Investigating how researcher-defined buffers and self-drawn neighbourhoods capture adolescent availability to physical activity facilities and greenspaces: An exploratory study.

CHRISTENSEN, A <http://orcid.org/0000-0001-8508-8424>, RADLEY, D <http://orcid.org/0000-0003-3458-7201>, HOBBS, Matthew, GORSE, C <http://orcid.org/0000-0001-9490-3144> and GRIFFITHS, C <http://orcid.org/0000-0002-2588-1022>

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Investigating how researcher-defined buffers and self-drawn neighbourhoods capture adolescent availability to physical activity facilities and greenspaces: An exploratory study

A. Christensen[a,*], D. Radley[a], M. Hobbs[b,c], C. Gorse[d], C. Griffiths[a]

[a] Carnegie School of Sport, Leeds Beckett University, Leeds, United Kingdom, LS6 3QT, UK
[b] Faculty of Health, University of Canterbury, Christchurch, Canterbury, New Zealand
[c] GeoHealth Laboratory, Geospatial Research Institute, University of Canterbury, Christchurch, Canterbury, New Zealand
[d] School of Built Environment and Engineering, Carnegie, Leeds Beckett University, Leeds, LS6 3QT, UK

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ABSTRACT

Background: Modifying the environment is considered an effective population-level approach for increasing healthy behaviours, but associations remain ambiguous. This exploratory study aims to compare researcher-defined buffers and self-drawn neighbourhoods (SDN) to objectively measured availability of physical activity (PA) facilities and greenspaces in adolescents.
Methods: Seven consecutive days of GPS data were collected in an adolescent sample of 14–18 year olds ($n = 69$). Using Points of Interest and greenspace data, availability of PA opportunities within activity spaces were determined. We compared 30 different definitions of researcher-defined neighbourhoods and SDNs to objectively measured availability.
Results: :Findings showed low agreement for all researcher-defined buffers in measuring the availability of PA facilities in activity spaces. However, results were less clear for greenspace. SDNs also demonstrate low agreement for capturing availability to the PA environment.
Conclusion: This exploratory study highlights the inadequacy of researcher-defined buffers and SDNs to define availability to environmental features.

Introduction

Globally, designing environments to promote healthy living is increasingly considered an important strategy to improve wellbeing (United Nations 2015). With high levels of obesity (Health and Social Care Information Centre 2019) and inactivity (Sport England 2017) in the UK, it is theorised that modifying the PA environment may provide an effective population wide approach for increasing PA and decreasing obesity (Swinburn et al., 1999; Rose, 2001). For example, a recent systematic review has found some evidence that neighbourhoods with better walking and cycling infrastructure or better walkability have greater levels of PA in children and young people (Prince et al., 2022). Theoretically, it is important to understand how features of the environment affect health (Caprio et al., 2008). However, it is also equally important to understand methodologically how we measure the impact of environmental effects on health. Yet, the evidence relating the environment to behaviour often remain inconsistent in scale and direction (Bauman et al., 2012). In a review for instance, (Bauman et al., 2012) found that in nine papers, only two identified neighbourhood design (i.e. walkability or street connectivity) as correlates of transport physical activity, but no other consistent correlates. As results rarely support our unspoken expectations either for scale or direction, this suggests shortcomings in both our theoretical and methodological understanding (Hobbs and McKenna, 2019).

Shortcomings in our understanding are often related to methodological issues (Chun et al., 2019). Environmental health research often relies on static definitions of neighbourhoods such as administrative areas, census-defined tracts, or buffers created around the home location of an individual as a proxy for access or availability. A recent review highlights that using predefined boundaries such as buffers (53.1% of papers) is the most common method used to investigate environmental features (Wilkins et al., 2019). Additionally, important inconsistencies

* Corresponding author.
E-mail address: Alex.christensen@leedsbeckett.ac.uk (A. Christensen).

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also occur when defining a neighbourhood, as well as a persistent lack of clarity around how and where to draw its boundaries (Hobbs and McKenna, 2019). Many studies still operate on the assumption that individuals operate within their defined residential neighbourhood (Wilkins et al., 2019; Feng et al., 2010; Leal and Chaix, 2011). However, individuals do not limit themselves to the nearest opportunity for PA and spend vast amounts of time outside these predetermined areas typically used in research. Internationally, several studies demonstrate that buffers fail to accurately nor adequately measure daily life (Wiehe et al., 2008; Troped et al., 2010; Hillsdon et al., 2015; Christensen et al., 2021). For example, a recent exploratory study in adolescents in the UK (n = 40) found that out of 30 different types of buffers, no buffer was adequate in capturing objectively measured activity space (Christensen et al., 2021). While many studies often include objective measures of health outcomes, there is less emphasis on accurately capturing actual exposure to the environment (Kwan, 2012; Perchoux CC et al., 2013). Using new methods may help understand the geographical area at which the environment exerts influence on behaviour and health and will help improve evidential consistency.

Based on Tobler (1970) first law of geography that "everything is related to everything else, but near things are more related than distant things", assumptions that the availability of physical activity facilities and/or greenspace influences physical activity behaviour have long existed within the field of research. Intuitively, it would seem likely that the greater presence of physical activity facilities, the increased likelihood of physical activity behaviour, however this is not necessarily the case. Studies in the United States have found different associations between the amount of physical activity opportunities and behaviour depending on which buffer size is used (Roux et al., 2007; JF Sallis et al., 1990). For example, in the Netherlands, proportion of greenspace (mean proportion of greenspace was 9.8, 13.8, and 20.1 within a 400 m, 800 m, and 1600 m buffer respectively) was positively associated with MVPA within a 400 m buffer, but not within the 800 m or 1600 m buffer (Jansen et al., 2018). These different associations lead to questions as to which buffer or neighbourhood size is the 'correct' scale (Matthews and Yang, 2013).

Activity space, in reflecting daily movement, is an individual measure of spatial behaviour and can be defined in both space and place (Perchoux et al., 2013). Using individualise measures of activity space may address some of these and may provide insight into the accuracy of buffers. Unfortunately, methodologically, measuring activity space requires more data, is computationally more intensive, and requires a more complex analysis, which has resulted in its underutilisation and has led to questions on the necessity of going to such lengths (Sherman et al., 2005). Studies have yet to sufficiently consider the difference between assumed availability based on arbitrary buffers and actual availability based on objectively measured activity space and the effect this may have on results. Therefore, this exploratory study aims to compare researcher-defined buffers to objectively measured availability of PA facilities and green spaces in adolescents. Second, it examines how adolescent self-drawn neighbourhoods (SDN) capture the availability of PA facilities and greenspace.

Methods

Participants, settings and protocol

Adolescents aged 14–18 years were recruited from secondary schools and colleges in West Yorkshire, England. Recruitment took place between May 2017 and March 2018. Sixty-nine participants (24 male, 45 female) written parental consent and written participant assent to participate in the study. Data collection occurred in two waves, autumn (September/October 2017) and spring (March/April 2018) due to restrictions in school timetables. Individual demographics data on age, gender, postcode, and ethnicity (amalgamated into White British and all other ethnic groups due to small sample sizes in other ethnic groups) were collected using an online questionnaire developed in Qualtrics (Qualtrics, Provo, USA). Institutional approval was received from Carnegie School of Sport, Leeds Beckett Research, Research Ethics Committee (ref: 37,750).

Daily movement

To objectively collect individual's daily movement, participants either wore a GPS device (Garmin Forerunner 401) (n = 39) or ran a proprietary GPS smartphone application (Tracker) (n = 30) for seven consecutive days, collecting data over 15 second epochs (Jankowska et al., 2015). Participants were instructed to wear the GPS device during all waking hours, except if they were participating in a water activity (i. e. swimming or bathing). GPS data were visually inspected and cleaned to ensure that any data outside of the study period were removed. Furthermore, data were separated by days, using time stamps, and total daily wear time was calculated. Using a similar approach to Quigg et al. (2010), upon inspection of participants' GPS wear time, prior to data analysis, but after data collection, it was decided a 5 hour wear time criteria, which includes a trip from home to school, would be used in this study; this maximised data inclusion, but additionally provided a cut-off for insufficient compliance. Less than five hours was considered insufficient compliance and was therefore excluded. Data adhering to the wear time criteria was uploaded and visually inspected within ArcGIS (v. 10.6.1) to ensure the data was of good quality (i.e. logical GPS path, data within the study area, etc.).

Researcher- and participant defined neighbourhoods

Radial, network and ellipse buffers

Within ArcGIS (v. 10.6.1), five buffer sizes (400 m, 800 m, 1 km, 1600 km, 3 km) were created around the home (based on postcode) and school of each participant- both radially and based on the street network. Additionally, a straight line ellipse and network line ellipse were also created. Straight line and road network paths (based on the shortest network route) between the home and school were used to create ellipse buffers at the five buffer sizes (described in detail in (Christensen et al., 2021)).

Activity space

A "daily path" was used to represent individual's daily movement (Christensen et al., 2021). A daily path buffers all GPS points into a single line or space (Zenk et al., 2011) and was determined to be the most appropriate method for this research as it would allow a more accurate representation of an individual's daily movement without over or underestimating the space an individual used, as seen with other types of activity spaces (Christensen et al., 2021).

All GPS data was displayed in ArcGIS. GPS points were converted into a line, using ArcMap's point to line tool. This allowed for visualisation of the daily path for each participant. In some instances, there was a gap in GPS data, resulting in inaccurate daily path lines. These lines were removed as they were seen as inaccurate representation of the data. After a true daily path line was determined, a 100 metre buffer was created around the daily path to create activity space (AS). 100 metres was used to account for potential GPS errors (Peak et al., 2010; Donaire-Gonzalez et al., 2016). AS size was determined by calculating the area the 100 metre buffer covered and was reported in square kilometres (km^2) (Lee et al., 2016).

Self-drawn neighbourhoods

Participants were given instructions to complete a self-drawn neighbourhood (SDN) activity within Google My Maps. Participants entered their postcode and were asked to "*create a boundary of what you consider as your neighbourhood on the map*". This was left open for interpretation for the participant as to what "neighbourhood" meant to them in order to provide a richer qualitative understanding of what residents perceive a neighbourhood to be. Within Google My Maps, the ‘draw a line’ tool was used by participants to create their bespoke neighbourhood within the map. Participants’ SDN were downloaded from Google My Maps and converted to a feature in ArcMap, allowing for visualisation and comparison. SDNs size were than calculated by determining the area the SDN covered in square kilometres (km^2).

Availability

Using the POI Classification Scheme, a database was amalgamated as previously defined by Hobbs et al. (2019) to represent physical activity facilities, and imported into ArcGIS. The X, Y location of each POI was then mapped in ArcGIS and projected using the British National Grid coordinate system. Duplicates were removed by dissolving the feature, so those with the same coordinates were aggregated. Additionally, Ordnance Survey Open Greenspace data were downloaded and imported into ArcGIS. Due to some cross over between POI data and greenspace data (i.e. both containing athletic facilities and play spaces), only Public Parks and Allotments were used from greenspace data as these were not included in POI data and are other locations for physical activity to occur. Similar to POI data, greenspace data was imported in ArcGIS and projected using the British National Grid coordinate system. Duplicates were removed by dissolving the feature to aggregated polygons.

Analysis

The count of PA facilities and greenspace that were within, or intersecting with, activity space was reported. Additionally, a count of PA facilities and greenspace within each buffer type (radial, network, and ellipse) and size (400 m, 800 m, 1 km, 1.6 km, and 3 km) was recorded. True positives were determined (count of facilities that were within both activity space and buffer). Additionally, to assess agreement across different methods in measuring activity facilities positive predictive values (PPV) and sensitivity were determined (PPV: true positive versus false positive; sensitivity: true positive vs false negative) (see Table 1 for definitions and Fig. 1 for diagram).

Similarly, the count of facilities and greenspace within SDNs were also determined. This was compared to AS to determine true positives, PPV and sensitivity values. It should be noted that the PPV value largely declines, due to the denominator getting lager while the numerator stays the same.

Results

Study sample

This study had a relatively high participant burden and asked participants to complete multiple tasks and comply over a weeklong time period, resulting in only 44 participants providing GPS data. This loss to

Table 1
Definitions of terms used to describe availability.

Term	Definition
True Positives	A POI facility identified within the buffer and is also within activity space
False Positives	A POI facility identified within the buffer but is not within activity space
False Negatives	A POI facility within activity space, but not identified within the buffer
Positive Predictive Value	The proportion of correctly identified POI facilities (true positives) divided by the amount of total POI facilities within the buffer (true positives + false positives)
Sensitivity	The proportion of correctly identified POI facilities (true positives) divided by the amount of total POI facilities within activity space (correctly identified and not identified (true positives + false negatives))

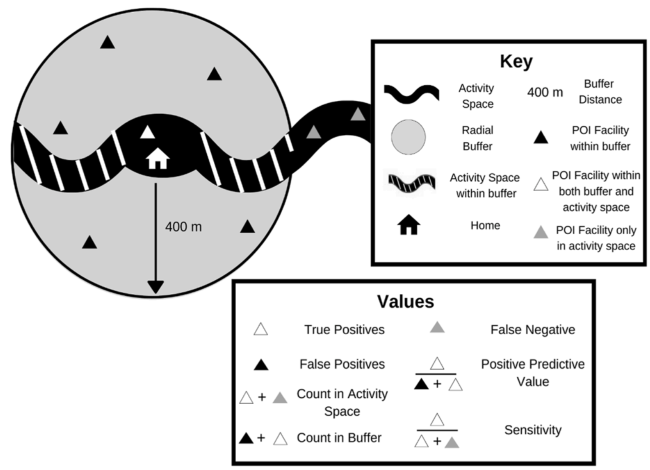

Fig. 1. Diagram depicting count of physical activity facilities and how values were determined.

follow-up is likely due to low compliance (e.g. not turning GPS device on or logging into the GPS app). Additionally, four participants were excluded (2 participants only had weekend days available, 1 participant only had data at the home and school, and 1 participant had continuous large gaps in data that made daily path illogical/not feasible/accurate. Therefore, 40 participants were included in the final sample. Participants averaged 3.36 days meeting the inclusion criteria, averaging 10.46 h of wear time per day. Thirty-three participants had both completed SDNs and AS. Study sample characteristics are provided in Table 2.

Activity spaces and researcher-defined buffers

Physical activity facilities

Results of agreement (positive predictive values and sensitivity values) by the different methods of measuring PA facilities can be found in Table 3. On average, within activity spaces, participants had 13 available PA facilities. Two participants didn’t have a PA facility available within their activity space.

True positives increased as buffer sizes increased, across all buffer types. PPV was higher in the smaller buffer distances, for all buffer types. For example, a 400 metre home radial buffer had a PPV of 40.2% whereas a 3 km home radial buffer had a PPV of 7.7%. Overall, home network buffers reported the highest PPV across all buffer types when comparing equivalent buffer distances. For example, a 400 metre home network buffer had a PPV of 90.0%, whereas a 400 metre home radial

Table 2
Study sample characteristics.

Characteristic	Frequency
Gender	
Female	26 (65.0)
Male	14 (35.0)
Age	16.12±1.20
Ethnicity	
White British	31 (77.5)
All other ethnic backgrounds	9 (22.5)
Area Level Deprivation	
1 (most deprived)	11 (27.5)
2	10 (25.0)
3	4 (10.0)
4	9 (22.5)
5 (least deprived)	6 (15.0)
Activity Space Size (km^2) (n = 40)	6.99±7.72
Self-Drawn Neighbourhood Size (km^2) (n = 33)	2.70±7.53

Data are presented as n (%) unless stated otherwise. [1]Mean ±SD

Table 3
Available physical activity facilities.

Activity Space= 13.2 (0–66)				
	Count Within Buffer	True Positives	PPV (%)	Sensitivity (%)
Home Radial				
400 m	2.4 (0–9)	1.2 (0–6)	40.2 (0–100)	20.0 (0–100)
800 m	7.7 (1–20)	2.1 (0–7)	26.9 (0–100)	27.9 (0–100)
1 km	11.9 (4–25)	2.7 (0–8)	23.8 (0–87.5)	36.8 (0–100)
1.6 km	28.8 (9–56)	4.3 (0–13)	16.0 (0–65)	49.3 (0–100)
3 km	90.3 (40–165)	6.5 (0–21)	7.7 (0–40)	69.3 (0–100)
Home Network				
400 m	0.5 (0–4)	0.4 (0–4)	90.0 (0–100)	12.9 (0–100)
800 m	2.9 (0–10)	1.5 (0–6)	50.8 (0–100)	21.7 (0–100)
1 km	4.7 (0–13)	1.8 (0–6)	36.0 (0–100)	24.9 (0–100)
1.6 km	13.5 (4–35)	3.2 (0–11)	25.3 (0–75)	38.4 (0–100)
3 km	49.1 (17–111)	5.1 (0–16)	10.9 (0–47.06)	55.7 (0–100)
School Radial				
400 m	0.3 (0–2)	0.1 (0–2)	70.0 (0–100)	7.6 (0–100)
800 m	3.8 (3–8)	0.6 (0–4)	14.2 (0–66.67)	19.3 (0–100)
1 km	9.5 (8–18)	0.8 (0–75)	8.0 (0–62.5)	21.7 (0–100)
1.6 km	23.7 (22–33)	1.7 (0–6)	7.1 (0–22.73)	35.4 (0–100)
3 km	91.2 (90–98)	4.3 (0–16)	4.7 (0–17.78)	55.4 (0–100)
School Network				
400 m	0	0	0	50.0 (0–100)
800 m	1.2 (1–2)	0.3 (0–2)	20.0 (0–100)	94.4 (0–100)
1 km	1.5 (1–4)	0.3 (0–3)	19.4 (0–100)	12.0 (0–100)
1.6 km	9.8 (8–20)	1.0 (0–4)	10.4 (0–37.5)	25.2 (0–100)
3 km	35.0 (32–52)	2.1 (0–6)	5.9 (0–15.63)	40.8 (0–100)
Ellipse-Straight Line				
400 m	10.9 (0–58)	2.6 (0–14)	29.7 (0–100)	38.9 (0–100)
800 m	26.7 (3–104)	4.8 (0–20)	19.5 (0–57.14)	55.6 (0–100)
1 km	36.4 (3–119)	5.6 (0–21)	16.2 (0–45.45)	63.4 (0–100)
1.6 km	64.8 (14–177)	7.2 (0–29)	11.2 (0–36.54)	74.4 (13.79–100)
3 km	162.9 (64–363)	9.1 (0–33)	5.8 (0–31.76)	83.9 (24.14–100)
Ellipse-Network Line				
400 m	14.6 (1–39)	3.4 (0–14)	26.5 (0–70)	42.7 (0–100)
800 m	32.1 (8–92)	5.4 (0–21)	17.7 (0–40.38)	59.9 (0–100)
1 km	43.2 (15–135)	6.0 (0–23)	14.4 (0–38.33)	64.9 (10.34–100)
1.6 km	75.3 (24–201)	7.5 (0–29)	9.9 (0–30.53)	75.3 (13.79–100)
3 km	182.1 (106–379)	9.5 (0–37)	5.0 (0–15.48)	84.6 (27.59–100)

Data are presented as: Mean (minimum, maximum)

buffer had a PPV of 40.2%, 400 metre ellipse buffers had PPVs of 26–29% and school radial buffers had a PPV of 70.0%; a 400 metre school network buffer did not contain any PA facilities.

Sensitivity increased as buffer size increased in all buffer types except school network buffers. Ellipse buffers had notably higher sensitivity than other buffer types at equivalent buffer distances. For example, 3 km ellipse buffers (both straight line and network line) sensitivity values were between 83 and 85%, whereas a 3 km home radial buffer had a sensitivity value of 69.3%, 3 km home network had a sensitivity value of 55.7%, a 3 km school radial buffer had a value of 55.4%, and a school network buffer had a value of 40.8%. In summary, true positives increased as buffer sizes increased, and sensitivity increased as buffer size increased in all buffer types except school network buffers.

PPVs and sensitivity values of the buffers were plotted to visualise the full agreement (Fig. 2). The upper right quadrant on the figure demonstrates high agreement (high amount of PPV and sensitivity) where the lower left quadrant represents the lowest agreement (low amount of PPV and sensitivity). For all buffers except the school network, the scatterplot shows a negative trend where, as buffer size increases, PPV decreases and sensitivity increases. Additionally, no buffer falls within the upper right quadrant, meaning that all buffers either demonstrate a low amount of sensitivity, PPV, or both. The majority of buffers had low PPV values, with only 400 metre home network and 400 metre school radial buffers having PPV values greater than 50%.

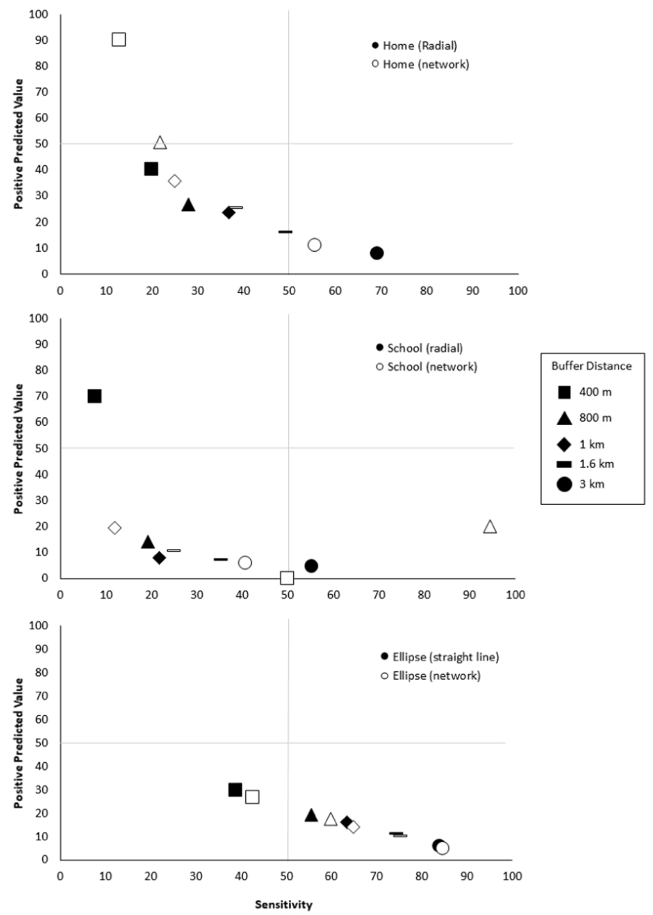

Fig. 2. Scatterplot of buffers PPV and sensitivity in capturing activity space POI facilities.

Green space

Results of agreement (positive predictive values and sensitivity values) in different methods measuring greenspace can be found in Table 4. On average, within activity spaces, participants had 5 greenspaces available. Seven participants had no available greenspace within their activity space. School network and radial buffers reported no available greenspace at the smaller buffer distances (radial 400 m; network 400 m, 800 m and 1 km).

True positives increased as buffer sizes increased, across all buffer types. PPV was higher in the smaller buffer distances than larger buffer distances, for all buffer types. For example, a 400 metre straight line ellipse had a PPV of 59.0%, whereas at 3 km a straight line ellipse had a PPV of 10.18%. Overall, home network buffers reported the highest PPV across all buffer types when comparing equivalent buffer distances. For example, at a 3 km distance, a home network buffer had a PPV of 22.2%, whereas a home radial had a PPV of 12.9%, school buffers had PPV between 10 and 14%, and ellipse buffers had PPVs between 9 and 11%.

Sensitivity increased as buffer size increased in all buffer types

Table 4
Count of available greenspace.

	Activity Space= 5.3 (0–29)			
	Count Within Buffer	True Positives	PPV (%)	Sensitivity (%)
Home Radial				
400 m	0.8 (0–3)	0.6 (0–2)	83.8 (0–100)	34.5 (0–100)
800 m	2.5 (0–8)	1.1 (0–4)	47.7 (0–100)	46.1 (0–100)
1 km	3.4 (0–11)	1.3 (0–5)	44.0 (0–100)	50.1 (0–100)
1.6 km	7.0 (0–17)	1.8 (0–7)	27.5 (0–100)	56.4 (0–100)
3 km	22.0 (12–39)	2.8 (0–13)	12.9 (0–68.4)	73.1 (0–100)
Home Network				
400 m	0.4 (0–2)	0.4 (0–2)	98.8 (50–100)	29.7 (0–100)
800 m	1.1 (0–5)	0.7 (0–2)	78.5 (0–100)	36.4 (0–100)
1 km	1.7 (0–10)	0.9 (0–4)	67.3 (0–100)	42.7 (0–100)
1.6 km	3.9 (0–12)	1.4 (0–6)	40.7 (0–100)	50.5 (0–100)
3 km	12.1 (3–24)	2.4 (0–11)	22.2 (0–100)	68.0 (0–100)
School Radial				
400 m	0	0	0	17.5 (0–100)
800 m	0.9 (0–1)	0.2 (0–1)	30.0 (0–100)	20.6 (0–100)
1 km	2.9 (2–3)	0.4 (0–3)	12.1 (0–100)	25.2 (0–100)
1.6 km	5.9 (5–6)	0.6 (0–3)	10.3 (0–50)	36.1 (0–100)
3 km	19.9 (8–22)	2.2 (0–11)	10.8 (0–50)	68.9 (0–100)
School Network				
400 m	0	0	0	17.5 (0–100)
800 m	0	0	0	17.5 (0–100)
1 km	0	0	0	17.5 (0–100)
1.6 km	1.2 (1–2)	0.2 (0–1)	16.3 (0–100)	21.9 (0–100)
3 km	8.7 (7–9)	1.2 (0–5)	13.2 (0–55.6)	45.6 (0–100)
Ellipse-Straight Line				
400 m	3.1 (0–7)	1.4 (0–5)	59.1 (0–100)	49.8 (0–100)
800 m	6.5 (0–15)	2.1 (0–10)	36.0 (0–100)	61.1 (0–100)
1 km	9.3 (2–19)	2.5 (0–11)	26.5 (0–100)	69.1 (0–100)
1.6 km	16.2 (5–35)	3.1 (0–17)	17.9 (0–63.6)	75.9 (0–100)
3 km	38.0 (14–68)	4.1 (0–20)	10.2 (0–42.9)	87.9 (22.2–100)
Ellipse-Network Line				
400 m	4.3 (1–10)	1.7 (0–7)	53.5 (0–100)	56.1 (0–100)
800 m	7.9 (0–22)	2.4 (0–13)	35.8 (0–100)	67.3 (0–100)
1 km	10.9 (1–25)	2.6 (0–13)	22.2 (0–60)	70.7 (0–100)
1.6 km	17.7 (5–43)	3.3 (0–16)	17.4 (0–66.7)	77.2 (0–100)
3 km	39.5 (14–75)	4.1 (0–20)	9.9 (0–40)	88.5 (33.3–100)

Data are presented as: Mean (minimum, maximum)

except school network buffers. Ellipse buffers had notably higher sensitivity than other buffer types at equivalent buffer distances. For example, 3 km ellipse buffers (both straight line and network line) sensitivity values were between 87 and 88%, whereas a 3 km home radial buffer had a sensitivity value of 73.1%, 3 km home network had a sensitivity value of 68.0%, a 3 km school radial buffer had a value of 68.9%, and a school network buffer had a value of 45.6%. In summary, true positives increased as buffer sizes increased, across all buffer types and sensitivity increased as buffer size increased in all buffer types except school network buffers.

PPVs and sensitivity values of the buffers were plotted to visualise the full agreement of buffers in assessing greenspace (Fig. 3). The upper right quadrant on the figure demonstrates high agreement (high amount of PPV and sensitivity) where the lower left box represents low agreement (low amount of PPV and sensitivity). For all buffers except school radial and network buffers, the scatter plot demonstrates a negative trend, as buffer size increases, PPV decreases and sensitivity increases. A 400 metre network ellipse buffer was the only buffer to have greater than 50% PPV and sensitivity values (54% and 56% respectively). All other buffers either demonstrate a low amount of sensitivity, PPV, or

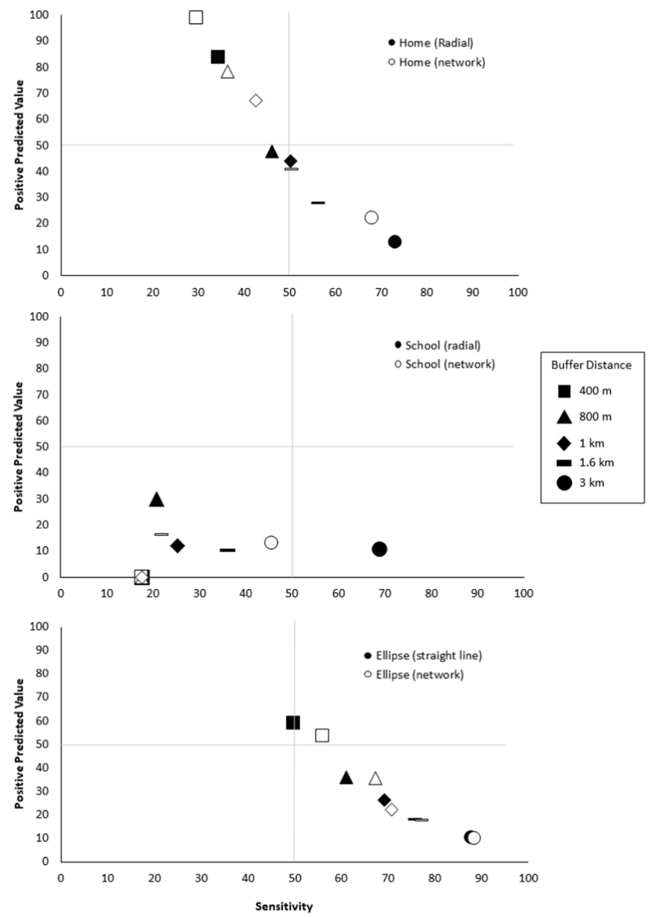

Fig. 3. Scatterplot of buffers PPV and sensitivity in capturing activity space greenspace.

both.

Activity space and self-drawn neighbourhoods availability

Thirty-three participants had both activity space and SDN measures. Results of PPV values and sensitivity values in assessing availability for PA facilities and greenspace can be found in Table 5. Participants had, on average, 14.5 available PA facilities within their activity space and 4.12 available PA facilities within SDN. On average, only 1.2 facilities were a true positive, with a PPV of 28.1% and sensitivity of 16.5%. Additionally, participants had, on average, 5.76 greenspaces available to them within their activity space and 1.8 available within SDN. Only 0.7 greenspace were a true positive, with a PPV of 24.4% and a sensitivity value of 28.8%.

Discussion

This exploratory study aimed to compare researcher-defined buffers

Table 5
Count of available physical activity facilities, and greenspace within activity space and self drawn neighbourhoods with PPV and sensitivity values.

	Count in activity space	Count in self-drawn neighbourhood	True Positives	PPV (%)	Sensitivity (%)
PA Facilities	14.5 (0–66)	4.1 (0–23)	1.2 (0–7)	28.2 (0–100)	16.5 (0–100)
Greenspace	5.8 (0–29)	1.5 (0–6)	0.7 (0–5)	24.4 (0–100)	28.8 (0–100)

and self-drawn neighbourhoods (SDN) to objectively measured availability of PA facilities and greenspaces in adolescents. We extend evidence by considering the difference between arbitrary buffer availability and actual availability based on individual activity space behaviour measured by GPS and attempt to quantify the effect this may have on study findings. Our findings show low agreement (low PPV and sensitivity) for all researcher-defined buffers in measuring the availability of PA facilities. However, our results were less clear for greenspace. We extend evidence by demonstrating that SDN also do not adequately capture locations where time is spent. Considered alongside other emerging evidence (Christensen et al., 2021; Laatikainen et al., 2018; Holliday et al., 2017) we highlight the inadequacy of researcher-defined and SDN to define availability to environmental features.

Intuitively, a greater availability of PA facilities or greenspaces is associated with increased PA. However, evidence often relies on researcher-defined buffers to approximate environmental exposure (Wilkins et al., 2019; Feng et al., 2010; Leal and Chaix, 2011; Hobbs et al., 2019). Indeed, different associations between the amount of PA opportunities and PA behaviour have been found depending on which researcher-defined buffer size is used (Roux et al., 2007; JFH Sallis et al., 1990). Our study shows low agreement for all buffers in measuring availability of PA facilities (low PPV values, low sensitivity values, or both) in activity spaces. In practice, this means buffers have either high amounts of falsely identified PA facilities as available to the individual, high amounts of unidentified PA facilities that are actually available to the individual, or high amounts of both falsely identified and unidentified facilities. This supports emerging evidence on the food environment which found that measures of foodscapes (i.e. local density of food sources) differ significantly when using activity space measures when compared to residential measures of exposure (Kestens et al., 2010). More recent evidence, by Shearer et al. (2015) found food location availability and accessibility was greater and visits occurred more commonly outside of the residential buffer than within it and concluded that traditional buffers overestimate the importance of the neighbourhood food environment. Considered alongside other emerging evidence (Christensen et al., 2021) our findings caution against the use of buffers, as it vastly differs from objectively measured behaviour.

Interestingly, our results were less clear in buffers measuring available greenspace. Results indicate that a 400 metre network line ellipse had high agreement (PPV and sensitivity >50%). Similarly, (Perchoux et al., 2016) found no overall difference when comparing the proportion of greenspace within activity space and network buffers. This may mean that greenspaces closer to the home environment are more likely to be used than physical activity facilities. Additionally, this may suggest that depending on the buffer method chosen, greenspace may be adequately assessed. More research is required using larger samples, however, researchers should be cautious when investigating associations between availability to PA facilities and greenspace and PA behaviours when using researcher-defined buffer methods.

Past research has suggested that adolescent SDN better capture locations where individuals spend their time (Robinson and Oreskovic, 2013). However, the results within our study contradict this suggestion. Our findings indicate low agreement between SDN availability and GPS measured activity space. In practice this means SDN either have high amounts of falsely identified facilities/greenspace as available to the individual, high amounts of unidentified facilities/greenspace that are actually available to the individual, or high amounts of both falsely identified and unidentified facilities/greenspace. Based on the PPV and sensitivity values, SDN demonstrate low agreement in assessing PA facility availability in AS. This confirms previous results by Morris et al. (2007) who found perceived access to services to be unrelated to objectively measured total PA. Additionally, it provides further support for the non-concordance between perceived and objective measures of the environment. For example, Gebel et al. (2011) and Arvidsson et al. (2012) both found one-third of individuals misperceive their neighbourhood when assessing neighbourhood walkability. Additionally, (Perchoux et al., 2016) found that proportion of green spaces and the density of destinations were lower in activity space than in the perceived residential neighbourhood.

This difference found in this research and others, may be highlighting other factors that influence perceptions and behaviour. For example, Jones et al. (2009) suggests that perceptions may be more driven by social factors that act to moderate associations with physical activity than actual greenspace provision. Furthermore, Baldock et al. (2012) highlights that "the availability or accessibility of environmental features recognised to be important for health, may have little effect on health outcomes if they are not perceived to be available or accessible". This can have important methodological considerations as even if the data analysis deems a feature of the environment as available to the participant, the participant may not perceive this feature as available, or may not even be aware of it. For example, if a PA facilities is within an individual's activity space, it, by researchers is considered available, however, the individual may perceive this facility as unsafe (Bennett et al., 2007) or inaccessible (Mota et al., 2005). This also mirrors qualitative work using ecological momentary assessment which suggests adolescents used public open spaces most often with friends/classmates, followed by siblings, parents and alone (Van Hecke et al., 2018). This highlights that perceived availability may be equally as important as objectively measured availability and the context in which the behaviour occurs may also allow the spatial-temporal complexities of PA behaviour to be better understood. Future research should consider and acknowledge these differences and seek to understand how they affect health outcomes and behaviour.

This study is limited by the small sample size. This could be due to the high participant burden and large amounts of invalid days. Consequently, the findings within this study are not generalisable and results may differ from other samples and in other settings. For example, it is very likely that adults have different results, due to higher car usage (Chatterjee et al., 2019), typically reporting higher number of trip rates per year (Department of Transport 2020), and greater access to services. Another limitation is that adolescents may also self-select into areas, therefore activity spaces may, in part, be a reflection of neighbourhood self-selection bias. A current ongoing criticism of research to date is most studies rely on cross-sectional designs that do not control for neighbourhood self-selection (Slater et al., 2019). Many studies have observed that residents of higher-density, mixed land use neighbourhoods tend to walk more and drive less than residents of lower-density, single-use residential areas (Frank et al., 2006; Cervero and Duncan, 2003; Crane and Crepeau, 1998; Cao et al., 2009). However, it is suggested that residents who prefer walking may consciously choose to live in neighbourhoods more conducive to walking, and therefore walk more. This raises questions of if associations between the built environment and behaviour reflect true impact or rather an effect of individual preference and choice (Cao et al., 2009). Neighbourhood preference and self-selection could be important to account for in future analyses. Finally, this study is limited by not capturing other important aspects of the environment such as quality. Past research has established that perceptions of the environment such as aesthetics, walkability, and safety, play a role in health outcomes and healthy behaviour (Baldock et al., 2012; De Bourdeaudhuij et al., 2015). Perceived environmental features may play an important role in behaviour and should be accounted for.

Overall, results from this paper caution against the use of predefined buffer boundaries. Results clearly show the high inaccuracy amongst buffers and SDNs in assessing availability. This means that when interpreting previous and current research that use these predefined boundaries, researchers need to be cautious when drawing conclusions from these studies While this paper demonstrates the importance of using objective measures when possible, it should be acknowledged that in the real world, buffers provide a more practical and simplistic analysis, and therefore, the use of other more accurate methods are unlikely due to lack of time and resources. Thus, there needs to be something that is 'good enough' that can, and will, be used in the real world to provide sufficient answers on the influence of the environment on behaviour. Although this research did not set out to make methodological recommendations, this research suggests that future studies may need to consider using flexible geographical scales (Hillsdon et al., 2015) or using buffers that encompass more than one key location to an individual such as an ellipse buffer or methods such as the ones used by Laatikainen et al. (2018) or Kestens et al. (2018). By avoiding a one-size fits all approach and ensuring more than one key location is collected in data sets (e.g. home and school or home and workplace) it will allow a better representation of environmental influences on individual behaviour. Additionally, when possible, future research should seek to investigate explanatory accounts of environmental perceptions as well as how individual define their neighbourhoods, as this might provide a greater insight to potential leverage points to increase healthy behaviours. These methods hold promise for future research and should be investigated further.

Conclusion

In summary, our exploratory study extends evidence by comparing researcher-defined buffers and self-drawn neighbourhoods (SDN) to objectively measured availability of PA facilities and greenspaces in adolescents. Our findings show that PPV and sensitivity varied by environmental exposure. Specifically, results showed low agreement for all researcher-defined buffers in measuring the availability of PA facilities, but findings were less clear for greenspaces. We also add to evidence by demonstrating that SDNs inadequately measure the availability of the PA environment. We add to emerging evidence which highlights the inadequacy of researcher-defined and participant defined SDNs to define exposure to environmental features. Future research is required to confirm our novel findings in larger samples.

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

The authors do not have permission to share data.

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