neighbourhood sidewalks. Q_{29}: It is easy for people with disabilities to use the existing elevators. Q_{30}: The existing elevators are well maintained.	Q_{40}: The existing signs along the neighbourhood sidewalks are readable and understandable (consider colour and contrast with background). Q_{41}: The existing signs give me enough information regarding the surrounding environment.
Factor 2: Bollards	Factor 8: Driveways	Factor 14: Tactile Pavement
Q_7: There are sufficient bollards along neighbourhood sidewalks to prevent vehicles from entering the sidewalk. Q_8: It is easy for wheelchair users to pass the bollards. Q_9: The bollards do not obstruct the continuous path of travel. Q_{10}: The bollards have an attractive design.	Q_{31}: There are not a lot of driveways crossing the neighbourhood sidewalks. Q_{32}: The slope of existing driveways is suitable for wheelchair users. Q_{33}: I feel safe when I am approaching or crossing the driveways through the neighbourhood sidewalks.	Q_{42}: There is sufficient tactile pavement along the neighbourhood sidewalks for blind and visually impaired people. Q_{43}: The tactile pavement is raised and coloured properly to warn and guide blind and visually impaired people. Q_{44}: The existing detectable warnings are sufficient and helpful at intersections, driveways, and subsequent direction changes along the neighbourhood sidewalks.
Factor 3: Drinking Fountains	**Factor 9: Slope**	**Factor 15: Ramps**
Q_{11}: There are sufficient drinking fountains along the sidewalks in the neighbourhood. Q_{12}: It is easy for me to use the existing drinking fountains on the sidewalk. Q_{13}: There are enough drinking fountains that are suitable for kids and wheelchair users. Q_{14}: The existing drinking fountains do not obstruct the continuous path of travel. Q_{15}: The existing drinking fountains on your neighbourhood sidewalks have an attractive design.	Q_{34}: The slope of the neighbourhood sidewalks allows me to walk easily.	Q_{45}: The slope of existing ramps along the neighbourhood sidewalks is appropriate for wheelchair users. Q_{46}: There are sufficient ramps where any level change exists along the neighbourhood sidewalks.
Factor 4: Landscape and Trees	**Factor 10: Material/Surface**	**Factor 16: Curb ramps**
Q_{16}: There are sufficient trees to provide a sidewalk canopy and shade for pedestrians. Q_{17}: Suspended tree branches do not obstruct the neighbourhood sidewalks. Q_{18}: There are enough trees to separate the neighbourhood sidewalks from the streets. Q_{19}: Existing trees do not obstruct the continuous path of travel. Q_{20}: Existing trees and landscape along the neighbourhood sidewalks have an attractive design.	Q_{35}: The material and surface of the neighbourhood sidewalks are even and slip resistant and allow me to walk freely. Q_{36}: The surface material is suitable for wheelchair users. Q_{37}: There are no holes, bumps, and cracks on the neighbourhood sidewalks.	Q_{47}: There are sufficient curbs cut for the existing crosswalks. Q_{48}: The slope and design of existing curb ramps are appropriate for wheelchair users.
Factor 5: Toilets	Factor 11: Effective Sidewalk Width	Factor 17: Cleanliness
Q_{21}: There are sufficient toilets along the neighbourhood sidewalks. Q_{22}: It is convenient to use existing toilets along the neighbourhood sidewalks.	Q_{38}: The neighbourhood sidewalks are sufficiently wide for me to pass with other pedestrians.	Q_{49}: There are no litter, graffiti or broken facilities along the neighbourhood sidewalks.

Table 4 (*continued*)

Factor 5: Toilets	Factor 11: Effective Sidewalk Width	Factor 17: Cleanliness
Q_{23}: Existing toilets along the neighbourhood sidewalks have suitable facilities for people with disabilities.		
Q_{24}: Existing toilets are clean.		
Factor 6: Trash Receptacles	**Factor 12: Signals**	**Factor 18: Lighting**
Q_{25}: There are sufficient trash receptacles on the neighbourhood sidewalks.	Q_{39}: The existing audible signals are sufficient and helpful at intersections.	Q_{50}: There is adequate pedestrian scale lighting on the neighbourhood sidewalks.
Q_{26}: The existing trash receptacles do not obstruct the continuous path of travel.		
Q_{27}: The existing trash receptacles are well maintained.		

expert review. This study evaluates the selected factors to ensure the safety, attractiveness, and accessibility for people with disability.

As mentioned earlier, a comprehensive list of potential proposed tool items was developed, with each item supported by literature review as being important for using the sidewalks for walking by all users. The complete list was submitted to the group of experts from fields of planning and public health for review. Reviewers were provided space to enter written comments on each statement and were also asked to identify important statements that were missed, statements that should be deleted, and whether the proposed tool adequately addressed issues of safety and attractiveness, as well as accessibility for people with disability in neighbourhoods. This study also performed a pilot study with 38 respondents to improve content validity and test the practicability and communicability of the statements. Changes to the proposed tool were minimal and involved clarifying unclear statements by inserting pictures and parenthetical examples.

4.3. Mathematical definition

Mathematically, the NSAT score can be defined as follows:

$$\text{NSAT Score}=\sum_{j=1}^{18} SI_j W_j \tag{1}$$

Here, NSAT score = neighbourhood sidewalk assessment score, W = sidewalk indicator weight, SI = indicator score, and j = indicator number.

The relative weight of each indicator (W) presents the effectiveness of each sidewalk factor for the NSAT; thus, the importance and priority of each sidewalk factor is illustrated by (W). This research considered all sidewalk factors as important, so the range of rates starts from one. Therefore, the normalised weight of each sidewalk factor is defined as follows:

$$\mathrm{Wi} = \left(\frac{1}{\mathrm{R_t}}\sum_{i=1}^{n} \mathrm{R_{ij}}\right) \times 100 \tag{2}$$

Here, W = normalised weight of each sidewalk factor, R = indicator rate, R_t = sum of all indicator rates, i = indicator number, and j = respondent number (in this study the 600 residents of Johor Bahru were asked to rate the importance of the sidewalk factors).

To achieve the NSAT score, the SI must be calculated. The SI for each factor can be achieved by calculating the mean score from five-point Likert rating scale to indicate the level of agreement with the proposed statements for each factor. In this case, strongly agree was five points, agree was four points, neutral was three points, disagree was two points while strongly disagree was one. Therefore, the factor assessment score is defined as follows:

$$SI_j = \frac{1}{n} \sum_{\substack{1 \le i \le n \\ 1 \le j \le 18}} Q_{ij} \quad (3)$$

Here, SI = factor assessment score, Q = mean score of the statements within each sidewalk factor, i = number assigned to the statements (referring to Table 1), j = number assigned to the sidewalk factor (referring to Table 1), and n = total number of statements within each sidewalk indicator.

To calculate the mean score of the questions within each sidewalk indicator, Eq. 4 is used. In Eq. (4), the rates given by the respondents to the questions within each sidewalk indicator are added up and then are divided by the total number of respondents.

$$Q_{ij} = \frac{\sum_{1 \le j \le 18}^{1 \le i \le n} R_{ij}}{N} \quad (4)$$

Here, Q = mean score of the statements within each sidewalk factor, R = the rates given by the respondents to the statements within each sidewalk factor, N = total number of respondents, i = number assigned to the statements (referring to Table 1), and j = number assigned to the sidewalk factors (referring to Table 1).

Explaining the results of NSAT by means of percentage facilitates the understanding of the NSAT value. This percentage show scores that existing neighbourhood sidewalks can achieve from total possible points. The percentage of NSAT is indicated as follows:

$$\text{NSAT\%} = \frac{\text{NSAT Score}}{5 \times \sum_{j=1}^{18} w_j} \times 100 \quad (5)$$

Here, NSAT% = percentage of neighbourhood sidewalk assessment, and NSAT Score = neighbourhood sidewalk assessment score.

The NSAT% can be simplified as shown in Eq. (6).

$$\text{NSAT\%} = \frac{\text{NSATScore}}{5} \quad (6)$$

Table 5 presents the different range of scores, descriptions, and required levels of improvement (RLI). NSAT ‘A’ (80 ≤ NSAT% ≤ 100) indicates that the sidewalk is in very good condition. NSAT ‘B’ (60 ≤ NSAT% ˂ 80) indicates that the sidewalk is in good condition and limited improvements are needed. NSAT ‘C’ (40 ≤ NSAT% ˂ 60) means the sidewalk condition is acceptable, but needs some improvements. NSAT ‘D’ (20 ≤ NSAT% ˂ 40) and ‘E’ (0 ≤ NSAT% ˂ 20) show that the sidewalks are in poor condition and not appropriate for walking; these sidewalks need to get special attention to be improved.

4.4. Selected neighbourhoods

To keep abreast with the changes of urban planning strategies over time, this research selected randomly three neighbourhoods from different eras: the neighbourhood established during the 80 s considered as old-aged type; the neighbourhood established during the 90 s considered as middle-aged type; and the neighbourhood established during the 2000 s considered as young-aged type. To attain this, three case studies of neighbourhoods within the Johor Bahru District in Malaysia have been randomly selected: Bandar Baru Uda (old-aged type), Taman Universiti (middle-aged type), and Taman Scientex Mutiara Mas (young-aged type).

Table 5
NSAT% interpretation.

SEUA%	Grade	Condition	Description	Level of required improvements
80 ≤ *SEUA%* ≤ 100	A	Very Good	The neighbourhood sidewalks provide excellent support for the residents	Very limited improvements are required
60 ≤ *SEUA%* < 80	B	Good	The neighbourhood sidewalks adequately serve the residents	Limited improvements are required
40 ≤ *SEUA%* < 60	C	Regular	The neighbourhood sidewalks serve the residents adequately	Some improvements are required
20 ≤ *SEUA%* < 40	D	Poor	The neighbourhood sidewalks do not support the residents	Many improvements are required
0 ≤ *SEUA%* < 20	E	Awful	The neighbourhood lacks appropriate sidewalks to serve the residents	Too many improvements are required

Table 6
Socio-demographic characteristics of the respondents in the selected neighbourhoods.

Characteristic	Taman Universiti (n = 136)		Taman Scientex (n = 96)		Bandar Baru Uda (n = 153)	
	N	Percentage (%)	N	Percentage (%)	N	Percentage (%)
Gender						
Male	56	41.2	36	37.5	57	37.3
Female	80	58.8	60	62.5	96	62.7
Age						
18-24	24	17.6	24	25	49	32
25-44	86	63.2	47	49	59	38.6
45-64	20	14.7	21	21.9	42	27.5
65 and over	6	4.4	4	4.2	3	2
Disability						
Yes	5	3.7	2	2.1	2	1.3
No	131	96.3	94	97.9	151	98.7
Race						
Chinese	28	20.6	40	41.7	12	7.8
Indian	9	6.6	4	4.2	3	2
Malay	98	72.8	52	54.2	138	90.2

4.5. Sampling design

This study has categorised the different area types within the selected neighbourhoods. Based on field observations, the study has defined three types of areas, i.e. areas with good sidewalks, areas with regular sidewalks, and areas with poor sidewalks. The samples were stratified according to the sidewalk condition of the area. This grouping attempts to include responses of residents who live in different areas with different sidewalk conditions into the study and estimate the overall sidewalk conditions.

4.5.1. Weighting stage

600 of Johor Bahru residents were randomly asked to rate the importance of sidewalk factors. This number ensures that the perception of the wide range of people of Johor Bahru District toward the importance of sidewalk factors is captured.

4.5.2. Assessment stage

385 residents of the selected neighbourhoods of Johor Bahru participated in the assessment of sidewalk factors. Ninety-six residents were from Taman Scientex, 136 residents from Taman Universiti, and 153 residents were from Bandar Baru Uda. The minimum sample size was calculated at a confidence level of 95% and a 10% margin of error. Table 6 presents the socio-demographic profile of the respondents in the selected neighbourhoods.

4.6. Reliability

This study used internal consistency to test the reliability of the measurement items of the proposed tool. Cronbach's alpha (α) was used to assess the internal consistency of the tool. It estimates how well a set of items (questions) measures a single unidimensional object. It has been suggested that the alpha value of 0.7 and above indicates reliability of scale (George and Mallery, 2003; Vaus, 2002).

5. Analysis results

5.1. Assessment results

Neighbourhoods with different characteristics can be evaluated with the NSAT tool because it involves a wide range of sidewalk factors and can be used in various contexts. The collected data from the first questionnaire (weighting questionnaire) have been analysed to generate a normalised weight for each sidewalk factor (refer to Eq. 2). Table 7 shows the generated weights before and after normalisation. This table also indicates the weighting results based on respondents' characteristics such as gender and age. A t-test and ANOVA were used to analyse differences in mean scores between gender and age groups. The gender of respondents caused significant differences only in the ranking of drinking fountains (P-value = 0.03) and elevators next to skybridges (P-value = 0.0001). The significant differences were observed only for ramp (P-value = 0.03), signal (P-value = 0.04), and seating area (P-value = 0.03) regarding the impact of respondents' age.

The NSAT% is calculated for the three neighbourhoods (refer to Eq. 6). To obtain the NSAT% for each of the sidewalk factors and overall NSAT% for the neighbourhood sidewalks, it is crucial to determine the level of improvements of the sidewalks as a whole and the sidewalk facilities, in particular. Table 8 presents the NSAT% for the selected neighbourhoods,

Table 7
Attributed weights to the sidewalk factors[a].

Sidewalk Factor	RWG		RWA				Cumulative	
	Male	Female	18-24	25-44	45-64	≥ 65	Raw weight	Normalized weight
Bollard	1211	1228	311	1577	528	23	2439	5.54
Cleanliness	1244	1304	322	1647	552	27	2548	5.79
Curb ramp	1184	1216	306	1548	523	23	2400	5.46
Drinking Fountain	1033	1127*	277	1403	458	22	2160	4.91
Driveway	1189	1221	314	1559	510	27	2410	5.48
Effective width of the sidewalk	1255	1265	322	1636	538	24	2520	5.73
Elevator	1012	1132*	270	1388	466	20	2144	4.87
Landscape and tree	1313	1331	343	1710	565	26	2644	6.01
Lighting	1309	1336	330	1719	571	25	2645	6.01
Ramp	1233	1256	319	1623	525	22*	2489	5.66
Signal	1204	1244	304	1604	517	23*	2448	5.57
Signage	1256	1258	326	1624	540	24	2514	5.72
Seating area	1234	1279	318	1643	527	25*	2513	5.71
Slope	1194	1219	320	1561	510	22	2413	5.49
Surface/material	1228	1266	325	1615	530	24	2494	5.67
Tactile pavement	1169	1222	307	1551	510	23	2391	5.44
Toilet	1155	1209	315	1528	499	22	2364	5.37
Trash receptacles	1208	1244	318	1600	513	21	2452	5.57

Raw Weight for Gender Groups = RWG: 6 = Male; 7 = Female.
Raw Weight for Age Groups = RWA: 1 = 18-24; 2 = 25-44; 3 = 45-64; 4 = 65 and over.
* *P-value* $<$ 0.05.
[a] The Cronbach's alpha of the 18 items is 0.878.

and also the level of required improvements (LRI) for the sidewalk facilities and the whole sidewalk. Results from Table 5 indicate that the NSAT% for Taman Univerisiti and Bandar Baru Uda are 35.43, and 39.28, respectively; therefore, the grade of the sidewalks of these neighbourhoods is ‘D’, which shows that the sidewalks are in poor condition and need too many improvements (refer to Table 5). Looking at the NSAT%, Taman Scientex achieves 41.60; therefore, the grade of the sidewalks of this neighbourhood is ‘C’, which means that the sidewalk condition in this neighbourhood is acceptable, but needs some improvements. Across the three neighbourhoods, the sidewalk factors that achieve ‘poor’ and ‘awful’ NSAT% need too many

Table 8
NSAT% and level of required improvements.

Indicator	TU	TSC	BBU	Indicator Weighting	SEUA% and level of required improvements (LRI)					
	Mean Score	Mean Score	Mean Score		TU		TSC		BBU	
					%	LRI	%	LRI	%	LRI
Seating areas	1.02	1.13	1.18	5.71	20.39	4	22.59	4	24.13	4
Bollards	1.14	1.66	1.57	5.54	22.82	4	33.21	4	32.02	4
Drinking fountains	0.13	0.40	0.26	4.91	2.61	5	7.98	5	5.54	5
Landscape and trees	2.60	3.15	3.00	6.01	52.01	3	63.00	2	60.00	2
Toilets	0.19	0.18	0.14	5.37	3.80	5	3.61	5	2.79	5
Trash receptacles	2.84	2.82	2.61	5.57	56.80	3	56.41	2	52.32	3
Elevators next to skybridges	0.44	0.10	0.30	4.87	8.79	5	2.01	5	6.24	5
Driveways	2.37	2.20	2.05	5.48	47.41	3	44.01	3	40.69	3
Slope	3.27	3.45	3.46	5.49	65.39	2	69.00	2	69.29	2
Material/surface	2.88	3.18	3.46	5.67	57.60	3	63.60	2	69.10	2
Effective sidewalk width	3.05	3.53	3.67	5.73	61.01	2	70.61	2	73.33	2
Signals	1.69	1.34	1.10	5.57	33.79	4	26.79	4	21.29	4
Signage	2.99	3.15	3.07	5.72	59.79	2	63.01	2	61.26	2
Tactile pavement	0.27	0.35	0.12	5.44	5.40	5	6.99	5	2.54	5
Ramps	0.95	1.28	1.29	5.66	19.01	5	25.58	4	26.01	4
Curb ramps	0.69	1.68	1.26	5.46	13.81	5	33.59	4	25.24	4
Cleanliness	2.19	3.20	2.83	5.79	43.80	2	64.01	2	56.72	3
Lighting	2.53	2.95	3.11	6.01	50.62	2	59.00	2	62.63	2
Overall NSAT%					**35.43**		**41.60**		**39.28**	
Overall level of required improvements					**4**		**3**		**3**	

Taman Universiti: TU; Taman Scientex: TSC; Bandar Baru Uda: BBU
Level of required improvements = LRI: 1 = Very limited improvements are required; 2 = Limited improvements are required; 3 = Some improvements are required; 4 = Many improvements are required; 5 = Too many improvements are required

Table 9
Alpha value for the sidewalk factors across the case study neighbourhoods.

Sidewalk Factor or Subscale	Number of items	Taman Universiti (n= 136) Reliability (α)	Taman Scientex (n= 96) Reliability (α)	Bandar Baru Uda (n= 153) Reliability (α)
Seating areas	6	0.988	0.977	0.990
Bollards	4	0.983	0.982	0.984
Drinking fountains	5	0.981	0.886	0.993
Landscape and trees	5	0.974	0.952	0.979
Toilets	4	0.973	0.996	0.998
Trash receptacles	3	0.957	0.979	0.988
Elevators next to skybridges	3	0.970	0.996	0.980
Driveways	3	0.986	0.990	0.994
Path characteristics (slope + material/surface + effective sidewalk width)	5	0.707	0.859	0.774
Warning and guiding facilities (signals + signage)	3	0.800	0.781	0.756
Tactile pavement	3	0.992	0.998	0.998
Ramps	2	0.996	0.993	0.981
Curb ramps	2	0.991	0.999	0.984
Qualitative characteristics (Cleanliness + lighting)	2	0.714	0.727	0.809

improvements, such as seating areas, bollards, drinking fountains, toilets, elevators next to skybridges, signals, tactile pavements, ramps, and curb ramps. A limited number of sidewalk factors achieved 'good' NSAT% over the selected neighbourhoods; factors like slope, effective sidewalk width, and lighting need very little improvements.

5.2. Internal consistency

Table 9 shows the internal consistency reliability results for the elements grouped by factor type as shown in Table 1. As mentioned earlier, the alpha value should be at least 0.7 to show that the scale is reliable. For this research, the coefficients of Cronbach's alpha were 0.707 or higher during the assessment stage for all scales in the case study neighbourhoods. The high moderate and high value of alpha in the three neighbourhoods can show that the questionnaire yield same results over time and across neighbourhoods with different characteristics.

6. Discussion and conclusions

The present study was designed to describe the developments and evaluation of the neighbourhood sidewalks assessment (NSAT) tool. The previous studies neglected the importance of microscale sidewalk factors when it comes to assessing the physical environment at the neighbourhood level. The proposed tool considers people's needs and selects a wide range of sidewalk factors. This broad spectrum of sidewalk factors is capable of making this tool to be universally applicable. In addition, NSAT tool developed an easy-to-follow methodology for assessing the sidewalks of different neighbourhoods. Internal consistency test was used to determine the reliability of the sidewalk design factors within NSAT. Across the selected neighbourhoods, all factors showed moderate and high reliability. High reliability factors were mostly objective, as expected. Only a small number of questions relying on subjective assessments of sidewalk factors (qualitative characteristics in Taman Universiti and Taman Scientex) had a marginal reliability of more than 0.7, because of their intrinsically subjective nature. In total, the reliability results indicated that all items measure the same underlying sidewalk factors. The proposed tool was not designed for collecting data regarding walking behaviour and trip level, since collecting these data is not common for community-based survey tools. However, simple checks on the results of assessment show that the scores of the assessment items are consistent across the neighbourhoods. For instance, drinking fountain which is very scarce in the selected neighbourhoods has obtained an NSAT% below ten, which shows the awful condition of this item in the neighbourhoods (see Table 5). The NSAT% of drinking fountain across neighbourhoods correspond with the observation survey in the selected neighbourhoods. The consistency between the results of assessment items and their condition in real world provides strong support for the validity of the tool subscale constructs.

The NSAT tool is useful to city planners and designers for increasing the awareness about sidewalk conditions among local policy makers, prioritising investments, and finally upgrading the sidewalk facilities of the neighbourhoods. With respect to using the microscale factors to assess the physical environment of the neighbourhoods, researchers can use similar methodology and process to develop new assessment tools for other neighbourhood facilities and environments such as facilities for bicycling and even motoring. The proposed tool can be used in both rural and urban areas with appropriate modifications.

Acknowledgements

The authors wish to thank those who have supported this research for their useful comments. In particular, we would like to acknowledge the Universiti Teknologi Malaysia Research Management Centre (RMC) and Centre for Innovative Planning and Development (CIPD). The funding for this project was made possible through a research grant from the Ministry of Education, Malaysia under the Fundamental Research Grant Scheme (FRGS) 2015 [FRGS grant number R. J130000.7821.4F739].

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