Original Article

Test-retest reliability of a modified International Physical Activity Questionnaire (IPAQ) to capture neighbourhood physical activity

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ABSTRACT

Introduction: Few self-report tools capture neighbourhood physical activity. The aim of our study was to modify a widely-used self-report tool (International Physical Activity Questionnaire – IPAQ) to capture neighbourhood physical activity and estimate the test-retest reliability of these modifications. Material and Methods: Seventy-five adults completed the modified IPAQ twice, 7-days apart, capturing neighbourhood days·week^{-1} and usual minutes·day^{-1} of bicycling and walking for transport and leisure, moderate physical activity, and vigorous physical activity. Test-retest reliability was assessed with Intraclass Correlations (ICC), percent of overall agreement and Kappa statistics (κ). Results: Consistency in participation in neighbourhood PA ranged from k = 0.21 for moderate physical activity to k = 0.55 for vigorous physical activity, while proportion of overall agreement ranged from 64.0% for moderate physical activity to 81.3% for bicycling for transportation. ICC for reported neighbourhood PA between the two occasions ranged from ICC = 0.33 for moderate physical activity to ICC = 0.69 for bicycling for transportation for days·week^{-1}, ICC = 0.17 for bicycling for transportation to ICC = 0.48 for walking for leisure for minutes·day^{-1}, and ICC = 0.31 for vigorous physical activity to ICC = 0.52 for walking for leisure for minutes·week^{-1}. Conclusions: With the exception of minutes spent bicycling for transportation, our findings suggest that IPAQ items can be modified to provide

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reliable estimates of neighbourhood physical activity. **Key words:** INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE, IPAQ, PHYSICAL ACTIVITY, ADULTS, NEIGHBOURHOOD.

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INTRODUCTION

The determinants of physical activity are complex and multi-faceted (Bauman et al., 2012); however, during the past two decades there has been increasing consistent evidence demonstrating the importance of the neighbourhood built environment for supporting physical activity (Hillsdon, Coombes, Griew, & Jones, 2015; McCormack & Shiell, 2011; Saelens & Handy, 2008). A recent umbrella review (a review of reviews) synthesized 19 peer-reviewed publications related to environmental correlates of physical activity (Choi, Lee, Lee, Kang, & Choi, 2017). Within these 19 reviews, the authors identified 27 environment characteristics grouped into facility, safety, regional location, climate, home and neighbourhood factors, that were identified has having a relationship with physical activity (Choi et al., 2017). Several self-reported and objectively-measured built characteristics were found to be associated with physical activity including accessibility of facilities, availability of sidewalks, neighbourhood aesthetics, and land-use mix (Choi et al., 2017). For objectively measured built characteristics only, accessibility to facilities, population density, land-use mix, urban location, and crime rates were particularly important correlates of physical activity (Choi et al., 2017). Notably, in their review of primary studies, Ferdinand, Sen, Rahurkar, Engler, & Menachemi (2012) found that studies using objective measures of physical activity (e.g., accelerometers, pedometer, systematic observation) were less likely to result in positive associations between the built environment and physical activity or obesity. The limitations of self-report measures of physical activity are well documented (Sallis & Saelens, 2000); however, this approach may be the most feasible when capturing physical activity in large samples and where budgets and expertise for conducting objective measurement of physical activity are limited. Therefore, adaptions of self-report measures to capture contextual or locational information may provide more precise estimates of the associations between neighbourhood built characteristics and self-reported physical activity (Ding & Gebel, 2012).

Several studies report associations between objective neighbourhood built characteristic's (e.g., population density, land used mix, street connectivity, walkability, and aesthetics) and self-reported neighbourhood-based physical activity (Cerin et al., 2017; Christian et al., 2011; Humpel et al., 2004; McCormack et al., 2012). In Australian adults, after adjustment for land use mix, residents from a higher walkable neighbourhood had significantly higher odds of participating in any walking and transportation walking inside the neighbourhood compared with residents of low walkable neighbourhoods (Christian et al., 2011). In another Australian study, men living in coastal areas were more likely to walk in their neighbourhood compared with those living in non-coastal areas (Humpel et al., 2004). In Canadian adults, residents of high walkability neighbourhoods (characterized by higher land-use mix, population density and street connectivity) were more likely to walk for transportation and to spend more time walking for transportation inside their neighbourhood compared with residents of less walkable neighbourhoods (McCormack et al., 2012). Moreover, Cerin et al. (2017) conducted a meta-analysis for active travel in older adults and found strong evidence that neighbourhood walking was associated with a greater access to destinations, land use mix, and open spaces or parks, with weaker evidence of an association with street connectivity, food destinations, street lighting, and having places to sit such as benches. These studies highlight the importance of capturing neighbourhood-based physical activity when examining the role of neighbourhood built characteristics.

Self-reported neighbourhood physical activity items have typically captured physical activity undertaken in a usual week within a pre-determined distance from home [e.g., walking within 15-minutes or 1600 meters from home (Christian et al., 2011; Ding et al., 2013; Giles-Corti et al., 2006)]. For example, the Neighbourhood Physical Activity Questionnaire (NPAQ), developed and tested in Australia (Giles-Corti et al., 2006) and more recently tested in Canada (McCormack et al., 2009), China (Cerin et al., 2011), and Korea (Bae, Cho, & Son, 2015), captures habitual neighbourhood transportation and leisure walking and bicycling inside and outside the neighbourhood during a usual week. Despite being reliable (Bae et al., 2015; Cerin et al., 2011; Giles-Corti et al., 2006; McCormack et al., 2009), the NPAQ may not provide an accurate representation of physical activity undertaken in the last week or past seven days, recall periods that may be of interest in intervention studies.

The International Physical Activity Questionnaire (IPAQ) is a well-established tool that captures self-reported physical activity, including transportation and leisure walking and bicycling, and leisure moderate-intensity and vigorous-intensity physical activity undertaken in the last week. However, the original IPAQ items were not designed to capture neighbourhood-based physical activity (Hallal & Victora, 2004; Kim, Park, & Kang, 2013; Sundquist et al., 2011; Van Dyck, Cardon, Deforche, & De Bourdeaudhuij, 2015). Given the IPAQ's established reliability and validity and administration in many countries (Hallal & Victora, 2004; Kim et al., 2013; Sundquist et al., 2011; Van Dyck et al., 2015), adapting IPAQ items to capture neighbourhood physical activity could be useful for future studies estimating associations between neighbourhood built characteristics and physical activity.

Despite their limitations, self-report questionnaires provide a low cost, convenient, and often rapid approach for capturing physical activity, especially in population studies (Prince et al., 2008). However, few extensively tested self-report questionnaires that capture neighbourhood physical activity are available to researchers (Cerin et al., 2013; Ding et al., 2013; Giles-Corti et al., 2006). Thus, more options for reliable and valid questionnaires capturing neighbourhood physical activity are needed. The purpose of our study, therefore, was to adapt the IPAQ long form (IPAQ-LF) items to capture neighbourhood physical activity undertaken during the last 7 days to estimate the test-retest reliability of these modified items and to assess if these modifications can detect differences in high and low walkable communities in a Canadian adult population.

MATERIAL AND METHODS

Participants and procedures

This study included a convenience sample (n = 75) of adults (≥20 years of age) recruited from a larger sample of participants who had completed a previous study (The "Pathways to Health Study") (McCormack et al., 2013). The "Pathways to Health Study" included a stratified-random sample of participants recruited from 12 Calgary (Alberta, Canada) neighbourhoods. These neighbourhoods were chosen based on their different street patterns (grid, warped-grid, and curvilinear) and socioeconomic status (SES) (McCormack et al., 2013). In 2014, 10,500 randomly selected households from the 12 neighbourhoods were mailed a survey package that included instructions for completing two online questionnaires (a physical activity, health, and demographic questionnaire and the Canadian Diet History questionnaire). Among study recruits (n = 1,023) and those who had agreed to be contacted for follow-up research, we approached (via email or telephone) 211 participants from the grid (i.e., n = 2 high walkable) and curvilinear (i.e., n = 2 low walkable) medium SES neighbourhoods to participate in this test-retest reliability study. A total of 75 participants agreed to complete a paper version of the modified-IPAQ on two occasions (Time 1 questionnaire and Time 2 questionnaire) at least 7 days apart. Time 1 and Time 2 questionnaires were identical. Between July and December 2016, we delivered and collected the informed consent forms and the modified-IPAQ from participants' homes directly. Each participant was instructed to undertake their typical weekly routine between the two questionnaire administrations. The University of Calgary Conjoint Health Research Ethics Board approved this study (Ethics ID: REB15-2940).

Measures

Modified International Physical Activity Questionnaire

The IPAQ has been shown to be reliable and valid (Craig et al., 2003). We modified physical activity items from the IPAQ-LF (www.ipaq.ki.se) to capture frequency (number of days) and usual minutes (on one of those days) of neighbourhood walking for transportation, bicycling for transportation, bicycling for leisure, walking for leisure, moderate physical activity, and vigorous physical activity undertaken in the last 7-days (Supplementary File 1). To make these items neighbourhood-based, we modified the wording of each item to include the phrase "…inside your neighbourhood." For example, "During the last 7 days, on how many days did you bicycle to go from place to place inside your neighbourhood?" followed by "How much time did you usually spend on one of those days to bicycle from place to place inside your neighbourhood?". The preamble instructed participants to think about activities undertaken inside and outside their residential neighbourhood, but did not include reference to any specific geographical area or size, thus allowing participants to report their physical activity based on their own interpretation of "neighbourhood".

Sociodemographic characteristics

Participants indicated their sex, reported their year of birth, number of dependents living at home, number of dogs living in the household, if they had access to a motor vehicle for personal use, if they had access to a bicycle for personal use, and the highest level of education they had completed.

Analysis

We estimated descriptive statistics including measures of central tendency (means, medians), variation (standard deviations, interquartile range) and frequencies for all physical activity and sociodemographic variables. We estimated the weekly minutes of physical activity by multiplying the reported frequency (in days per week) by the duration of activity (in minutes on a usual day). Reported days per week for each physical activity were recoded into participation (at least 1 day·week^{-1}) versus no participation (0 days·week^{-1}). Any missing weekly minutes of each physical activity data were recoded to 0 minutes if the participant indicated no participation. We used the same approach to remove outliers as used in previous studies using the self-reported physical activity [all variables were truncated at the 99th percentile and weekly physical activity (days x daily duration) was truncated to 1680 minutes] (Al-Hazzaa, Abahussain, Al-Sobayel, Qahwaji, & Musaiger, 2011; Cerin, Saelens, Sallis, & Frank, 2006; McCormack, Giles-Corti, & Bulsara, 2008).

Cohen's Kappa coefficients (κ) and the proportion of overall agreement were used to assess agreement for self-reported participation (yes/no) in any bicycling for transportation, walking for transportation, bicycling for leisure, walking for leisure, moderate physical activity and vigorous physical activity between Time 1 and Time 2. To estimate the consistency in self-reported minutes of these physical activities between Time 1 and Time 2, we used two-way mixed effects intraclass correlations (ICC). Specifically, we estimated intraclass correlations 1) including those participants who reported 0 minutes in a physical activity variable and 2) excluding those participants who reported 0 minutes in a physical activity variable. Since the self-reported minutes of some physical activities were not normally distributed because of high levels of non-participation, we used Wilcoxson Sign-rank tests to estimate the differences in minutes of physical activity between Time 1 and Time 2. We used established cut points for determining the adequacy of our agreement and consistency estimates (i.e., ICC, and κ correlations: poor <0.40, moderate ≥0.40 to 0.75, and excellent >0.75, and; proportion of overall agreement ≥75% was considered acceptable) (Landis & Koch, 1977). Chi-square (for participation) and Mann-Whitney U (for duration) tests were used to compare self-reported physical activity between the high and low walkable neighbourhoods at Time 1. All statistical analyses were completed using STATA version 14.2 (StataCorp, TX, USA). Statistical significance was set at $\alpha \leq 0.05$.

RESULTS

Sample characteristics

The mean (SD) age of our sample was 54 (14) years. The sample had 65.3% women, 80.0% were university educated, 65.3% were non-dog owners, 100% had access to a motor vehicle, and 81.3% had access to a bicycle. Just over one-half (54.7%) of participants resided in a low walkable (curvilinear) neighbourhood (Table 1).

Table 1. Sample demographic characteristics

Demographic characteristic	n	Estimate
Age in years (mean[SD])	75	54[14]
Female (%)	49	65.3
Dependents living in the home (%)		
One or more <6yrs old	12	16.0
One or more 6-18yrs old	15	20.0
Dogs living in the home (%)	26	34.7
Had access to a motor vehicle for personal use (%)	75	100.0
Had access to a bicycle for personal use (%)	61	81.3
Highest level of education (%)		
Less than University	15	20.0
University	60	80.0
Neighbourhood type (%)		
High walkable	34	45.3
Low walkable	41	54.7

Agreement in self-reported participation in neighbourhood physical activity

With the exception of participation in moderate physical activity, the proportion of overall agreement in self-reported neighbourhood physical activities between Times 1 and 2 was excellent (77.3 - 98.7%). All Kappa estimates were statistically significant and demonstrated poor (κ = 0.21 for moderate physical activity) to moderate (κ = 0.55 for vigorous physical activity) consistency (Table 2).

Table 2. Proportion (%) of overall agreement (p0), and kappa (▯) coefficients for self-reported physical activity between time 1 and time 2

Physical activity	Time 1 % (n)	Time 2 % (n)	p_0	κ (95%CI)
Bicycled for transportation in neighbourhood	21.3 (16)	10.7 (8)	81.3	0.32* (0.06 to 0.58)
Walked for transportation in neighbourhood	78.7 (59)	74.7 (56)	80.0	0.44* (0.21 to 0.68)
Walked for recreation in neighbourhood	58.7 (44)	70.7 (53)	77.3	0.51* (0.32 to 0.71)
Vigorous physical activity in neighbourhood	40.0 (30)	49.3 (37)	77.3	0.55* (0.36 to 0.73)
Moderate physical activity in neighbourhood	38.7 (29)	29 3 (22)	64.0	0.21* (-0.02 to 0.43)

Physical activity	Time 1 % (n)	Time 2 % (n)	p_0	κ (95%CI)
Bicycled for transportation in neighbourhood	21.3 (16)	10.7 (8)	81.3	0.32* (0.06 to 0.58)
Walked for transportation in neighbourhood	78.7 (59)	74.7 (56)	80.0	0.44* (0.21 to 0.68)
Walked for recreation in neighbourhood	58.7 (44)	70.7 (53)	77.3	0.51* (0.32 to 0.71)
Vigorous physical activity in neighbourhood	40.0 (30)	49.3 (37)	77.3	0.55* (0.36 to 0.73)
Moderate physical activity in neighbourhood	38.7 (29)	29 3 (22)	64.0	0.21* (-0.02 to 0.43)

*Note. *p<.05. n=75 completed the time 1 and time 2 surveys. 7-days elapsed between time 1 and time surveys.*

Test-retest reliability in self-reported time spent in neighbourhood physical activity

Including those participants who reported zero minutes, the ICC estimated test-retest reliability in self-reported neighbourhood physical activities between Times 1 and 2 were poor (ICC = 0.33 for moderate physical activity) to moderate (ICC = 0.69 for bicycling for transportation) for days·week^{-1}, poor (ICC = 0.17 for bicycling for transportation) to moderate (ICC = 0.48 for bicycling for leisure) for minutes·day^{-1}, and poor (ICC = 0.31 for vigorous physical activity) to moderate (ICC = 0.62 for moderate physical activity) for minutes·week^{-1}. When those participants who reported zero minutes in the activity were excluded from the analysis, the magnitude of the estimated ICC for 7 of the 10 tested physical activity variables increased (Table 3). Despite the small absolute differences estimated, these were statistically significant for differences in self-reported neighbourhood bicycling for transportation days·week^{-1} and minutes·week^{-1}, and walking for transportation for days·week^{-1}, minutes·day^{-1}, and minutes·week^{-1} (Table 4) suggesting that on average participants may have changed the number of days spent in active transportation between Time 1 and Time 2 questionnaire administrations.

Table 3. Intra-class Correlations (ICC)# for self-reported neighbourhood physical activity between time 1 and time 2

Physical Activity Measure	**For all participants**		**Those reporting participation only**	
	n	**ICC (95%CI)**	**n**	**ICC (95%CI)**
Bicycling for transportation during the last 7 days. (Days)	75	0.69* (0.50 to 0.79)		
Usual time spent bicycling for transportation on one of those days? (Minutes)	75	0.17 (-0.06 to 0.38)	5	0.58 (-0.44 to 0.95)
Computed: Total transportation minutes/week by bicycle	75	0.35* (0.13 to 0.53)	5	0.77* (-0.10 to 0.97)
Walking for transportation during the last 7 days. (Days)	75	0.62* (0.46 to 0.74)		
Usual time spent walking for transportation on one of those days? (Minutes)	75	0.24* (0.02 to 0.44)	50	0.35* (0.08 to 0.57)
Computed: Total transportation minutes/week by walking	75	0.49* (0.30 to 0.64)	50	0.48* (0.23 to 0.67)
Walking for leisure during the last 7 days? (Days)	75	0.54* (0.36 to 0.69)		
Usual time spent walking or leisure on one of those days? (Minutes)	75	0.48* (0.29 to 0.64)	40	0.46* (0.17 to 0.67)
Computed: Total minutes/week spent walking for recreation, leisure, or exercise	75	0.52* (0.33 to 0.66)	40	0.56* (0.30 to 0.74)
Undertaking vigorous physical activity for leisure during the last 7 days? (Days)	75	0.58* (0.41 to 0.71)		
Usual time spent in vigorous physical activity for leisure on one of those days? (Minutes)	75	0.40* (0.19 to 0.58)	26	0.46* (0.10 to 0.72)
Computed: Total minutes/week spent in vigorous physical activity	75	0.31* (0.09 to 0.50)	26	0.26 (-0.13 to 0.58)
Undertaking moderate physical activity for leisure during the last 7 days? (Days)	75	0.33* (0.11 to 0.52)		
Usual time spent in moderate physical activity for leisure on one of those days? (Minutes)	75	0.43* (0.23 to 0.60)	12	0.65* (0.15 to 0.88)
Computed: Total minutes/week spent in moderate physical activity	75	0.62* (0.46 to 0.74)	12	0.80* (0.44 to 0.94)
Computed: Total minutes/week active^	75	0.63* (0.48 to 0.75)		

*Note. #Two-way mixed model. *p<.05. ^Sum of: Computed: Total transportation minutes/week by bicycle, Computed: Total transportation minutes/week by walking, Computed: Total minutes/week spent walking for recreation, leisure, or exercise, Computed: Total minutes/week spent in vigorous physical activity, and Computed: Total minutes/week spent in moderate physical activity. 7-days elapsed between time 1 and time 2 surveys.*

Table 4. Comparison of self-reported neighbourhood based physical activity between time 1 and time 2

Item	Time 1		Time 2		Difference T1-T2	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
Bicycling for transportation during the last 7 days. (Days)*	0.6 (1.5)	0 (0)	0.3 (1.1)	0 (0)	0.3 (1.0)	0 (0)
Usual time spent bicycling for transportation on one of those days? (Minutes)	9.01 (19.0)	0 (0)	7.4 (25.1)	0 (0)	1.6 (28.7)	0 (0)
Computed: Total transportation minutes/week by bicycle*	24.2 (65.7)	0 (0)	15.57 (59.1)	0 (0)	8.6 (71.3)	0 (0)
Walking for transportation during the last 7 days. (Days)*	3.0 (2.6)	2 (4)	2.4 (2.2)	2 (4)	0.6 (2.1)	0 (2)
Usual time spent walking for transportation on one of those days? (Minutes)*	36.3 (31.5)	30 (45)	27.5 (30.3)	20 (30)	8.9 (38.1)	0 (30)
Computed: Total transportation minutes/week by walking*	147.0 (175.6)	60 (190)	95.1 (140.7)	40 (120)	51.9 (160.7)	30 (120)
Walking for leisure during the last 7 days? (Days)	2.2 (2.4)	2 (4)	2.5 (2.4)	2 (4)	-0.3 (2.3)	0 (2)
Usual time spent walking or leisure on one of those days? (Minutes)	33.8 (41.7)	30 (55)	39.5 (47.1)	30 (60)	-5.67 (45.3)	0 (25)
Computed: Total minutes/week spent walking for recreation, leisure, or exercise	126.5 (188.2)	60 (180)	143.0 (221.8)	60 (210)	-16.5 (202.3)	0 (65)
Undertaking vigorous physical activity for leisure during the last 7 days? (Days)	1.1 (1.7)	0 (2)	1.2 (1.6)	1 (2)	-0.1 (1.5)	0 (0)
Usual time spent in vigorous physical activity for leisure on one of those days? (Minutes)	20.2 (31.6)	0 (30)	33.7 (47.7)	0 (60)	-13.4 (44.2)	0 (10)
Computed: Total minutes/week spent in vigorous physical activity	53.2 (94.6)	0 (90)	83.9 (165.3)	0 (90)	-30.7 (157.9)	0 (15)
Undertaking moderate physical activity for leisure during the last 7 days? (Days)	1.0 (1.8)	0 (1)	0.7 (1.5)	0 (1)	0.3 (1.9)	0 (0)
Usual time spent in moderate physical activity for leisure on one of those days? (Minutes)	26.6 (41.0)	0 (35)	25.8 (54.7)	0 (40)	0.8 (51.4)	0 (10)
Computed: Total minutes/week spent in moderate physical activity	79.1 (194.1)	0 (60)	61.1 (260.1)	0 (45)	18.0 (200.6)	0 (30)
Computed: Total minutes/week active^	423.1 (447.2)	280 (480)	380.3 (389.7)	240 (345)	42.8 (358.3)	20 (290)

*Note. *p<.05 Wilcoxon Sign-rank Test between T1 and T2. ^Sum of: Total of weekly transportation bicycling, transportation walking, recreation walking, vigorous physical activity, and moderate physical activity minutes. 7-days elapsed between time 1 and time 2 surveys.*

Differences in self-reported neighbourhood physical activity by neighbourhood walkability

Using Time 1 data, participants in high and low walkable neighbourhoods did not differ statistically in mean age [53 (13) vs. 56 (14) years old], sex (female: 61.0 vs. 70.6%) or education (university: 73.2 vs. 88.2%). Compared with participants from low walkable neighbourhood, those from high walkable neighbourhoods self-reported statistically significantly higher participation in bicycling for transportation (35.3 vs. 9.8%) and walking for transportation (91.2 and 68.3%) and more bicycling for transportation days·week^{-1} [1.0 (1.9) vs 0.2 (0.9) days·week^{-1})], minutes·day^{-1} [12.1 (18.6) vs 6.6 (19.3) minutes·day^{-1}], and minutes·week^{-1} [33.1 (62.8) vs 16.8 (67.8) minutes·week^{-1})]. Compared with participants from low walkable neighbourhoods, those from high walkable neighbourhoods also self-reported more walking for transportation days·week^{-1} [3.8 (2.5) vs 2.4 (2.5) days·week^{-1})] and minutes·week^{-1} [175.3 (173.0) vs 123.5 (176.4) minutes·week^{-1})]. No other differences in self-reported neighbourhood physical activity were found between the high and low walkable neighbourhoods (Table 5).

Table 5. Comparison of participation and duration of self-reported neighbourhood based physical activity between objectively-measured high- and low-walkable neighbourhoods (time 1 survey only)

Item	High-walkable % (n)		Low-walkable % (n)	
Participation	**Yes**	**No**	**Yes**	**No**
Bicycled for transportation in neighbourhood*	35.3 (12)	64.7 (22)	9.8 (4)	90.2 (37)
Walked for transportation in neighbourhood*	91.2 (31)	8.8 (3)	68.3 (28)	31.7 (13)
Walked for recreation in neighbourhood	64.7 (22)	35.3 (12)	53.7 (22)	46.3 (19)
Vigorous physical activity in neighbourhood	44.1 (15)	55.9 (19)	36.6 (15)	63.4 (26)
Moderate physical activity in neighbourhood	35.3 (12)	64.7 (22)	41.5 (17)	58.5 (24)
Duration	**Mean (SD)**	**Median (IQR)**	**Mean (SD)**	**Median (IQR)**
Bicycling for transportation during the last 7 days. (Days)*	1.0 (1.9)	0 (1)	0.2 (0.9)	0 (0)
Usual time spent bicycling for transportation on one of those days? (Minutes)*	12.1 (18.6)	0 (30)	6.6 (19.3)	0 (0)
Computed: Total transportation minutes/week by bicycle*	33.1 (62.8)	0 (40)	16.8 (67.8)	0 (0)
Walking for transportation during the last 7 days. (Days)*	3.8 (2.5)	3.5 (5)	2.4 (2.5)	2 (4)
Usual time spent walking for transportation on one of those days? (Minutes)	41.0 (27.1)	30 (40)	32.4 (34.6)	30 (45)
Computed: Total transportation minutes/week by walking*	175.3 (173.0)	150 (150)	123.5 (176.4)	60 (180)
Walking for leisure during the last 7 days? (Days)	2.3 (2.3)	2 (3)	2.1 (2.5)	1 (4)
Usual time spent walking or leisure on one of those days? (Minutes)	38.2 (39.3)	30 (60)	30.1 (43.6)	20 (45)
Computed: Total minutes/week spent walking for recreation, leisure, or exercise	149.3 (220.9)	90 (180)	107.6 (156.4)	40 (180)
Undertaking vigorous physical activity for leisure during the last 7 days? (Days)	1.1 (1.6)	0 (2)	1.1 (1.8)	0 (2)
Usual time spent in vigorous physical activity for leisure on one of those days? (Minutes)	21.0 (30.9)	0 (30)	19.6 (32.5)	0 (30)
Computed: Total minutes/week spent in vigorous physical activity	47.8 (85.2)	0 (75)	57.7 (102.7)	0 (90)
Undertaking moderate physical activity for leisure during the last 7 days? (Days)	1.0 (1.9)	0 (1)	1.0 (1.7)	0 (1)
Usual time spent in moderate physical activity for leisure on one of those days? (Minutes)	20.3 (34.4)	0 (30)	31.8 (45.5)	0 (40)
Computed: Total minutes/week spent in moderate physical activity	62.8 (176.6)	0 (60)	92.6 (208.7)	0 (60)
Computed: Total minutes/week active^	456.2 (435.3)	340 (460)	395.7 (460.3)	270 (300)

*Note. *p<.05. ^Sum of: Total of weekly transportation bicycling, transportation walking, recreation walking, vigorous physical activity, and moderate physical activity minutes. Participation: Chi^2 tests. Duration: Mann-Whitney U tests.*

DISCUSSION

Our findings suggest that a modified version of the IPAQ designed to capture neighbourhood-based physical activity demonstrates sufficient test-retest reliability for epidemiologic and intervention studies as an assessment tool to capture neighbourhood physical activity. For the majority (68.8%) of the modified IPAQ physical activity variables that we tested, we observed at least moderate test-retest reliability, with the most reliable variables being days walked for transportation followed by days engaging in vigorous physical activity. In contrast, the weakest test-retest reliability observed was for days being moderately active and minutes per day in moderate activity. It may be easier to recall a specific behavior in a particular setting (e.g. walking to the store in the neighbourhood to do an errand) than estimating the total amount of moderate activity (McCormack et al., 2009). In addition, our dichotomized participation variables demonstrated strong test-retest reliability, suggesting that this tool could be used to estimate a variety of neighbourhood-based physical activity variables including prevalence. Furthermore, we indirectly assessed some aspects of construct validity and found, as expected (Owen et al., 2007; Sundquist et al., 2011), that participants from objectively-determined high walkable neighbourhoods reported more active transportation than those from low walkable neighbourhoods.

Our results are consistent with previous research as well as local studies measuring neighbourhood physical activity (McCormack et al., 2009; McCormack et al., 2012; Saelens, Sallis, Black, & Chen, 2003). A previous study on a similar population administered a telephone version of the NPAQ found weaker test-retest reliability with moderate physical activity variables and the stronger test-retest reliability for active transport variables (Bae et al., 2015; McCormack et al., 2009). Further, although one of our study team members visited participants' homes during this study, which is more resource-intensive than a telephone-administered questionnaire, this team member did not aid in the completion of the questionnaire. Consequently, the modified IPAQ should be tested in other self-administered modes (e.g., postal survey and/or online survey). A strength of our study was that we used the IPAQ, a widely known and used self-report physical activity questionnaire (Craig et al., 2003; Hallal & Victora, 2004; Kim et al., 2013), and demonstrated that modification of this questionnaire to capture neighbourhood physical activity was easy to administer, hence, it should be useful and appropriate for future research studies.

A common characteristic of high walkable neighbourhoods is that they generally have a higher land use mix (i.e. residential and commercial) (Saelens et al., 2003). This design characteristic could explain the higher participation in active transportation and is consistent with previous research (Saelens & Handy, 2008; Saelens et al., 2003), since residents can access local shops and/or business to complete errands. Our results indicated that residents in high-walkable neighbourhoods reported an increase in participation of 25.5 and 22% for bicycling and walking for transportation compared to the residents in the low-walkable neighbourhood. In fact, almost all (91.2%) of the residents in the high-walkable neighbourhood reported walking for transportation. Furthermore, residents from the high-walkable neighbourhoods self-reported 51.8 more minutes a week walking for transportation than low walkable residents. This result is similar to a Swedish study that found a 50 minute weekly difference in walking for transportation between residents in high and low walkable neighbourhoods (Sundquist et al., 2011). The difference in active transportation could potentially produce different health outcomes between residents of high- and low-walkable neighbourhoods since bouts of activity as short as 10 minutes has been shown to convey health benefit, especially in already sedentary individuals (Warburton, Nicol, & Bredin, 2006). Therefore, increasing the ability for adults to undertake active transportation may be an important area for public health interventions (Sallis, Frank, Saelens, & Kraft, 2004). Previous research has also demonstrated an increase in walkability associated with an increase in time spent in active transportation, a decrease in body mass index, a decrease in distance travelled in a vehicle, and a decrease in greenhouse gas emissions (Frank et al., 2006). Thus, addressing the walkability of the environment not only influences physical activity but, may also have other indirect positive outcomes, such as a decrease in sedentary time, an improved body composition, personal economic savings by decreasing motor vehicle use, and a decrease in environmental (Frank et al., 2006). The positive health outcomes associated with neighbourhood walkability demonstrate the need for reliable measurements tools to further explore and strengthen the relationship between these variables.

Our study had several limitations. Our convenience sample was recruited from a previous study and the participants were highly-educated which limits the generalizability of the results. We did not undertake pre-testing of the modified physical activity items to investigate how the revised wording might be interpreted by participants, because we used items from a reliable and valid tool, and because we broadly defined the context in which the physical activity was being recalled (i.e., "neighbourhood" was interpreted by the participant's themselves when responding to the items). Our next step is to compare self-reported neighbourhood physical activity using this modified tool, against neighbourhood-based physical activity captured via simultaneous use of accelerometers and global position system (GPS) monitors, followed by a qualitative investigation to better understand how adults define and interpret "neighbourhood" in relation to their physical activity behaviour. We modified an established tool that captured physical activity undertaken in the last 7-days however, notably measurement issues related to physical activity recall type (i.e., past- or usual-week) exist (Doma, Speyer, Leicht, & Cordier, 2017). Using a last 7-day recall may not reflect habitual or typical physical activity patterns, although this may be addressed by capturing on multiple occasions, past week physical activity, and averaging responses over time to obtain estimates of typical physical activity (Doma et al., 2017). In relation to our findings, capturing physical activity undertaken in the last 7-days on two occasions one week apart could have resulted in an underestimate of the test-retest reliability, especially if participant's neighbourhood physical activity levels varied week-to-week. Participants at recruitment however, were instructed to not change their typical physical activity patterns during the study. Moreover, the lack of individual's reporting bicycling likely impacted our reliability estimates for this behaviour [e.g., time spent bicycling for transportation resulted in a ICC of 0.17, when this variable was restricted to participants who reported (n=5) the ICC increased to 0.58]. Our conclusions regarding the reliability of the modified item to capture duration of neighbourhood bicycling would be strengthened in a sample containing a larger number of bicyclists.

In our study, we estimated test-retest reliability of neighbourhood specific physical activity items. Further, we also provided evidence for construct validity via comparing self-reported neighbourhood physical activity between objectively measured high and low walkable neighbourhoods. We suggest that further testing of the neighbourhood modified IPAQ items is necessary. Concurrent validity should be assessed by comparing self-reported neighbourhood-based physical activity captured using the modified IPAQ against objective location-based measures of physical activity (e.g., using accelerometers with time-synced GPS monitors). Construct validity of the modified items could be further assessed by examining the direction and magnitude of associations between, specific neighbourhood built characteristics and self-reported neighbourhood physical activity and comparing these associations with previous evidence. Capturing neighbourhood physical activity of residents using the modified IPAQ items before and after implementation of a neighbourhood-level program or intervention (e.g., built environment changes) may provide further evidence of these items validity. Future studies should also consider evaluating the reliability and validity of these neighbourhood-based items when administered via different modes (e.g., via telephone interview or online survey) and in different populations.

CONCLUSIONS

Our findings indicate that a modified version of the IPAQ, designed to capture neighbourhood-based physical activity, can provide moderately reliable estimates of physical activity. This modified version of the IPAQ could provide an inexpensive tool for capturing self-report neighbourhood-based physical activity when investigating built environment correlates, especially in large population-based studies. Further research is needed to assess aspects of reliability of the modified neighbourhood-based IPAQ items when administered using different modes and to assess the validity of these items by comparing responses to objective measures of physical activity.

REFERENCES

Al-Hazzaa, H. M., Abahussain, N. A., Al-Sobayel, H. I., Qahwaji, D. M., & Musaiger, A. O. (2011). Physical activity, sedentary behaviors and dietary habits among Saudi adolescents relative to age, gender and region. International Journal of Behavioral Nutrition and Physical Activity, 8(1), 140. https://doi.org/10.1186/1479-5868-8-140

Bae, W. K., Cho, B., & Son, K. Y. (2015). Validity and reliability of the korean version of neighborhood physical activity questionnaire. Korean Journal of Family Medicine, 36(3), 135–40. https://doi.org/10.4082/kjfm.2015.36.3.135

Bauman, A. E., Reis, R. S., Sallis, J. F., Wells, J. C., Loos, R. J. F., Martin, B. W., & Lancet Physical Activity Series Working Group. (2012). Correlates of physical activity: Why are some people physically active and others not? The Lancet, 380(9838), 258–271. https://doi.org/10.1016/S0140-6736(12)60735-1

Cerin, E., Barnett, A., Sit, C. H. P., Cheung, M., Lee, L. J., Ho, S., & Chan, W. (2011). Measuring walking within and outside the neighborhood in Chinese elders: reliability and validity. BMC Public Health, 11(1), 851. https://doi.org/10.1186/1471-2458-11-851

Cerin, E., Conway, T. L., Cain, K. L., Kerr, J., De Bourdeaudhuij, I., Owen, N., … Sallis, J. F. (2013). Sharing good NEWS across the world: developing comparable scores across 12 countries for the Neighborhood Environment Walkability Scale (NEWS). BMC Public Health, 13(1), 309. https://doi.org/10.1186/1471-2458-13-309

Cerin, E., Nathan, A., van Cauwenberg, J., Barnett, D. W., Barnett, A., & Council on Environment and Physical Activity (CEPA) – Older Adults working group. (2017). The neighbourhood physical environment and active travel in older adults: a systematic review and meta-analysis. The International Journal of Behavioral Nutrition and Physical Activity, 14(1), 15. https://doi.org/10.1186/s12966-017-0471-5

Cerin, E., Saelens, B. E., Sallis, J. F., & Frank, L. D. (2006). Neighborhood Environment Walkability Scale: validity and development of a short form. Medicine and Science in Sports and Exercise, 38(9), 1682–91. https://doi.org/10.1249/01.mss.0000227639.83607.4d

Choi, J., Lee, M., Lee, J., Kang, D., & Choi, J.-Y. (2017). Correlates associated with participation in physical activity among adults: a systematic review of reviews and update. BMC Public Health, 17(1), 356. https://doi.org/10.1186/s12889-017-4255-2

Christian, H. E., Bull, F. C., Middleton, N. J., Knuiman, M. W., Divitini, M. L., Hooper, P., … Giles-Corti, B. (2011). How important is the land use mix measure in understanding walking behaviour? Results from the RESIDE study. The International Journal of Behavioral Nutrition and Physical Activity, 8(1), 55. https://doi.org/10.1186/1479-5868-8-55

Craig, C. L., Marshall, A. L., Sjöström, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., … Oja, P. (2003). International physical activity questionnaire: 12-country reliability and validity. Medicine and Science in Sports and Exercise, 35(8), 1381–95. https://doi.org/10.1249/01.MSS.0000078924.61453.FB

Ding, D., Adams, M. a, Sallis, J. F., Norman, G. J., Hovell, M. F., Chambers, C. D., … Bauman, A. E. (2013). Perceived neighborhood environment and physical activity in 11 countries: do associations differ by country? The International Journal of Behavioral Nutrition and Physical Activity, 10, 57. https://doi.org/10.1186/1479-5868-10-57

Ding, D., & Gebel, K. (2012). Built environment, physical activity, and obesity: what have we learned from reviewing the literature? Health & Place, 18(1), 100–5. https://doi.org/10.1016/j.healthplace.2011.08.021

Doma, K., Speyer, R., Leicht, A. S., & Cordier, R. (2017). Comparison of psychometric properties between usual-week and past-week self-reported physical activity questionnaires: a systematic review. The International Journal of Behavioral Nutrition and Physical Activity, 14(1), 10. https://doi.org/10.1186/s12966-017-0470-6

Ferdinand, A. O., Sen, B., Rahurkar, S., Engler, S., & Menachemi, N. (2012). The relationship between built environments and physical activity: A systematic review. American Journal of Public Health, 102(10), 7–13. https://doi.org/10.2105/AJPH.2012.300740

Frank, L. D., Sallis, J. F., Conway, T. L., Chapman, J. E., Saelens, B. E., & Bachman, W. (2006). Many Pathways from Land Use to Health: Associations between Neighborhood Walkability and Active Transportation, Body Mass Index, and Air Quality. Journal of the American Planning Association, 72(1), 75–87. https://doi.org/10.1080/01944360608976725

Giles-Corti, B., Timperio, A., Cutt, H., Pikora, T. J., Bull, F. C. L., Knuiman, M., … Shilton, T. (2006). Development of a reliable measure of walking within and outside the local neighborhood: RESIDE's Neighborhood Physical Activity Questionnaire. Preventive Medicine, 42(6), 455–9. https://doi.org/10.1016/j.ypmed.2006.01.019

Hallal, P., & Victora, C. (2004). Reliability and Validity of the International Physical Activity Questionnaire (IPAQ). Medicine & Science in Sports & Exercise, 36(3), 556. https://doi.org/10.1249/01.MSS.0000117161.66394.07

Hillsdon, M., Coombes, E., Griew, P., & Jones, A. (2015). An assessment of the relevance of the home neighbourhood for understanding environmental influences on physical activity: how far from home do people roam? The International Journal of Behavioral Nutrition and Physical Activity, 12(1), 100. https://doi.org/10.1186/s12966-015-0260-y

Humpel, N., Owen, N., Leslie, E., Marshall, A. L., Bauman, A. E., & Sallis, J. F. (2004). Associations of location and perceived environmental attributes with walking in neighborhoods. American Journal of Health Promotion : AJHP, 18(3), 239–42. https://doi.org/10.4278/0890-1171-18.3.239

Kim, Y., Park, I., & Kang, M. (2013). Convergent validity of the international physical activity questionnaire (IPAQ): meta-analysis. Public Health Nutrition, 16(3), 440–52. https://doi.org/10.1017/S1368980012002996

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. Biometrics, 33(1), 159–74. https://doi.org/10.2307/2529310

McCormack, G., Giles-Corti, B., & Bulsara, M. (2008). The relationship between destination proximity, destination mix and physical activity behaviors. Preventive Medicine, 46(1), 33–40. https://doi.org/10.1016/j.ypmed.2007.01.013

McCormack, G. R., Friedenreich, C., Sandalack, B. A., Giles-Corti, B., Doyle-Baker, P. K., & Shiell, A. (2012). The relationship between cluster-analysis derived walkability and local recreational and transportation walking among Canadian adults. Health & Place, 18(5), 1079–87. https://doi.org/10.1016/j.healthplace.2012.04.014

McCormack, G., & Shiell, A. (2011). In search of causality: a systematic review of the relationship between the built environment and physical activity among adults. The International Journal of Behavioral Nutrition and Physical Activity, 8, 125. https://doi.org/10.1186/1479-5868-8-125

McCormack, G., Shiell, A., Doyle-Baker, P., Friedenreich, C., Sandalack, B., & Giles-Corti, B. (2009). Testing the reliability of neighborhood-specific measures of physical activity among Canadian adults. Journal of Physical Activity & Health, 6(3), 367–73. https://doi.org/10.1123/jpah.6.3.367

Owen, N., Cerin, E., Leslie, E., duToit, L., Coffee, N., Frank, L. D., … Sallis, J. F. (2007). Neighborhood Walkability and the Walking Behavior of Australian Adults. American Journal of Preventive Medicine, 33(5), 387–395. https://doi.org/10.1016/j.amepre.2007.07.025

Prince, S., Adamo, K., Hamel, M., Hardt, J., Gorber, S., & Tremblay, M. (2008). A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review. International Journal of Behavioral Nutrition and Physical Activity, 5(1), 56. https://doi.org/10.1186/1479-5868-5-56

Saelens, B. E., & Handy, S. L. (2008). Built environment correlates of walking: a review. Medicine and Science in Sports and Exercise, 40(7 Suppl), S550-66. https://doi.org/10.1249/MSS.0b013e31817c67a4

Saelens, B. E., Sallis, J. F., Black, J. B., & Chen, D. (2003). Neighborhood-based differences in physical activity: an environment scale evaluation. American Journal of Public Health, 93(9), 1552–8. https://doi.org/10.2105/AJPH.93.9.1552

Sallis, J. F., Frank, L. D., Saelens, B. E., & Kraft, M. K. (2004). Active transportation and physical activity: Opportunities for collaboration on transportation and public health research. Transportation Research Part A: Policy and Practice, 38(4), 249–268. https://doi.org/10.1016/j.tra.2003.11.003

Sallis, J. F., & Saelens, B. E. (2000). Assessment of physical activity by self-report: status, limitations, and future directions. Research Quarterly for Exercise and Sport, 71(2 Suppl), S1-14. https://doi.org/10.1080/02701367.2000.11082780

Sundquist, K., Eriksson, U., Kawakami, N., Skog, L., Ohlsson, H., & Arvidsson, D. (2011). Neighborhood walkability, physical activity, and walking behavior: the Swedish Neighborhood and Physical Activity (SNAP) study. Social Science & Medicine (1982), 72(8), 1266–73. https://doi.org/10.1016/j.socscimed.2011.03.004

Van Dyck, D., Cardon, G., Deforche, B., & De Bourdeaudhuij, I. (2015). IPAQ interview version: convergent validity with accelerometers and comparison of physical activity and sedentary time levels with the self-administered version. The Journal of Sports Medicine and Physical Fitness, 55(7–8), 776–86.

Warburton, D. E. R., Nicol, C. W., & Bredin, S. S. D. (2006). Prescribing exercise as preventive therapy. CMAJ : Canadian Medical Association Journal = Journal de l'Association Medicale Canadienne, 174(7), 961–74. https://doi.org/10.1503/cmaj.1040750