

Where do the children play? An objective analysis of children's use of green space

Nadia Freeman¹, Ryan Gage ¹, Tim Chambers¹, Paul Blaschke¹, Hera Cook¹, James Stanley¹, Amber Pearson^{1,2}, Moira Smith¹, Michelle Barr¹, and Louise Signal^{1,*}

¹University of Otago, Wellington, 23A Mein street, Newtown, Wellington 6042, New Zealand and

²Department of Geography, Environment & Spatial Sciences, Geography Building, 67 Auditorium Road, Room 116, Michigan State University, East Lansing, MI 48824, USA

*Corresponding author. E-mail: louise.signal@otago.ac.nz

Summary

Green space is important for health, yet, objective research on children's use of green space is sparse. This study aimed to objectively assess children's use of green space in both public and private settings during their summer leisure time, using wearable cameras. Images from cameras worn by 74 children were analysed for green space use over 4 days. Children spent an average of ~1/10 h of leisure time in green space in the summer months, were physically active 68%, and with others 85%, of the time. Green spaces are important places for children's health because they are places they frequent and places where they are physically active and socialize. Wearable cameras provide an effective method for objective assessment of green space use.

Key words: green space, urban health, children, physical activity, wearable cameras

INTRODUCTION

Green space use has many benefits for health and well-being. A key benefit is its use for physical activity (Thompson Coon *et al.*, 2011; Bancroft *et al.*, 2015; Van Hecke *et al.*, 2018a). Exposure to green space is also linked with a number of mental and psychosocial benefits, including improved mood, concentration and behavioural development (Maas *et al.*, 2006; Amoly *et al.*, 2014; Mitchell *et al.*, 2015). Green space use is positively related to wellbeing through rest and the restorative effects of natural settings, and through providing opportunities for social contact and the building of social capital (Sullivan *et al.*, 2004; Waverijn *et al.*, 2014; Holtan *et al.*, 2015).

The majority of research about green space use focuses on the relationship with physical activity.

However, findings are equivocal, in part due to the need for objective, standardized methodology (Thompson Coon *et al.*, 2011; Bancroft *et al.*, 2015; Van Hecke *et al.*, 2018a). This research gap has contributed to a call for new methods of data collection (Mytton *et al.*, 2012; Van Hecke *et al.*, 2018a). Recently, studies have combined GPS devices with accelerometers to measure children's physical activity in green or other outdoor spaces (Klinker *et al.*, 2014; Pearce *et al.*, 2014; Ward *et al.*, 2016; Van Hecke *et al.*, 2018b). Using a dataset on the locations of parks, Ward *et al.* (2016) found that 11 14-year-old children in Auckland, New Zealand spent 1.2% of their time in public green spaces. Few studies have explored children's use of private green space (e.g. backyard gardens), a potentially significant

source of green space use amongst young children (Richardson *et al.*, 2010; Corder *et al.*, 2011).

Wearable cameras, which take images automatically on a timer, provide a new way to study the world in which children live (Signal *et al.*, 2017a). The study aimed to objectively assess children's use of green space in both public and private settings during their summer leisure time using wearable cameras.

MATERIALS

Study design and setting

This study is a sub-study of the Kids'Cam project, which is an observational study to assess children's everyday lives via wearable cameras, full details of which are described elsewhere (Signal *et al.*, 2017a,b). In brief, 168 school children aged 11–13 years were recruited from 16 randomly selected schools in the Wellington region. Participants were sampled with a stratified random sampling frame by deprivation and ethnicity to enable an equity analysis. The participants were then asked to wear a wearable camera around their necks for 4 consecutive days (Thursday to Sunday). The camera automatically captured a 136° image every 7 seconds. Participants were instructed to wear the camera at all times of the day, except when swimming or playing vigorous sport, and in situations/locations requiring privacy. Demographic data were obtained at enrolment and height/weight data at study completion. Data collection occurred over the 12 months from July 2014 to June 2015 and took place in the Wellington region of New Zealand (8049 km², estimated 2018 population 521 500) which includes four cities—Wellington, Hutt, Upper Hutt and Porirua. The study region features many opportunities for public green space contact, including council-maintained playgrounds and parks, coastal and harbour beaches and scenic reserves.

Ethical approval

The University of Otago Human Ethics Committee (Health; 13/220) granted ethical approval to study the world in which children live and their interaction with it, including their use of green space. School approval, child assent and parental consent were acquired in writing.

Data included in the current analysis

For this study, we included a subset of the Kids'Cam data. Specifically, we included all images captured during daytime hours (excluding school hours) in summer months (October–December 2014 and February–April

2015). These restrictions led to the inclusion of 74 children. Included images were only those captured between 3 and 7 pm on Thursday and Friday and from 8 am to 7 pm on Saturday and Sunday. This time period equates to all leisure time observed during this period (non-school time). Thus, these images characterize summer leisure time activities of children in the original Kids'Cam sample.

Image coding methods

A coding schedule was developed based on an initial assessment of the data. Green space use was defined as any situation in which the participant was in a green space environment. Thus, it included situations where the participant was passing through a green space to another destination (e.g. via active transport). It did not include situations where green space was in view but not physically visited (e.g. a sports field seen from a street or through a car window).

Any image coded as green space was additionally coded for: (i) the green space type; (ii) participant activity; and (iii) social contact and supervision status. Green space types included 'private' (e.g. backyards) and public green spaces (e.g. playgrounds, sports fields and beaches; see Table 1).

Participant activities were coded as 'sedentary' or 'active'. Activities coded as 'sedentary' included lying or sitting on the ground/sitting area, using screen-based devices, reading, eating, waiting to participate in a sports event and watching sport. Active activities included play, sport, gardening and 'other'. Activities were determined based on observed behaviour and situational cues observed in the images. In some circumstances, images were viewed in sequence to confirm an activity. Social contact was defined by the presence of another person. An additional 'supervision' code was applied to situations involving social contact with a person who appeared to be over 15 years old. Images were viewed in sequence to help determine how long the other person was present (as they may not be in view in every image) and also helped determine if the other person was in the company of the participant or passing through the area. All codes were entered into a secure database using bespoke annotation software developed by colleagues at Dublin City University.

Coding reliability

Before the development of the coding schedule, one researcher (N.F.) coded images for a pilot sample of 20 children. The pilot results were validated by another researcher (P.B.). The two researchers then collaborated to

Table 1: Coding definitions for green space type and activity type

Green space type	
Green natural	Outdoor green space with natural vegetation, e.g. bush trail, forest, river bed
Playground	Public green space with identifiable play equipment (the area must have a significant presence of natural elements, e.g. the play area is on grass, placed in a field or surrounded by a significant number of trees/plants)
Field	Open grassed area (this could include paddocks or sports fields)
Beach	Coastal environment, near sea or ocean
Public garden	Publicly accessible green space that has the presence of a maintained garden/park area, e.g. flower beds or crops
Private	Green space that has limited access to exclusive users, e.g. a backyard, garden or grass verge that is part of or contiguous with a residential lot
Activity type	
Gardening	Maintaining vegetation in green space
Play	Free play or unstructured activity
Sport	Participation in recognized sport whether formal or informal, including team sports and purposeful solo sports such as cycling, skateboarding, running, and walking for exercise
Other activity	Activity not defined as gardening, play, sport or sedentary for example household chores, animal interaction, gathering berries
Sedentary	Inactive or extremely low level of activity
Social contact	
Social contact	Situations where they were accompanied by another person of any age.
Supervised	Subset of social contact. Situations where they were accompanied by a person who appeared to be over 15 years old

develop the final coding methods, as reported here. The final coding schedule retained the green space type, activity and supervision definitions used in the pilot analysis, but dropped a component on the intensity of physical activity, which could not be determined with certainty by either researcher.

Statistical analyses

All analyses were conducted using Stata 14.1 (StataCorp. 2015. College Station, TX, USA). Negative binomial regression models were used to calculate the mean time spent in green spaces per 10 h of leisure time.

Table 2: Sample sociodemographic characteristics

Sociodemographic characteristic	
Sex	
Female, <i>n</i> (%)	40 (54.1)
Male, <i>n</i> (%)	34 (45.9)
Age, mean	12.6
Household deprivation	
Low, <i>n</i> (%)	18 (24.7)
Moderate, <i>n</i> (%)	25 (34.2)
High, <i>n</i> (%)	30 (41.1)
Ethnic group	
New Zealand European, <i>n</i> (%)	31 (41.9)
Māori (indigenous population), <i>n</i> (%)	31 (41.9)
Pacific, <i>n</i> (%)	12 (16.2)

Cameras automatically captured images every 7 s, thus, each image was considered 7 s of observation/exposure time (the average camera capture rate). The models accounted for the complex sampling design and differences in participants' observed leisure time. Multilevel regression models examined the differences in time spent in green space, after accounting for clustering within schools, using the following sociodemographic variables: sex, ethnicity and NZiDep a measure of household-level socioeconomic deprivation, with values ranging from 1 (low deprivation) to 5 (high deprivation) (Salmond *et al.*, 2006), which we aggregated into deprivation tertiles. Supervision status and social contact were calculated by taking the total number of exposures (images of green space) and dividing by the total number of photos. All inferential statistics (95% CI, *p*-values) also accounted for sample stratification and clustering of children within schools using Stata's svy prefix commands and associated weighting options.

RESULTS

There were slightly fewer females, low deprivation and Pacific children in the sample (see Table 2). These results largely reflect the stratified sampling design (Signal *et al.*, 2017b).

The participants captured a total of 290, 024 images during all leisure time over the 4-day period included in this study. An average of 3919 images (SD = 2897) per participant (corresponding to a mean recording time of 7.2 leisure hours per participant over the 28 h over the 4 days) were recorded.

Of the total of 554 h of leisure time, 58% (*n* = 47) of the participants had contact with green space at least once during their leisure time (*n* = 27 had no contact; see examples in Figure 1). The participants spent a mean



Fig. 1: Most frequently used types of green space: Private Garden, Playground, Green Nature and Field (Clockwise from top left).

of 0.94 h per 10 leisure hours in green space (95% CI: 0.32–2.73; (Table 3). Of all green space types, fields contributed most of the time (53%, 0.50 h), followed by private green spaces (22%, 0.20 h) and playgrounds (14%, 0.12 h).

On average, those participants visiting green space were physically active for 68% of the time they spent there. The time participants spent physically active was proportionately lower in beaches (46%) than the other green space types (all $\geq 65\%$), due to a larger proportion of time spent eating, socializing, sunbathing and sitting in the beach settings. The most commonly recorded

form of ‘active’ activity was ‘other’ (29%), which included domestic chores, animal interaction and picking berries (see examples in Figure 2). Other activity was followed by play (22%) and sport (16%).

On average, participants were in social contact for 84.7% of the time they spent in green space (95% CI 75.5–93.8) and supervised 59.1% (95% CI 46.8–71.3) of the time.

Children living in moderate deprivation households spent 2.6 times more time in green space than children living in the lowest deprivation households (95% CI 1.73–3.98; $p=0.001$). However, there were no

Table 3: Time spent in green space by green space type, activity and social contact

Green space type	Mean time spent / 10 leisure hours (95% CI) ^a	%	Activity (%)					
			Sedentary	Active				Total active
				Play	Sport	Gardening	Other	
Total	0.94 (0.32, 2.73)	100	32	22	16	<1	29	68
Field	0.50 (0.16, 1.56)	53	35	6	27	0	32	65
Private	0.20 (0.05, 0.07)	22	30	20	0	26	24	70
Playground	0.12 (0.02, 0.71)	14	21	77	1	0	1	79
Green nature	0.03 (0.01, 0.09)	4	0	31	31	12	26	100
Beach	0.03 (0.02, 0.07)	4	54	30	0	0	16	46
Public garden	0.01 (<0.01, 0.03)	2	4	25	0	51	20	96

^aCalculated using negative binomial regression models, accounting for complex sampling strategy and participant observation time.

significant differences between low and high deprivation, and thus no trend by deprivation for time spent in green space. Except for this finding, there were no significant associations between sociodemographic variables and the number of visits to green space or the time spent in green space (see Table 4). Although not statistically significant, girls spent 3.1 times (95% CI 0.7–14.0) more time in green space and had two times (95% CI 0.46–9.26) more interactions with green space than boys.

DISCUSSION

In this study, data collected from wearable cameras were used to document children's use of green spaces. The study revealed that children in the Wellington region spent an average of 0.94 h in green space per 10 h of summer leisure time (a total of 28 possible hours captured across 2 weekdays and a weekend). This is more time (roughly 10% of all leisure time) compared with the 1.17% found by Ward *et al.* (2016), who only assessed children's time spent in publically accessible parks, sports fields, and reserves in summer months as a percentage of their waking time over 1 week. This difference may not be surprising given the broader definition of green space used in this study, which included private green space. Although only 58% of children recorded visiting a green space during these 4 days, it is likely other visits were missed as participants were instructed to remove the camera at times of vigorous sport and when requested for privacy or they may have forgotten to wear the camera.

Of all green space types, fields contributed most of the time (53%, 0.5 h), followed by private green spaces (22%, 0.2 h) and playgrounds (14%, 0.12 h). On

average, children were physically active for 68% of the time they spent in green spaces undertaking play, sport and other activities. The low frequency of playground use may be because playgrounds are often designed for children younger than the 11–13 years old in this study (Veitch *et al.*, 2006; Van Hecke *et al.*, 2016). Although private or home environments often fall outside the scope of interventions aiming to promote physical activity among children, our study highlights the important role private green space plays in children's overall green space use and physical activity levels while there. Certainly, in New Zealand private green space is the easiest green space to access (Freeman *et al.*, 2015).

The study revealed that children who visited green space were in social contact 85% of the time and that 59% of the time they were supervised. This finding is largely consistent with past research on children's use of green or outdoor space and their reported reasons for visiting (Pearce *et al.*, 2014; Van Hecke *et al.*, 2018b). For example, Van Hecke *et al.* (2018b) found that 84.4% of children reported having company in urban open spaces, and a key reason for visiting included waiting for someone or having had a friend wanting to go there. This finding highlights the important role green spaces may play in facilitating and strengthening social networks and social capital (Waverijn *et al.*, 2014; Holtan *et al.*, 2015; Van Hecke *et al.*, 2018b).

Although there was no trend data for time spent in green space by deprivation, children from moderate deprivation households spent 2.6 times more time there than children from the lower deprivation households. This may be a result of both the way these children use their neighbourhoods and the green nature of these areas. Girls visited green spaces more often than boys and for longer and while the difference was not



Fig. 2: Most common activities in green space: Sport, Play, Sedentary and Other Activity (picking berries) (Clockwise from top left).

statistically significant, Pearce *et al.* found little difference in time spent outdoors by gender Pearce *et al.* (2014). Still, because children were instructed to remove the camera during vigorous activities, this could have led to less time in green space observed for boys who may be more likely to participate in more vigorous types of activities, such as sport (Powell *et al.*, 2016).

To our knowledge, this study is the first to objectively assess children's use of green space using wearable cameras, and it suggests such use is much higher than

previously thought (Ward *et al.*, 2016). The captured images provided rich contextual data sufficient to examine children's activities in both public and private green space, as well as their interaction with others. The study also has limitations. It is likely that the approach underestimated green space use as participants were asked to remove their camera at times. It was also not possible to determine the level of physical activity beyond active and sedentary, something that could be overcome in future research with the addition of accelerometers.

Table 4: Multivariable models (mutually adjusted for sex, ethnicity and household deprivation) showing differences in time spent in green space and interactions with green space by sociodemographic characteristics (rate ratio, per day, with 95% CI, from negative binomial)

Sociodemographic characteristics		Time spent/10 leisure hours		Number of visits	
		Rate ratio (95% CI)	p Value	Rate ratio (95% CI)	p Value
Sex	Male	1 (reference)		1 (reference)	
	Female	3.14 (0.71, 14.00)	0.115	1.95 (0.46, 8.26)	0.319
Ethnicity	New Zealand European	1 (reference)		1 (reference)	
	Māori	0.91 (0.21, 3.94)	0.888	1.06 (0.15, 7.37)	0.951
	Pacific	0.64 (0.17, 2.42)	0.461	0.58 (0.11, 2.96)	0.459
Household deprivation	Low	1 (reference)		1 (reference)	
	Moderate	2.62 (1.73, 3.98)	0.001	0.74 (0.28, 1.97)	0.504
	High	1.56 (0.62, 3.98)	0.301	0.60 (0.17, 2.05)	0.363

Analysis of data throughout the year would also be a valuable addition as would assessments of green space quality. The latter could be undertaken by doing observational studies of the green spaces children use concurrently with the wearing of cameras. A further limitation was the lack of power to detect differences in green space use by sociodemographic characteristics which could be overcome with larger sample sizes in future. Future studies could also assess the 'other activity' category to more fully understand the nature of children's use of green space.

CONCLUSIONS

This study successfully used wearable cameras to objectively assess New Zealand children's use of green space. It found that children aged 11–13 use green space such as fields, private green spaces and playgrounds on average nearly 10% of their observed summer leisure time for play, sport and other activities. The children were physically active most of the time they were in green spaces reinforcing the importance of green space for this purpose. The study also found that green spaces were places of social contact for children, reinforcing the social value of green space. Further, given the known mental and psychosocial benefits of green space and their capacity for rest and restoration, this research provides objective evidence of the value of green space in children's lives.

AUTHORS' CONTRIBUTION

L.S., M.S., M.B. and J.S. conceived the idea and developed the Kids'Cam study design. L.S., M.S., M.B. and

T.C. collected the data. J.S. led the statistical analysis. N.F., P.B., H.C., A.P. and L.S. conceived the green space study. N.F. analysed the data. All authors contributed to this article and approved the final version.

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