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Validation of the physical activity neighborhood environment scale using geographic information systems among urban men and women in regional China

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ABSTRACT

Aims: To examine the concurrent validity of the Chinese version of Physical Activity Neighborhood Environment Scale (PANES-CHN) among urban adults in regional China.
Methods: With multistage sampling approaches, 801 eligible urban adults aged 35–74 years were recruited from Nanjing municipality of China between July and September of 2019. The neighbourhood built environment features were measured subjectively with PANES-CHN and objectively with geographic information system. The concurrent validity of PANES was assessed using Spearman's correlations (r_s).
Results: Among the total 801 participants, the mean age was 54.4 (standard deviation = 11.5), while 48.7 % were men. Overall, of all the five objectively-measurable built environment characteristics, the Spearman correlations were examined significant between subjective and objective measurements for commercial facilities (item 2) (r_s = 0.19, 95CI%=0.12, 0.25), recreational facilities (item 6) (r_s = 0.10, 95CI%=0.02, 0.16), traffic junctions (item 12) (r_s = 0.15, 95CI%=0.07, 0.22), medical/education facilities (item 17) (r_s = 0.22, 95CI%=0.15, 0.29), but not for public transport stops. Similar scenarios were observed for participants aged 35–60 years, with sufficient physical activity, men or women. The r_s value for medical/education facilities (item 17) was significantly higher in participants aged 35–59 years (0.28 *vs.* 0.13; p = 0.04) than those aged 60 + years.
Conclusions: PANES-CHN generally has an acceptable validity for assessing built environment characteristics among urban adults in China, which implies that PANES-CHN can be used to measure built environment attributes in health-related population studies.

1. Introduction

The neighborhood built environment is a multi-dimensional concept, including urban design, land use and public transportation system, which can exert compulsory influence on patterns of activity for those inhabitants who live within the neighborhood (Handy et al., 2002). There is growing evidence that a well-planned built environment can have positive effects on residents' physical activity and health conditions (Fitzpatrick and Willis, 2020; Frank et al., 2022; Giles-Corti et al., 2016; Sallis et al., 2016; Stevenson et al., 2016). For built environment-related studies in the field of population health, it is critical that reliable and valid instruments are available to assess built environment characteristics. The assessment of built environment attributes can be classified as objective or subjective measures. Objective assessment refers to direct observational audits via objective measuring approaches (McKenzie et al., 2006; Jago et al., 2005; Pikora et al., 2006), such as geographic information system (GIS) (Porter et al., 2004); implemented by researchers, while subjective assessment involves perceived built environment characteristics self-reported by participants through questionnaire surveys (Saelens et al., 2003; Cerin et al., 2006; Sallis

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et al., 2010).

Objective assessment has great strengths that it can reflect the actually existing built environment characteristics with excellent reliability and validity. However, the costly and complicated technologies limit its application to small-scale studies. For large-scale epidemiological population studies, subjective assessment of built environment features is more convenient, practicable and meaningful relative to objective approaches. Nowadays, the most-widely used subjective built environment assessment instrument is The Physical Activity Neighborhood Environment Scale (PANES), a brief self-report questionnaire, which was developed for assessing physical activity-supportive built environment features in neighborhoods (International Physical Activity Prevalence Study, 2012).

The test–retest reliability of PANES has been examined among adults in USA, Sweden, and Nigeria (Sallis et al., 2010; Oyeyemi et al., 2008; Alexander et al., 2006). Moreover, the original English version of PANES has been translated into Chinese (PANES-CHN) and examined with good reliability for both adolescents and adults in China (Xu et al., 2016; Zhao et al., 2018). However, little is known about the accuracy of PANES in assessing built environment attributes, as few studies have documented the agreement between built environment characteristics measured with PANES and an objective assessment instrument among the same participants.

It is of public health interest to examine the validity of PANES among specific populations worldwide, particularly in China that is witnessing a rapid transition in economy, urbanization, residents' lifestyle and behavior patterns over the past decades. To fill the gap, a community-based study was conducted to measure neighborhood built environment characteristics subjectively with PANES-CHN and, meanwhile, objectively with GIS among urban adults in Nanjing municipality of China. The main purpose of the study was to examine the concurrent validity of PANES-CHN among urban adults in regional China.

2. Methods

2.1. Study design and participants selection

A cross-sectional community-based survey was conducted between July and September of 2019 in urban areas of Nanjing municipality of China. Nanjing, a typical mega-city in China, had 8.4 million registered residents within twelve districts (six urban and six suburban) by the end of 2018 (Nanjing Municipal Bureau of Statistics, 2019). An individual would be eligible for participating in the study, if he/she was a local registered resident who: 1) aged 35–74 years, 2) lived for at least 6 months in urban areas of Nanjing, 3) had no physical or psychiatric disorders, and 4) was without literal or cognitive problems.

As no study is available regarding the concurrent agreement between subjectively and objectively measured built environment characteristics with PANES and GIS, the sample size in this study was calculated with consideration of that determined in previous similar studies and the general rule used to estimate participant's number for an academic study. The Neighborhood Environment Walkability Scale (NEWS), an instrument similar to PANES, has been validated using objective measurement (Adams et al., 2009). In this NEWS validation study, 878 participants were analyzed with sufficient statistical power (Cerin et al., 2006). On the other hand, it is a general rule that at least 10 subjects per item of an instrument will warrant a sufficient overall statistical power for examining the instrument validity (Sousa and Rojjanasrirat, 2011). Based on this rule for estimating sample size, $\geq$170 participants would be sufficient for single-stratum analysis in the present study as PANES has just 17 items. Therefore, considering 878 participants included in NEWS validation study and stratified analysis by age and/or gender, response rate (80 %) and design effect (1.5), the overall sample size was estimated to be approximately 800 in our study.

A multistage sampling approach was employed to select participants. Firstly, one of the six urban districts was randomly determined in Nanjing municipality. Then, four administrative streets were randomly chosen from all the 12 streets in the selected district. Next, one neighborhood in each chosen street was randomly determined, although the number of neighborhoods in the four chosen streets were 5, 6, 10, and 13, separately. Consequently, four neighborhoods in total were involved in the study. Thus, considering an overall sample size of 800 estimated, it was expected that about 200 participants would be selected from each of the four neighborhoods. To select participants from each neighborhood, we firstly contacted the committee of each chosen neighborhood for the consent. Then, based on the household list of each neighborhood, 200 eligible subjects were randomly determined with consideration of gender (man *vs.* woman: 1 *vs.* 1) and age-group (a 5-year interval).

Written informed consent was obtained from each participant before the survey. This study was approved by the Academic and Ethical Committee of Nanjing Municipal Center for Disease Control and Prevention. All data analyzed in this study were de-identified. The methods employed in this study were in line with recommendations by the Declaration of Helsinki.

2.2. Data collection

Participants self-reported their socio-demographic characteristics, built environment attributes and physical activity level. The built environment features were assessed subjectively with PANES-CHN (Xu et al., 2016; Zhao et al., 2018) and objectively with GIS. Physical activity level was measured using a validated short Chinese version of the International Physical Activity Questionnaire (IPAQ-CHN) (Appendix A) (Qu and Li, 2004). The IPAQ-CHN was translated from the original English questionnaire (Qu and Li, 2004). It is a frequency-based instrument to measure physical activity level via asking about weekly frequency and average duration each time a participant engaging in walking, moderate/vigorous physical activity, and sitting, separately. Thus, the total time of each type of physical activities could be computed. Participants' physical activity level was subsequently classified into two categories based on the sum of moderate and double vigorous physical activity time: sufficient ($\geq$150 min per week) or insufficient ($<$150 min per week) (World Health Organisation, 2010). Participants' body height and weight were measured to the nearest 0.1 cm and 0.1 kg two times, respectively, with each subject standing barefoot in light clothes. Mean values of these two measurements were used to calculate body mass index (BMI). Then, participants' body weight status was assessed using BMI cutoffs recommended specifically for Chinese adults (Chen and Lu, 2004).

3. Subjective measurements of built environment characteristics

3.1. PANES-CHN

Neighborhood built environment characteristics was measured subjectively with PANES-CHN in this study (Appendix B). The PANES includes 17 items measuring participants' perceived built environment features in a local neighborhood (a residence area with a 10–15 min walk distance away from home, which is about 1.0 km from home) (International Physical Activity Prevalence Study, 2012; Zhao et al., 2018). The 17 items of PANES describe neighborhood built environment characteristics in seven domains: 1) residential density, 2) access to destinations, 3) neighborhood infrastructure, 4) esthetic qualities, 5) social environment, 6) street connectivity, and 7) neighborhood safety. Of these seven domains of built environment attributes, access to destinations, neighborhood infrastructure and street connectivity can be measured objectively using GIS. Therefore, the agreement of subjectively and objectively measured built environment attributes was examined only for these objectively-measurable PANES items, including item 2 (commercial facilities, "Many shops, stores, markets or other places to buy things I need are within easy walking distance of my

home"), item 3 (public transportation stops, "It is within a 10–15 min walk to a transit stop (such as bus, train, trolley, or tram) from my home"), item 6 (recreational facilities, "My neighborhood has several free or low cost recreation facilities, such as parks, walking trails, bike paths, recreation centers, playgrounds, public swimming pools, etc"), item 12 (traffic junctions, "There are many 4-way intersections in my neighborhood"), and item 17 (medical or education facilities, "There are many places to go within easy walking distance of my home").

Each of the PANES items, with the exception of item 1 and 11, was assessed using a five-level likert scale (International Physical Activity Prevalence Study, 2012; Zhao et al., 2018). A forward scoring system was applied to items 2–6, 8–10, 12–14 and 17, while an inverse scoring approach was employed to items 7–8 and 15–16 (International Physical Activity Prevalence Study, 2012; Zhao et al., 2018). The option 'don't know/refused' was not included in the analyses (International Physical Activity Prevalence Study, 2012; Zhao et al., 2018). Therefore, in this study, answer option 'strongly disagree', 'somewhat disagree', 'somewhat agree' and 'strongly agree' were scored as 1, 2, 3 and 4, respectively, for each of item 2, 3, 6, 12 and 17 in our analysis.

3.2. Objective measurements of built environment

Neighborhood built environment characteristics was measured objectively with GIS, Baidu e-map, in this study. In China, Baidu Map, a widely used GIS-based e-map like Google Map and Open Street Map, provides navigating and positioning, as well as accurate real-world data of Points of Interest (POIs) (Chuanming, 2011). Using Baidu Map, objective information was obtained on various types of POIs within 1 km of each participant's residential area, and the recommended walking routes (the shortest walking routes) from the POIs to the entrances of residential area. Python 3.8 was used to scrape POI data from the Baidu Map API (Application Programming Interface). After all the information on these specific POIs collected objectively, they were then imported into ArcGIS 10.6 (Esri, Redlands, CA) software for analysis and spatial visualization.

POIs referred to the proxies for real-world locations, which was represented as geometric point entities, such as commercial facilities, public transportation stops, recreational facilities, traffic junctions, or medical facilities and schools/colleges, etc (Psyllidis et al., 2022). In this study, POIs were defined according to those specifically addressed in PANES (International Physical Activity Prevalence Study, 2012; Zhao et al., 2018). Commercial facilities included shopping centers, restaurants, convenience stores, department stores, and nail salons, etc. The number of commercial facilities within each 1-km residential buffer was summed. Public transportation stops referred to bus or metro stations or stops. The number of transit stops within each 1-km residential buffer was summed. Recreational facilities included green-space, leisure plazas, fitness centers, gymnasiums, etc. A count of recreational facilities was computed by summing the number of facility points within each residential buffer. The traffic junctions included T-junctions, intersections. A count of traffic junctions was then calculated by summing the number of traffic junction points within each residential buffer. Other places included medical facilities and schools/colleges. Medical facilities included clinics, pharmacies specialized/ general hospitals, etc. while a count of schools/colleges was calculated by summing the number of facility points within each residential buffer.

Moreover, in the analysis, all those POIs were classified into categories matching to the objectively-measurable PANES items: commercial facilities (item 2), public transportation stops (item 3), recreational facilities (item 6), traffic junctions (item 12), or medical or education facilities (item 17). Then, the number of each category of POIs was calculated for each neighborhood. Thus, participants lived in the same neighborhood would share the number of POIs in this study.

3.3. Statistical analysis

The differences in percentages of participants' selected characteristics were compared between gender using chi-square tests. The concurrent validity of PANES was assessed with Spearman's correlations (r_s) between the PANES-based subjective measurements (scores of each PANES item) and GIS-based objective measurements (numbers of each corresponding type of POIs). Differences in Spearman correlations were treated as Pearson coefficients (95 % confidence intervals, CIs) using the Fisher's r-to-z transformation (Myers and Sirois, 2004). Stratified analysis was conducted by participants' gender (men or women), age group (35–60, 60 +) and self-reported physical activity (sufficient or insufficient), separately. Data were analyzed with SPSS 21.0 (IBM Corp, Armonk, NY, USA) and MedCalc 19.0 (MedCalc Software Ltd, Acacialaan, Ostend, Belgium).

4. Results

Totally, 801 eligible participants were included in this study. Table 1 displays selected personal characteristics of participants by gender. For all participants, the mean (±standard deviation) age was 54.4 (±11.5), while 48.7 % were men, 35.3 %, and 79.7 % with sufficient physical activity. There were no differences in main socio-demographic characteristics in terms of age, occupation, and physical activity level between men and women in this study.

Table 2 shows the results of neighborhood built environment attributes subjectively-measured with PANES and objectively-measured

Table 1
The distribution of selected socio-demographic and anthropometric characteristics of participants aged 35–74 years in study urban areas of Nanjing, China, 2019 (N = 801).

	Total, n (%)	n (%)		*P*
		Men	Women	
Gender	801	390 (48.7)	411 (51.3)	
Age (mean, standard deviation)	54.4 (11.5)	54.5 (11.5)	54.3 (11.4)	0.822‡
Age-group (years)				
35–60	518 (64.7)	250 (64.1)	268 (65.2)	0.744¶
60 +	283 (35.3)	140 (35.9)	143 (34.8)	
Occupation†				
Blue collar	380 (47.4)	190 (48.7)	190 (46.2)	0.481¶
White collar	421 (52.6)	200 (51.3)	221 (53.8)	
Education level (schooling years)				
9 −	276 (34.5)	114 (29.2)	162 (39.4)	**0.001**¶
10–12	279 (34.8)	135 (34.6)	144 (35.0)	
12 +	246 (30.7)	141 (36.2)	105 (25.6)	
Body weight status (BMI, kg/m^2)				
24 −	432 (53.9)	198 (50.8)	234 (56.9)	**0.013**¶
24–28	300 (37.5)	165 (42.3)	135 (32.9)	
28 +	69 (8.6)	27 (6.9)	42 (10.2)	
Physical activity‡				
Insufficient	163 (20.3)	86 (22.1)	77 (18.7)	0.244¶
Sufficient	638 (79.7)	304 (77.9)	334 (81.3)	

‡ *P* value was from *t*-test for continuous variable.
¶ *P* values were from chi-squared test for categorical variables.
† Blue collar: including farmer, factory worker, forestry worker, fisher, salesperson, houseworker and vehicle driver; White collar: including office worker, teacher, doctor, academic researcher and government official.
‡ Physical activity level was classified into two categories based on the sum of the moderate and double vigorous Physical activity time: sufficient (≥150 min per week) or insufficient (<150 min per week).

Table 2
The descriptive statistics of built environment attributes subjectively-measured with physical activity neighborhood environment scale (PANES) and objectively-measured with geographic information system (GIS) among participants aged 35–74 years in study urban neighborhoods of Nanjing, China, 2019 (N = 801).

Item content	PANES[†]					GIS[‡]
	Participants (N)	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree	Number of points of interest (POIs)
		n (%)				Medians, interquartile ranges (IQRs)
Many shops, stores, markets or other places to buy things I need are within easy walking distance of my home	794	17 (2.1)	37 (4.7)	83 (10.5)	657 (82.7)	272, 665
It is within a 10–15 min walk to a transit stop (such as bus, train, trolley, or tram) from my home	797	19 (2.4)	3 (0.4)	48 (6.0)	727 (91.2)	12, 12
My neighborhood has several free or low cost recreation facilities, such as parks, walking trails, bike paths, recreation centers, playgrounds, public swimming pools, etc	772	88 (11.4)	85 (11.0)	205 (26.6)	394 (49.2)	18, 98
There are many 4-way intersections in my neighborhood	727	44 (6.1)	153 (21.0)	228 (31.4)	302 (41.5)	50, 33
There are many places to go within easy walking distance of my home[♯]	753	31 (4.1)	64 (8.5)	176 (23.4)	482 (64.0)	60, 89

[†] PANES = Physical activity neighborhood environment scale.
[‡] GIS = Geographic information system.
[♯] The places: including hospitals, clinics, schools and kindergartens.

with GIS. The measurement results of the PANES were presented as percentages based on the composition of options for each question. The measurement results of GIS were displayed using the medians and interquartile ranges (IQRs) of the number of POIs. For the five objectively-measurable attributes of built environment (commercial facilities, commercial facilities, recreational facilities, traffic junctions and medical/education facilities), there were 93.2 %, 97.2 %, 75.8 %, 72.9 % and 87.4 % of participants, respectively, responded "(somewhat + strong) agree" to the questions, while the medians of corresponding POI recorded by GIS were 272, 12, 18, 50 and 60, separately.

Table 3 demonstrates the correlations between built environment attributes subjectively-measured with PANES and objectively-assessed using GIS among participants. Overall, of all the five objectively-measurable built environment characteristics, the Spearman correlations between subjective and objective measurements for commercial facilities (item 2) (r_s = 0.19, 95CI%=0.12, 0.25), recreational facilities (item 6) (r_s = 0.10, 95CI%=0.02, 0.16), traffic junctions (item 12) (r_s = 0.15, 95CI%=0.07, 0.22), medical/education facilities (item 17) (r_s = 0.22, 95CI%=0.15, 0.29) were significant, but the correlation for public transportation stops (item 3) (r_s = 0.003, 95CI%= −0.07, 0.08) was not significant. The scenario of correlation between subjective and objective built environment attribute measurements for participants aged 35–60 years, with sufficient physical activity, men or women was similar to that observed in overall participants.

Moreover, the correlation coefficients of subjective and objective built environment attributes measurement for each PANES item were also investigated between subgroups of participants in the study. There was no significant difference in r_s values between age groups, men and women, participants with sufficient and insufficient physical activity for commercial facilities (item 2), recreational facilities (item 6), traffic junctions (item 12), and public transportation stops (item 3). However, r_s value for medical/education facilities (item 17) was significantly higher in participants aged 35–60 years than those aged 60 + years (0.28 *vs.* 0.13; p = 0.04).

5. Discussion

This population study aimed to examine the concurrent validity of PANES-CHN among urban adults in regional China. All the five objectively-assessable items of PANES-CHN were compared concurrently with their objective corresponding measurements determined with GIS among all participants. It was observed that four of the five objectively-measurable PANES-CHN items had significant correlations of weak to moderate strength with GIS-based measures. The findings from this study suggested that those objectively-assessable PANES-CHN items other than public transport stops could be used to measure neighborhood built environment attributes validly among adults in urban areas in China.

The concept of validity usually refers to the extent to which a measurement or assessment accurately captures what it intends to measure (Villasis-Keever et al., 2018). It has been documented that PANES has good construct validity among adults in Oman and Nigeria (De Siqueira et al., 2023; Oyeyemi et al., 2013). However, the PANES concurrent validity, a more important and meaningful domain of validity concept, has not been examined previously worldwide. In this study, the first one globally, to assess the concurrent validity of PANES through comparing the agreement between subjectively and objectively measured built environment attributes, all the five objectively-assessable items of PANES have been investigated showing a significantly mild to moderate concurrent validity among urban men and women in China, with an exemption of public transport stops (item 3). Moreover, PANES-CHN has been previously examined with good test–retest reliability for the same age-group urban adults in China (Zhao et al., 2018). Therefore, PANES-CHN can be used for investigating neighborhood built environment characteristics among urban adults in China, as its concurrent validity and test–retest reliability have been examined acceptable for population-based epidemiological studies.

It is difficult to make direct comparison between findings in our study and others, because no report on concurrent validity of PANES was available. Usually, the estimation of concurrent validity based on correlation was not highly satisfactory, and the approximate coefficient of correlation varies usually from around 0.2 to 0.6 (Liu, 1997). For the five objectively-measurable PANES items in this study, the Spearman correlations were significant with an exemption that the r_s value of item 3 (regarding the number of transits stop). The highest r_s value was 0.22 for item 17, while the lowest r_s values was 0.10 for item 6, which was regarding access to free or low-cost recreation facilities. Our findings were in line with those reported in a similar study on the validity of NEWS from USA. The NEWS was found also with a mild to moderate agreement between self-reported and objectively measured built environment features (Adams et al., 2009).

No significant correlation was observed between subjective and objective measures regarding public transport stops (item 3) in this study. This might be due to that not all participants took use of public transportation systems. If a resident did not use public transport system, he/she would not pay attention to local transport stops and thus could not recall specific information on transport stops appropriately. Unfortunately, data on participants' transport mode was not available in the

Table 3
The Spearman's correlation between built environment attributes subjectively-measured with physical activity neighborhood environment scale (PANES) and objectively-measured with geographic information system (GIS) among participants aged 35–74 years in study urban neighborhoods of Nanjing, China, 2019 (N = 801).

	PANES* Item content	n	r_s (95 %CI) ¶	*p*
Overall				
	Many shops, stores, markets or other places to buy things I need are within easy walking distance of my home	794	**0.19 (0.12, 0.25)**	**<0.001**
	It is within a 10–15 min walk to a transit stop (such as bus, train, trolley, or tram) from my home	797	0.003 (−0.07, 0.08)	0.929
	My neighborhood has several free or low cost recreation facilities, such as parks, walking trails, bike paths, recreation centers, playgrounds, public swimming pools, etc	772	**0.10 (0.02, 0.16)**	**0.007**
	There are many 4-way intersections in my neighborhood	727	**0.15 (0.07, 0.22)**	**<0.001**
	There are many places to go within easy walking distance of my home†	753	**0.22 (0.15, 0.29)**	**<0.001**
Age-group (years)				
35–60				
	Many shops, stores, markets or other places to buy things I need are within easy walking distance of my home	513	**0.19 (0.10, 0.27)**	**<0.001**
	It is within a 10–15 min walk to a transit stop (such as bus, train, trolley, or tram) from my home	515	0.003 (−0.09, 0.09)	0.954
	My neighborhood has several free or low cost recreation facilities, such as parks, walking trails, bike paths, recreation centers, playgrounds, public swimming pools, etc	501	**0.12 (0.03, 0.20)**	**0.005**
	There are many 4-way intersections in my neighborhood	473	**0.18 (0.09, 0.28)**	**<0.001**
	There are many places to go within easy walking distance of my home†	494	**0.28 (0.19, 0.36)** ‡	**<0.001**
60+				
	Many shops, stores, markets or other places to buy things I need are within easy walking distance of my home	281	**0.19 (0.08, 0.30)**	**<0.001**
	It is within a 10–15 min walk to a transit stop (such as bus, train, trolley, or tram) from my home	282	0.003 (−0.11, 0.14)	0.963
	My neighborhood has several free or low cost recreation facilities, such as parks, walking trails, bike paths, recreation centers, playgrounds, public swimming pools, etc	271	0.05 (−0.07, 0.17)	0.395
	There are many 4-way intersections in my neighborhood	254	**0.10 (0.05, 0.23)**	**0.011**
	There are many places to go within easy walking distance of my home†	259	**0.13 (0.04, 0.23)** ‡	**<0.001**
Gender				
Men				
	Many shops, stores, markets or other places to buy things I need are within easy walking distance of my home	386	**0.17 (0.06, 0.26)**	**0.001**
	It is within a 10–15 min walk to a transit stop (such as bus, train, trolley, or tram) from my home	389	−0.01 (−0.11, 0.09)	0.816
	My neighborhood has several free or low cost recreation facilities, such as parks, walking trails, bike paths, recreation centers, playgrounds, public swimming pools, etc	378	**0.09 (0.01, 0.19)**	**0.038**
	There are many 4-way intersections in my neighborhood	359	**0.13 (0.03, 0.26)**	**0.012**
	There are many places to go within easy walking distance of my home†	366	**0.16 (0.05, 0.26)**	**0.003**
Women				
	Many shops, stores, markets or other places to buy things I need are within easy walking distance of my home	408	**0.21 (0.11, 0.30)**	**<0.001**
	It is within a 10–15 min walk to a transit stop (such as bus, train, trolley, or tram) from my home	408	0.02 (−0.09, 0.12)	0.728
	My neighborhood has several free or low cost recreation facilities, such as parks, walking trails, bike paths, recreation centers, playgrounds, public swimming pools, etc	394	**0.11 (0.01, 0.20)**	**0.029**
	There are many 4-way intersections in my neighborhood	368	**0.16 (0.06, 0.27)**	**0.002**
	There are many places to go within easy walking distance of my home†	387	**0.27 (0.16, 0.36)**	**<0.001**
Physical activity‡				
Insufficient				
	Many shops, stores, markets or other places to buy things I need are within easy walking distance of my home	158	**0.13 (0.003, 0.30)**	**0.034**
	It is within a 10–15 min walk to a transit stop (such as bus, train, trolley, or tram) from my home	161	−0.04 (−0.19, 0.11)	0.631
	My neighborhood has several free or low cost recreation facilities, such as parks, walking trails, bike paths, recreation centers, playgrounds, public swimming pools, etc	157	0.09 (−0.09, 0.24)	0.284
	There are many 4-way intersections in my neighborhood	144	**0.11 (0.01, 0.30)**	**0.017**
	There are many places to go within easy walking distance of my home†	156	**0.21 (0.13, 0.29)**	**<0.001**
Sufficient				
	Many shops, stores, markets or other places to buy things I need are within easy walking distance of my home	636	**0.20 (0.12, 0.28)**	**<0.001**
	It is within a 10–15 min walk to a transit stop (such as bus, train, trolley, or tram) from my home	636	0.02 (−0.07, 0.09)	0.700
	My neighborhood has several free or low cost recreation facilities, such as parks, walking trails, bike paths, recreation	615	**0.10 (0.02, 0.18)**	**0.011**

(*continued on next page*)

Table 3 (*continued*)

	PANES* Item content	n	r_s (95 %CI)¶	*p*
	centers, playgrounds, public swimming pools, etc			
	There are many 4-way intersections in my neighborhood	583	**0.18 (0.06, 0.24)**	**<0.001**
	There are many places to go within easy walking distance of my home†	597	**0.25 (0.08, 0.41)**	**0.002**

* PANES = Physical activity neighborhood environment scale.

¶ rs: Spearman's correlation coefficients between items measured with PANES and GIS; CI: Confidence interval.

♯ $p < 0.05$ for the difference in rs between age-groups, and p value was from Fisher's r-to-z transformation.

† The places: including hospitals, clinics, schools and kindergartens.

‡ Physical activity level was classified into two categories based on the sum of the moderate and double vigorous physical activity time: sufficient (≥150 min per week) or insufficient (<150 min per week).

present study. Thus, it is not possible for us to make further stratified analysis to examine the correlation of subjective and objective measures regarding public transport stops within those often taking use of public transportation systems. In future, validity of item 3 shall be investigated additionally among residents who are users of public transportation systems.

Sometimes, a statistical relationship between independent and outcome measures may exist for overall participants, but not for each age-, gender-, or characteristic-specific sub-population. For the purpose to interpret such a relationship correctly it is necessary and appropriate to investigate the relationship stratified by age, gender-, or selected characteristics. As for PANES, it is expected that it can be used to assess neighborhood built environment attributes not only for overall population, but also for each of age- and gender-specific sub-populations. Moreover, physical activity level was documented to be associated with accuracy of self-reported built environment attributes (Adams et al., 2009). Therefore, in this study, the concurrent validity was also examined among participants stratified by gender, age group and physical activity level in addition to that among overall participants.

Compared to elders aged 60 + years, a stronger agreement between subjectively and objectively measured destinations (hospitals, clinics, schools and kindergartens) was observed among participants aged 35–59 years. No differences in PANES-CHN validity was examined between men and women, although gender differences in education level and body weight status were observed in present study. Previous study documented that active individuals tended to spend more time walking, running, or biking in their neighborhoods, allowing them to observe built environment characteristics more carefully and report them more accurately (Adams et al., 2009; Troped et al., 2001). However, in this study, there was no significant difference in PANES-CHN validity of all the five selected items between sub-populations by physical activity. These findings suggest that PANES-CHN can be used for population-based studies on built environment features among overall urban adults in China regardless of their age group, gender or physical activity level.

This study has several strengths. First, subjective and objective data on built environment attributes were collected concurrently in the study, allowing us to make direct comparison of agreement between them. Second, a neighborhood defined as 1-km buffer street networks represents what is truly accessible for participants, which is better than straight-line buffers. Finally, the correlations between subjective and objective measures of built environment features were also investigated by stratification of age group, gender and physical activity level in the study, showing a broad validity of PANES-CHN among urban adults in China.

This study also has four main potential limitations. First, because only five of the 17 PANES-CHN items are objectively-measurable and then validated in this study, it should be highly prudent for researchers to interpret the validity of entire PANESE-CHN. Second, item 3 regarding public transport stops was examined without acceptable validity between subjective and objective measures in the study. Third, participants were limited to urban adults in the study, which may not warrant its application among rural residents. Finally, participants lived in the same neighborhood would share the number of POIs, and thus every 200 individuals' subjective responses were matched to the same objective data. This could lead to increased sampling errors due to clustering effects.

This study has particular significance for researchers to conduct future investigations on built environment and public health in China. With the continuous economic growth over the past decades, China has been witnessing a rapid urbanization and people's lifestyle/behavior transition. Future studies are welcome to investigate the association of different built environment attributes and behaviors as well as health outcomes among residents. Consequently, behavior/health friendly built environment characteristics are encouraged to be considered in city planning and urban design for the purpose of sustainable community-based behavior/health promotion.

In conclusion, PANES-CHN generally has a mild to moderate validity in terms of objectively-measurable built environment characteristics among urban adults in China, which adds the evidence that, in addition to reliability examined previously, validity of PANES-CHN is also acceptable in built environment −related population studies in China. This study has significant public health implications that PANES-CHN can be used to assess built environment attributes easily via self-report among urban adults in population-based behavior/health promotion campaigns in China.

CRediT authorship contribution statement

Qing Ye: Writing – review & editing, Writing – original draft, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Zhenzhen Qin:** Writing – review & editing, Writing – original draft, Investigation. **Zhen Xu:** Writing – review & editing, Writing – original draft, Investigation. **Yihan Yang:** Writing – review & editing, Writing – original draft. **Bing Zhang:** Writing – review & editing, Writing – original draft, Investigation. **Fei Xu:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Funding acquisition, Conceptualization. **Zhibin Hu:** Writing – review & editing, Writing – original draft, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Role of the funder/sponsor

All funders did not have any role in the whole study.

Ethics approval

Written informed consent was obtained from each participant before the study, which was approved by the Academic and Ethical Committee of Nanjing Municipal Center for Disease Control and Prevention. The methods employed in this study were in line with recommendations by the Declaration of Helsinki.

Appendix A

国际体力活动水平测量量表 (IPAQ-CHN).

d1a **在最近的七天, 您有几天参与了高强度的体力活动？**（高强度体力活动:与平时相比, 感觉到呼吸很吃力, 包括拎重物, 挖掘, 有氧运动, 快速骑车；单次至少持续10′）.

____天/周 〔若回答0天、拒绝回答、不知道则跳到问题2a〕.

d1b **在参与这种高强度体力活动的日子里, 您通常每天花费多长时间参与高强度的体力活动？.**

_____小时_____分钟/天（若活动持续时间不固定, 则跳过本题, 而直接问1c）.

d1c **在最近的七天, 您总共花费多长时间参与这种高强度的体力活动？.**

_____小时_____分钟/周.

d2a **在最近的七天, 您有几天参与了中等强度的体力活动？**（中等强度体力活动:感觉到呼吸比平时稍微困难一些, 包括搬运轻的东西, 以正常速度骑车, 或者打双人网球。但是并不包括走路；单次至少持续10′）.

____天/周 〔若回答0天、拒绝回答、不知道则跳到问题3a〕.

d2b **在参与这种中等强度体力活动的日子里，您通常每天花费多长时间参与中等强度的体力活动？**_____小时_____分钟/天（若活动持续时间不固定, 则跳过本题, 而直接问2c）.

d2c **在最近的七天, 您总共花费多长时间参与这种中等强度的体力活动？.**

_____小时_____分钟/周.

d3a **在最近的七天， 您有几天单次连续走路至少十分钟？**（步行:包括工作场所、在家、娱乐、休闲、体育锻炼、饭后散步时花费的步行时间）____天/周 〔若回答0天、拒绝回答、不知道则跳到问题4a〕.

d3b **在参与这种步行的日子里, 您通常每天花费多长时间步行？**（若步行持续时间不固定, 则跳过本题, 而直接问3c）_____小时_____分钟/天.

d3c **你通常的步行速度是:**___快速(与正常情况相比, 感觉呼吸很吃力) = 1;

中速(与正常情况相比, 感觉呼吸稍微有点吃力) = 2;

慢速(感觉不到呼吸的改变) = 3.

d4a **在最近的1周， 于周一至周五期间， 您静坐的时间总共有多长？(**静坐:包括工作时、访问朋友时、看书时、坐着或躺着看电视时的时间）_____小时_____分钟/周.

d4b **在最近的1周, 于周六和周日二天期间, 您静坐的时间总共有多长？.**

_____小时_____分钟/周.

d5a **在最近的1周,** 正常情况下, 你平均每天骑自行车的时间 分钟/天（包括上下班途中）.

d6a **在最近的1周,** 正常情况下, 你平均每天乘机动车的时间 小时/天（包括上下班途中）.

Appendix B

体力活动相关人居环境测量量表 (PANES-CHN).

说明:本调查表中所说的“社区”是指以你家为中心步行**10-15**分钟范围内的区域。下列**1-17**个问题均为单选题, 所有问题均没有统一的标准答案、也没有对错之分, 请你根据你本人以及所居住社区的具体情况逐题回答、并在你认为最适合的答案序号上打“√”。

e1 你所居住的社区里主要的房屋类型是什么？.

（1.）独户别墅；（2.）联排别墅、多户4层以下层公寓；.

（3.）独户别墅与联排别墅、公寓的混合；（4.）7层及以下的公寓；.

（5.）7层以上的公寓；（99.）不知道或不好评价.

e2 你家附近可以轻松步行的距离内, 都有所必需的购物商店、市场、菜场等。你对这个说法的看法是下列哪一个？

（1.）完全不同意；（2.）有些不同意；（3.）有些同意；

（4.）完全同意；（99.）不知道或不好确定

e3 从你家出发, 10-15分钟的步行距离内, 有公共交通（公共汽车、地铁等公车）车站。你对这个说法的看法是下列哪一个？

（1.）完全不同意；（2.）有些不同意；（3.）有些同意；

（4.）完全同意；（99.）不知道或不好确定

e4 你所居住社区内的绝大多数道路都有人行道。你对这个说法的看法是下列哪一个？

（1.）完全不同意；（2.）有些不同意；（3.）有些同意；

（4.）完全同意；（88.）在我居住社区不适用 （99.）不知道或不好确定

e5 在你所住社区内或附近, 道路上有自行车隔离车道。你对这个说法的看法是下列哪一个？

（1.）完全不同意；（2.）有些不同意；（3.）有些同意；

（4.）完全同意；（88.）在我居住社区不适用 （99.）不知道或不好确定

e6 你所居住的社区内, 有一些免费或收费很少的娱乐、锻炼设施, 比如:公园、步行道、自行车道、娱乐中心、对社会开放的操场、公共游泳池等。你对这个说法的看法是下列哪一个？

（1.）完全不同意；（2.）有些不同意；（3.）有些同意；

（4.）完全同意；（99.）不知道或不好确定

e7 你所居住社区内, 由于犯罪率较高而变得夜间行走不安全。你对这个说法的看法是下列哪一个？

（1.）完全不同意；（2.）有些不同意；（3.）有些同意；

（4.）完全同意；（99.）不知道或不好确定

e8 在你所居住的社区内, 由于道路的车流量很大以致在道路上步行变得有些困难或不方便。你对这个说法的看法是下列哪一个？

（1.）完全不同意；（2.）有些不同意；（3.）有些同意；

（4.）完全同意；（88.）在我居住社区不适用 （99.）不知道或不好确定

e9 你看到在所居住的社区内，许多人都会积极锻炼身体，比如散步、慢跑等体育活动。你对这个说法的看法是下列哪一个？

（1.）完全不同意；（2.）有些不同意；（3.）有些同意；

（4.）完全同意；（99.）不知道或不好确定

e10 在社区内步行时，能欣赏到许多让人轻松或感兴趣的事情。你对这个说法的看法是下列哪一个？

（1.）完全不同意；（2.）有些不同意；（3.）有些同意；

（4.）完全同意；（99.）不知道或不好确定

e11 你家有几辆性能良好的机动车（汽车、摩托车等）？ 辆（请填写具体数量）；.

（99.）不知道或不好确定.

e12 在你所居住的社区内，有很多四岔路口的马路。你对这个说法的看法是下列哪一个？

（1.）完全不同意；（2.）有些不同意；（3.）有些同意；

（4.）完全同意；（88.）在我居住社区内没有马路；（99.）不知道或不好确定

e13 在你所居住社区内，道路的人行步道维护的良好、并且没有障碍物影响到行人走路。你对这个说法的看法是下列哪一个？

（1.）完全不同意；（2.）有些不同意；（3.）有些同意；

（4.）完全同意；（99.）不知道或不好确定

e14 在你所居住社区内或周围，马路的自行车道维护的良好、并且没有障碍物影响到骑自行车。你对这个说法的看法是下列哪一个？

（1.）完全不同意；（2.）有些不同意；（3.）有些同意；

（4.）完全同意；（99.）不知道或不好确定

e15 在你所居住社区内，由于马路上车辆量很大，让人觉得骑自行车比较困难或不方便。你对这个说法的看法是下列哪一个？

（1.）完全不同意；（2.）有些不同意；（3.）有些同意；

（4.）完全同意；（99.）不知道或不好确定

e16 在你所居住的社区内，由于犯罪率的原因，让人白天出去散步、步行觉得不安全。你对这个说法的看法是下列哪一个？

（1.）完全不同意；（2.）有些不同意；（3.）有些同意；

（4.）完全同意；（99.）不知道或不好确定

e17 在你家附近，有许多可以轻松步行就到达的场所。你对这个说法的看法是下列哪一个？

（1.）完全不同意；（2.）有些不同意；（3.）有些同意；

（4.）完全同意；（99.）不知道或不好确定

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