Studying Physical Activity in Children's Environments across Scotland (SPACES). Decision making processes using global positioning systems (GPS) and accelerometer data in a geographic information system (GIS)

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1. Introduction

There is a body of knowledge that relates to the 'how much', 'how often', and 'how intense' of Scottish children's activity levels, however, little is known about the 'where' of Scottish children's activity, and how this activity changes depending on geographic location (e.g. urban v rural living) and area level deprivation. Gaining insight into the answers of these important questions can be used in a number of ways, with the ultimate ambition of increasing population activity levels and reducing any social inequalities.

In developed countries, daily living has become increasingly sedentary. There are major concerns over rising overweight/obesity levels among children and young people. In Scotland the 'Scottish Health Survey 2009' indicates that 14.8% of boys and 14.2 % of girls can be classified as obese or morbidly obese (Ormston, 2010). To prevent and protect the body from these various health issues, physical activity has been highlighted as one of the easiest and most cost effective behaviours to engage in.

Positive associations in increased levels of PA are reported for the amount of greenspace close to home (Kaczynski et al., 2009) and the features within that greenspace, in particular, the presence of paved trails (Kaczynski et al., 2009). Scotland is fortunate in being the first country to comprehensively map all greenspace types for all urban settlements with a population of 3,000 or more.

The SPACES study aims to quantify physical activity (PA) levels occurring in greenspace[7] in adolescent boys and girls within 1st year of secondary school via objective measurement of PA using accelerometers and global positioning systems (GPS). Geographic information systems (GIS) will be used to map out the greenspace of the local environment and compare it with the objective PA data. Participants were from a rural secondary school in North Ayrshire *(N=40)* and an urban secondary school in Glasgow *(N=33)* in order to provide a large urban and small urban/rural comparison of PA occurring in greenspace.

Using GPS and accelerometer technologies and analysing them in a G.I.S. is still a relatively new area of research with new technologies emerging all the time. There is no superior method or gold standard approach to this type of research at present and work with other researchers and the sharing of knowledge of best practise is essential. However, despite some technical limitations (e.g. GPS signal accuracy) and the often rather subjective nature of how access to, and use of, greenspace is measured, these technologies provide a far more objective and accurate account of actual movements in multiple locations across time and space than self reported travel surveys or activity diaries. (Kerr et al, 2011). Another advantage of the technique is the ability to collect valuable contextual information such as the occurrence of physical activity in certain types of greenspace and what features of that greenspace attract more physical activity than others. (Maddison and Mhurchu, 2009)

1.1 Objectively measuring PA

Participants in the study were each issued with an ActiGraph GT3X+ accelerometer and a watch-like Garmin Foretrex 301 global positioning system (GPS) and asked to wear the devices for a week to record their PA levels and where the PA occurred. The gathered data was downloaded from the respective devices and exported to a .csv text file that could be imported into a GIS for analysis.

1.1.1 Importing data into a GIS

Two methods were employed to import the data into a GIS. Firstly the Garmin GPS device came with software that automatically combined the GPS and accelerometer data and output the results to a .csv data file. However, the Garmin company was unable to tell us how this was done and therefore there was a concern that data could be mis-matched. To avoid the potential for error and to provide a valuable check on the data, the GPS and accelerometer data were imported separately and then joined via the date/time stamp.

The GPS .csv data file was imported into the free and open source Quantum GIS Desktop 1.8 and then converted into a shape file for use in ArcGIS for Desktop 10.0. The accelerometer data was also imported into ArcGIS at 30 second epochs and then matched to the GPS data using the date/time stamp automatically recorded for each track point using the atomic clock (sometimes referred to as the Universal Time Clock) and adjusted to British Summer Time (BST). The data was transformed and projected from latitude longitude points to British National Grid coordinates (BNG).

1.1.2 Data cleansing

A data cleansing operation was conducted on the GPS data to remove erroneous track points and unnecessary data such as activity occurring between 11 pm and 7 am. The data was then categorised in to physical activity (PA) modes based on the speed from one track point to the next as shown in Table 1. Activity occurring at speeds greater than 15 kilometres per hour were considered not to be physical activity movements but some form of motorised transport and therefore excluded from the PA analysis.

Table 1. Speed classifications

Speed (kmph)	Mode
< 5	Walking / playing
>= 5 and < 10	Running / cycling
>= 10 and < 15	Cycling / slow motor
>15	Motorised

The accelerometer data was also categorised into four physical activity levels based on the number of movements taken (axis 1 counts) by the participant as shown in Table 2. Some results combined the moderate and vigorous data into a new category, moderate and vigorous physical activity or MVPA.

Table 2. Physical activity classifications

Axis 1 count	PA mode
<= 50	Sedentary
> 50 and < 1148	Light
>= 1148 and < 2006	Moderate
>= 2006	Vigorous

1.1.3 Greenspace

Data on urban greenspaces was obtained from Greenspace Scotland and joined to the matched GPS and accelerometer data so that each GPS track point was associated with the greenspace and land use category in which it resides.

1.1.4 Integrated Transport Network (ITN) and Urban Path Theme

A network dataset that modelled the extent of the road and path network of the captured GPS track points was built using the Network Analyst extension in ArcGIS using converted .gml data files of ITN and Urban Path lines, nodes and connections obtained under licence from Ordnance Survey. This road and path network was used to build individual service areas around participant's homes and to measure distances to greenspace.

1.1.5 Walk time buffers and service areas

Although walking times vary by age, person and terrain, for the SPACES study a 400 metre walk represents 5 minutes walking time (Pikora, et al 2002; Day, et al 2011). Euclidean buffers (as the crow flies) and service areas (along the road and path network) of 400 and 800 metres (5 and 10 minute walks) were created around each participants home to represent the individual's local neighbourhood.

1.1.6 Methodology

A count of each participant's time spent in greenspace and a measurement of the intensity of their physical activity levels taking place therein was calculated for their individual local neighbourhood (800 metres from home) and the wider area that they visited. An illustration of a participants local neighbourhood, their road and path network service area (blue), greenspace (light green), used greenspace (dark green) and their physical activity track points are shown in figure 1 below.

The distance from each participant's home to all types of greenspaces within their local neighbourhood was calculated to ascertain whether physical activity was taking place in the greenspaces nearest to their homes or whether they more often used greenspaces further from their homes. Data on the size, amount and type of greenspace used (park, school grounds, civic space etc.) is currently being analysed to ascertain what features or components of a particular greenspace make it more attractive or 'useable' for physical activity purposes than others.

1.1.7 Animation and anonimisation of data

Several maps and video animations of physical activity levels occurring in greenspace were produced to illustrate the participant's movements across time and space however, sensitive data, particularly around their homes, was removed to protect their identities. Physical activity classifications were represented by circular symbols (boys=blue, girls=pink) of varying size from small (sedentary behaviour) to large (vigorous physical activity).

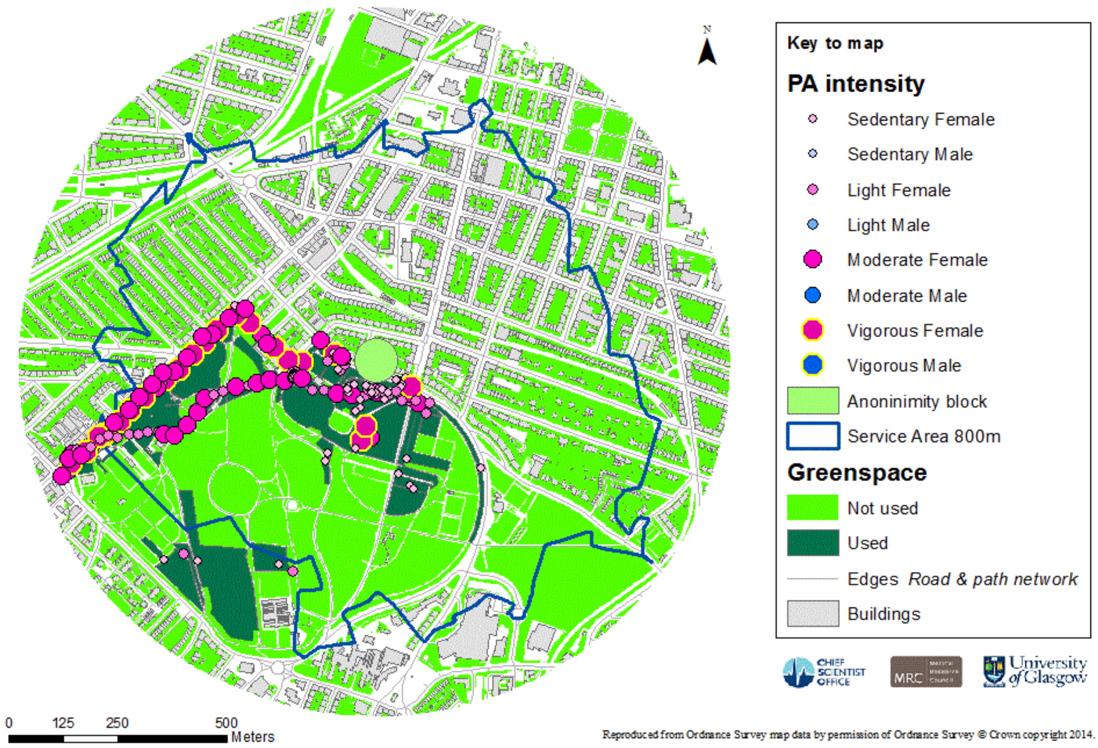

Figure 1. An 800 metre local neighbourhood area, greenspace and PA intensity

2. Results

Time spent in neighbourhood greenspace within 800 metres from home (Euclidean or 'crow-flies' measurement) was analysed. There were no differences between urban and rural neighbourhood greenspace use that was sedentary (56% v 66%, urban and rural respectively), or light (20% v 24%), however, urban participants spent a greater proportion of neighbourhood greenspace time in MVPA than their rural counterparts (24% v 10%, $p = 0.12$). Although a significant main effect, it would seem that the availability of greenspace in a participant's neighbourhood interacts with these results, where MVPA neighbourhood greenspace use *increases* as the amount of greenspace in the neighbourhood *increases* for rural children, but MVPA neighbourhood greenspace use *decreases* as the amount of greenspace in the neighbourhood *increases* for urban children. Figure 2 illustrates this difference, the shaded areas are confidence limits which are quite wide as there are relatively few data points: with more data this is likely to improve but it does give an idea of what is happening. (p of interaction = 0.001).

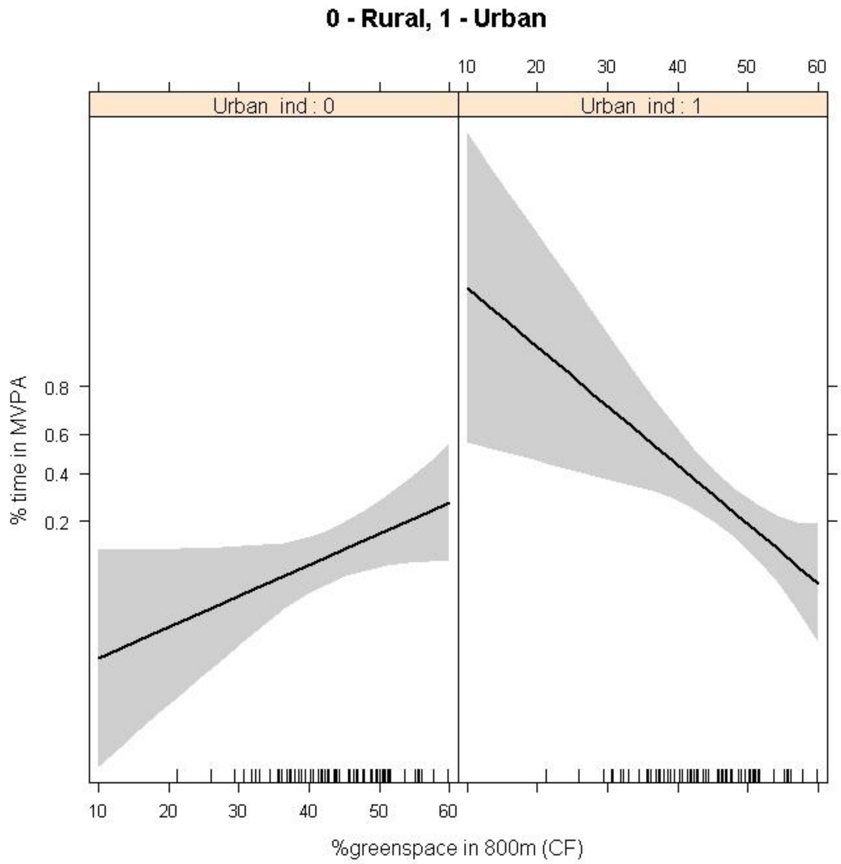

Figure 2. As the precentage of local greenspace increased, time spent in MVPA increased for rural students but decreased for urban ones (p=0.001)

To explain the interaction that seems to be present, future analyses include breaking the greenspace variable into specific types (e.g. parks, farmland, private gardens, and shrub-land). Our hypothesis is that although greenspace availability may be increasing, it may not, in relation to urban settings, be accompanied by quality, usable greenspace - and therefore may result in less MVPA. Whereas in rural settings, as greenspace availability increases, this is most likely accompanied by an increase in quality, usable greenspace which produces higher levels of MVPA.

3. Acknowledgements

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[7]Greenspace – there are 23 different greenspace types based on the typology set out in the Scottish Government's Planning Advice Note 65 Planning and Open Space; these include public parks, play areas, allotments, amenity greenspace, private gardens.

4. References

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5. Biography

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[4] *Felicity Hayball is a PhD student in the Neighbourhoods and Health team of the Social and Public Health Sciences Unit of the University of Glasgow's Institute of Health and Wellbeing. Felicity has a First Class BSc (Hons) degree in Equine Sports Science and an MSc by Research degree.*

[5] *Laura MacDonald began working for the Social and Public Health Sciences Unit in February 2001 as a Research Assistant investigating the processes by which features of the local social and physical environment might influence health and the ability to lead a healthy life. Laura graduated from the University of Glasgow in 1999 with an M.A. (Hons) in Sociology, and also holds a postgraduate diploma in Information Technology.*

[6] *Professor Anne Ellaway is head of the Social and Public Health Sciences Unit's programme of research on Neighbourhoods and Health. Anne has a BA (Hons) in Social Sciences (majoring in psychology), an MSc in Applied Social Sciences and a PhD (obtained from the University of Glasgow).*