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Neighbourhood access to open spaces and the physical activity of residents: A national study

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ABSTRACT

Objective. Increasing population levels of physical activity is high on the health agenda in many countries. There is some evidence that neighbourhood access to public open space can increase physical activity by providing easier and more direct access to opportunities for exercise. This national study examines the relationship between travel time access to parks and beaches, BMI and physical activity in New Zealand neighbourhoods.

Methods. Access to parks and beaches, measured in minutes taken by a car, was calculated for 38,350 neighbourhoods nationally using Geographic Information Systems. Multilevel regression analyses were used to establish the significance of access to these recreational amenities as a predictor of BMI, and levels of physical activity and sedentary behaviour in the 12,529 participants, living in 1178 neighbourhoods, of the New Zealand Health Survey 2002/3.

Results. Neighbourhood access to parks was not associated with BMI, sedentary behaviour or physical activity, after controlling for individual-level socio-economic variables, and neighbourhood-level deprivation and urban/rural status. There was some evidence of a relationship between beach access and BMI and physical activity in the expected direction.

Conclusions. This study found little evidence of an association between locational access to open spaces and physical activity.

Introduction

Physical inactivity is a major determinant of obesity and chronic conditions such as diabetes, stroke and cardiovascular disease (Task Force on Community Prevention Services, 2002; US Department of Health and Human Services, 1996) hence the high priority placed on increasing levels of exercise in New Zealand and elsewhere (Ministry of Health, 2003). Evidence that place of residence may influence physical activity, independently of the individual characteristics of residents, has generated interest in identifying aspects of neighbourhood environments that may increase levels of physical activity (Ellaway et al., 2005; Kavanagh et al., 2005; King et al., 2005; Li et al., 2005).

A striking feature of the literature examining neighbourhood effects on physical activity is the extensive list of potential built environmental variables investigated (Li et al., 2005; Ewing et al., 2003; Frank et al., 2006; Giles-Corti et al., 2005a; Lopez-Zetina et al., 2006; Sallis et al., 2002; van Lenthe et al., 2005). To aid the systematic investigation of relationships between physical environments and physical activity, Pikora et al. (2003) proposed a framework that groups environmental factors into four categories: functional factors (traffic speed, street and path design), safety factors, neighbourhood aesthetics, and destinations (access to desired locations and amenities). The framework provides a useful starting point for exploring specific pathways through which neighbourhood context may impact on variation in levels of physical activity. Access to destinations that provide opportunities for physical activity is the built environment variable examined in this paper.

The accessibility of utilitarian destinations, such as shops, schools, and recreational amenities, as a determinant of physical activity has been indicated in a number of studies (Li et al., 2005; van Lenthe et al., 2005). There is some evidence that individual physical activity levels increase as the number or density of accessible exercise amenities increases (Diez Roux et al., 2007; Parks et al., 2003), and that the use of active modes of transport such as walking and cycling increases as distances to neighbourhood amenities decreases (Social Exclusion Unit, 2003). Self selection into neighbourhoods by people with a preference for active transport and proximate amenity access may explain some of this association (Frank et al., 2007).

Related work has shown that utilisation of recreational facilities increases as the distance between home and facilities decreases (King

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et al., 2005; Giles-Corti et al., 2005a; Tinsley et al., 2002) and that use of public open spaces is more sensitive to distance than other types of sporting and recreational venues (Giles-Corti and Donovan, 2002). While higher rates of physical activity and reduced levels of obesity have been associated with better access to leisure facilities, including open green space and beaches (Bauman and Smith, 1999; Ellaway et al., 2005; Sallis et al., 1997), recreational amenity access has been relatively weak as a predictor of physical activity compared to individual and social environmental factors (Giles-Corti and Donovan, 2002; Wendel-Vos et al., 2007).

Common weaknesses of studies in this field have been a reliance on self reported measures of neighbourhood accessibility, physical activity, and height and weight measurements used for body mass index (BMI) calculations. This is beginning to change with the increasing use of Geographic Information Systems (GIS) to provide objective measures of locational access to specific destination types and other neighbourhood access measures such as street connectivity, diversity of land use and dwelling density. There is some evidence of increasing precision in the measurement of physical activity for example through the use of accelerometers. A number of the multilevel studies noted earlier have used direct measurement of neighbourhood context but relied on self reported physical activity data (Ellaway et al., 2005; Li et al., 2005; Diez Roux et al., 2007; Ross et al., 2007). We are unaware of research reporting the use of objective measures of physical activity and neighbourhood accessibility within a multilevel framework.

Evidence that physical inactivity levels vary by socio-economic position (Parks et al., 2003; SPARC) and findings from a US study that neighbourhood differences in physical activity remain after adjusting for individual socio-demographic and health characteristics (Yen and Kaplan, 1999), have raised the question of whether a social gradient exists in access to recreational resources. Studies that have investigated this question have generated mixed findings. These have ranged from evidence of an inequitable distribution in recreational facilities in favour of high income neighbourhoods (Estabrooks et al., 2003; Macintyre et al., 1993; Powell et al., 2006), to no association (Lee et al., 2005; Timperio et al., 2007), to results indicating better access to recreational amenities in more deprived neighbourhoods (Giles-Corti and Donovan, 2002; Craddock et al., 2005; Ellaway et al., 2007). Our New Zealand research has shown access to parks and recreational centres improves as area-level deprivation increases, with no association between deprivation and beach access (Pearce et al., 2007a), although this relationship is not consistent in rural areas and in some regions (Pearce et al., in press). Thus it is important to take social deprivation into account in a study of accessibility and obesity related outcomes.

This national study investigates the association between travel time access to recreational amenities – parks and beaches – and the physical activity patterns and BMI of residents in New Zealand. The selection of parks and beaches was based on the availability of national datasets, the ubiquitous nature of beaches as sites of recreational activity in New Zealand, given its island nation status, and the work of Giles-Corti and Donovan (2002) that identified parks and beaches as the most frequently used venues for recreational activity, after streets, in the coastal city of Perth.

Methods

In 2005 locational information was obtained from Land Information New Zealand (LINZ) and Department of Conservation for all parks in New Zealand (Pearce et al., 2006). Data on all beaches were also obtained from LINZ. To account for the large surface areas often represented by parks and beaches, each park and beach was converted in a GIS to represent multiple access points 100m apart. In total there were 46,274 access points for parks and 13,313 for beaches. Neighbourhood was defined as the meshblock, the smallest unit of dissemination of census data in New Zealand with each area representing approximately 100 people. Travel time access to the nearest park and beach was calculated independently for all 38,350 neighbourhoods across the country using the meshblock population-weighted centroid, the road network and network functionality in ArcInfoGIS. Variations in speed limits, type of road surface, sinuosity and differences in topography were taken into account in travel time calculations (Pearce et al., 2006).

These travel time data were then appended to the 2002/03 New Zealand Health Survey (NZHS), a face-to-face national survey of 12,529 adults aged 15+ (target population 2.6million) that included anthropometric measures of height and weight (Ministry of Health, 2004). The survey had a 72% response rate. For reasons of confidentiality the neighbourhood travel time measures were divided into quartiles before they were linked to each survey respondent. Three individual-level outcome variables were developed: BMI (a continuous variable available for 11,233 respondents which was normalised, using normal scores, for the analysis), and two dichotomous variables — sedentary/non sedentary behaviour and meeting recommended levels of exercise (or not) per week (available for 12,425 respondents): Sedentary behaviour was defined as less than 30min physical activity in the past week and the recommended level of physical exercise was at least 2.5h of physical activity on five or more days over the preceding week. On the basis of BMI measurements 35.2% (34.0, 36.4) of the NZHS sample were classified as overweight and 20.9% (19.9, 22.0) as obese. Recommended levels of exercise were met by 52.1% (50.7, 53.6) of the sample and 13.1% (12.1, 14.1) met the criteria for sedentary behaviour[1]. The physical activity measures are based on self-report data on time spent on brisk walking, moderate physical activity and vigorous physical activity. Each minute of vigorous physical activity (e.g. cycling at a fast pace, carrying heavy loads or aerobics) counted for 2min of brisk walking or moderate activity (e.g. cycling at a regular pace, carrying light loads or doubles tennis). The location of physical activity is not known.

Statistical analyses

Two level (neighbourhood and individual) models with a random intercept were fitted in MLWin version 2.0. A general linear regression model was fitted for BMI and for the sedentary and recommended physical activity variables logistic regression models were calculated using 2nd order Penalised Quasi Likelihood (PQL) estimation methods. Design, individual and neighbourhood-level variables were added sequentially to the models in four stages. In the first models, design variables were included to take into account the sample stratification and oversampling of ethnic minorities. The design variables were: stratum (ethnic composition of the meshblock), deciles of number of respondents in the meshblock, number of adults in the household and ethnicity (Maori, Pacific Islander, Asian or Other). Sex and age were also included in all models. Age was divided into four lifecycle groups for confidentiality reasons (15–24, 25–44, 45–64, 65 or older).

Second, individual-level socio-economic variables were added: education (no qualifications, school qualifications, post-school qualifications), social class (professional/managerial, other non manual, skilled manual, semi and unskilled manual), receipt of benefits, working/not working and household income (up to NZ$25k, NZ$25-$50k, over NZ$50k). In the third and fourth stage models two potential ecological confounders were added: area deprivation measured using the 2001 New Zealand Deprivation Index (NZDep 2001) (Salmond and Crampton, 2002) divided into quintiles, and a 5-level urban/rural classification based on the 2001 Urban Area Classification (Department of Statistics, 1992). Meshblocks were classified as a main urban area, secondary urban area, minor urban area, rural centre or a rural area. Potential individual socio-economic and ecological confounders were selected *a priori* for model building, but to ensure best model fit variables were only retained where they reached $p<.05$ in Wald tests.

Results

Odds ratios and 95% confidence intervals were calculated for each outcome for access to beach and access to park quartiles (Tables 1 and 2). The best access quartile was compared to the other three quartiles. For the BMI model the best access quartile took the value of 0. We hypothesised that those with best access to parks and beaches would have *lower* BMI so we would expect *positive B* values for the other quartiles.

For the physical activity logistic regression the best access quartile has its odds ratio set at 1 (ie, the null). Values above 1 indicate a greater likelihood of being sedentary or undertaking recommended exercise, and values below 1 indicate a lower likelihood. We hypothesised that those with the best access to parks and beaches would be *least* likely to be sedentary so we would expect values *greater* than 1 for the other quartiles. Conversely we hypothesised that those with the best access to parks and beaches would be *most* likely to do recommended exercise so we would expect values *below* 1 for the other quartiles.

[1] These results apply to the NZHS survey responses, are unweighted and not representative of the New Zealand population.

Table 1
Neighbourhood access to parks and beaches as a predictor of BMI (*B* values, 95% confidence intervals)

	Stage 1 baseline	Stage 2 individual SES	Stage 3 deprivation	Stage 4 urban/rural
Body Mass Index				
Access to parks by quartiles	Model 1	Model 2	Model 3	Model 4
Best (<0.8 min) *n*=3248	0	0	0	0
Better (.8 to 1.4 min) *n*=2835	−0.02 (−0.07,0.03)	−0.02 (−0.07, 0.03)	−0.03 (−0.08,0.02)	−0.03 (−0.08,0.02)
Worse (1.4 to 2.4 min) *n*=2897	−0.05 (−0.09,0.00)	−0.04 (−0.09,0.00)	−0.05 (−0.09,0.00)	−0.05 (−0.09,0.00)
Worst (>2.4) *n*=2253	−0.03 (−0.08,0.03)	−0.03 (−0.08,0.03)	0.00 (−0.05,0.06)	−0.02 (−0.08,0.05)
Neighbourhood-level variance (se)	0.010 (0.004)	0.009 (0.003)	0.008 (0.003)	0.007 (0.003)
Individual-level variance (se)	0.781 (0.011)	0.781 (0.011)	0.779 (0.011)	0.779 (0.011)
VPC	.013	.012	.010	.009
Access to beaches by quartiles	Model 5	Model 6	Model 7	Model 8
Best (<9.2 min) n=3009	0	0	0	0
Better (9.2 to 17.0 min) *n*=3101	0.06 (0.01,0.11)	0.06 (0.01,0.11)	0.06 (0.01,0.10)	0.06 (0.01,0.11)
Worse (17.0 to 31.8 min) *n*=2897	0.11 (0.06,0.16)	0.11 (0.06,0.16)	0.11 (0.06,0.15)	0.11 (0.06,0.15)
Worst (>31.8 min) *n*=2226	0.13 (0.08,0.18)	0.13 (0.08,0.18)	0.13 (0.08,0.18)	0.13 (0.07,0.18)
Neighbourhood-level variance (se)	0.008 (0.003)	0.007 (0.003)	0.006 (0.003)	0.006 (0.003)
Individual-level variance (se)	0.781 (0.011)	0.780 (0.011)	0.779 (0.011)	0.778 (0.011)
VPC	.010	.009	.008	.008

New Zealand Health Survey 2002/3 (*n*=11,233).
The VPC is the variance partition coefficient which is the proportion of the variance due to the level 2 variance which here is the neighbourhood/meshblock. For continuous outcomes: VPC VPC=neighbourhood-level variance/(neighbourhood+individual-level variance).

Table 2
Neighbourhood access to parks and beaches, physical activity exercise and sedentary/non sedentary behaviour (odds ratio and 95% confidence intervals)

	Stage 1 baseline	Stage 2 individual SES	Stage 3 deprivation	Stage 4 urban/rural
Sedentary/non sedentary				
Access to parks by quartiles	Model 1	Model 2	Model 3	Model 4
Best (<0.8 min) *n*=3606	1	1	1	1
Better (.8 to 1.4 min) *n*=3109	0.99 (0.79, 1.23)	0.97 (0.78, 1.21)	0.94 (0.76, 1.18)	0.95 (0.77, 1.19)
Worse (1.4 to 2.4 min) *n*=3161	0.98 (0.78, 1.22)	0.99 (0.79, 1.23)	0.98 (0.79, 1.22)	1.00 (0.80, 1.24)
Worst (>2.4) *n*=2549	0.72 (0.56, 0.93)	0.77 (0.60, 0.98)	0.80 (0.63, 1.03)	0.84 (0.63, 1.11)
Neighbourhood-level variance (se)	0.75(.07)	0.72(.07)	0.69(.07)	0.69(.07)
VPC	0.19	0.18	0.17	0.17
Access to beaches by quartiles	Model 5	Model 6	Model 7	Model 8
Best (<9.2 min) *n*=3317	1	1	1	1
Better (9.2 to 17.0 min) *n*=3428	1.38 (1.10, 1.72)	1.37 (1.10, 1.71)	1.36 (1.09, 1.69)	1.37 (1.10, 1.70)
Worse (17.0 to 31.8 min) *n*=3240	1.31 (1.05, 1.64)	1.27 (1.02, 1.60)	1.25 (1.00, 1.56)	1.25 (1.00, 1.56)
Worst (>31.8 min) *n*=2440	1.02 (0.79, 1.30)	1.03 (0.80, 1.31)	1.02 (0.80, 1.30)	1.04 (0.81, 1.33)
Neighbourhood-level variance (se)	0.73(.07)	0.70(.07)	0.68(.07)	.067(.07)
VPC	.18	.18	.17	.17
Recommended physical activity				
Access to parks by quartiles	Model 9	Model 10	Model 11	Model 12
Best (<0.8 min)	1	1	1	1
Better (.8 to 1.4 min)	0.97 (0.84, 1.12)	0.99 (0.86, 1.15)	1.00 (0.87, 1.16)	1.02 (0.88, 1.18)
Worse (1.4 to 2.4 min)	0.92 (0.80, 1.06)	0.91 (0.79, 1.05)	0.91 (0.79, 1.05)	0.91 (0.79, 1.05)
Worst (>2.4)	1.39 (1.19, 1.62)	1.27 (1.09, 1.49)	1.24 (1.06, 1.45)	1.15 (0.96, 1.37)
Neighbourhood-level variance (se)	0.32(.03)	0.31(.03)	0.31(.03)	0.30(.03)
VPC	0.09	0.09	0.09	0.08
Access to beaches by quartiles	Model 13	Model 14	Model 15	Model 16
Best (<9.2 min)	1	1	1	1
Better (9.2 to 17.0 min)	0.73 (0.63, 0.84)	0.72 (0.62, 0.83)	0.73 (0.63, 0.84)	0.74 (0.64, 0.85)
Worse (17.0 to 31.8 min)	0.86 (0.74, 0.99)	0.84 (0.73, 0.97)	0.85 (0.74, 0.99)	0.85 (0.74, 0.98)
Worst (>31.8 min)	0.98 (0.84, 1.15)	0.92 (0.79, 1.08)	0.93 (0.79, 1.08)	0.88 (0.76, 1.03)
Neighbourhood-level variance (se)	0.31(.03)	0.31(.03)	0.30(.03)	0.29(.03)
VPC	.09	.09	.08	.08

New Zealand Health Survey 2002/3 (*n*=12,425).
Sample sizes for recommended physical activity are the same as sedentary. Note quartiles are not exact due to missing data.
For binary outcomes: VPC=neighbourhood-level variance/(neighbourhood-level variance+3. (Rasbash et al., 2004). There is no single individual-level variance for binary outcome models (sedentary and recommended) because the level 1 variance is a function of the mean which depends on the values of the explanatory variables in the model.

Access to parks

With regard to parks there was little difference in BMI (Table 1, models 1–4) across the access quartiles. Contrary to our hypothesis, sedentary behaviour was less in neighbourhoods with worse access to parks (OR 0.72, CI 0.56–0.93, Table 2, model 1) and physical activity was higher (OR 1.39, CI 1.19– 1.62, Table 2, model 9). However, confidence intervals included 1.0 after accounting for individual SES, neighbourhood deprivation and rurality (ie, Table 2, models 4 and 12).

Access to beaches

There were stronger associations between the outcome variables and access to a beach, but the nature of the relationship was different for BMI and physical activity. Respondents living in neighbourhoods with best access to the beach had lower normalised BMI, even in the fully adjusted model (B=0.13 (0.07–0.18) (Table 1, models 5–8). Thus BMI was associated with access to beaches in the expected direction although the relationship was not particularly strong.

Respondents in the best access quartile to beaches were the most likely to undertake recommended levels of physical activity and least likely to be sedentary. However, effect sizes were small once adjusting for potential confounders with confidence intervals sometimes including 1.0. Also, there was no dose response; sedentary behaviour was more common, and physical activity less common, in the middle two quartiles of access to a beach.

Discussion

To our knowledge, this represents the first nationally representative study of the association of access to public open spaces with BMI and physical activity. The analysis showed very little association between access to parks and the outcome variables (and if anything there were indications of a negative association) and a weak association only between beach access, BMI and physical activity.

The strengths of the study are its national coverage of park and beach access, the use of physical activity outcome data sourced from a representative national sample, and adequate control of potential confounding variables at individual and neighbourhood levels. Further, the access measures are based on direct measurement of travel time. However there are a number of limitations in both the exposure and outcome measures used.

Travel time by car is a useful but limited measure of accessibility to amenities such as parks and beaches. Systematic variation in the quality, safety and aesthetics of recreational facilities and surrounding neighbourhood streetscapes have been suggested as attributes that may contribute to area-level variation in physical activity (Humpel et al., 2002; Talen and Anselin, 1998). As Giles-Corti et al. (2005a) note with respect to walking, quality attributes such as attractiveness, specific amenities and size determine use, and need to be measured to develop a more finely honed understanding of the relationship between access to public spaces and physical activity. Also as the Lee et al. (2005) study in three US cities indicated, quality and safety attributes of public spaces may vary systematically with deprivation or other area-level variables. While the physical activity resources in the high and low deprivation neighbourhoods in the Lee et al. (2005) study did not differ systematically in terms of the number or type of amenities, the appearance of resources was less favourable, and the level of incivilities was higher, in more deprived neighbourhoods.

Perhaps most importantly though, the travel time analysis indicates New Zealanders' overall access to recreational spaces is good; residents in three out of four neighbourhoods are able to travel by car to a local, regional or national park within 2.4 min and to a beach within 31.8 min. Limited variation in travel times (especially to parks) may be a reason why we do not observe associations in the hypothesised direction. Put another way, maybe the vast majority of people in New Zealand have good access to a park, rendering it a non-discriminatory predictor of health. While 72% of trips to open space recreational destinations in New Zealand (which would include, but not be limited to, parks and beaches) are undertaken as a car driver or passenger, 23% are made on foot (Huakau, 2008, pers com). Further studies in this area should take account of walking time to recreational destinations as well as travel times by car.

As a national study rural and urban neighbourhoods were included, however the meaning and patterns of use of recreational spaces is likely to vary greatly for urban and rural dwellers. For example, commercial recreational facilities will be unavailable and private open spaces more accessible in rural compared to urban neighbourhoods; differences that are likely to have implications for patterns of physical activity. The study included only outdoor public spaces as potential sites of physical activity whereas indoor recreational facilities also offer opportunities. Accounts of mall walking for exercise by the elderly (Duncan et al., 1995) further highlight the need to consider the range of recreational venues used by different population groups. A lack of data on social factors associated with physical activity such as having someone to exercise with are an additional limitation of the research (Giles-Corti and Donovan, 2002; Giles-Corti et al., 2005b; Wendel-Vos et al., 2007).

In terms of the outcome measures, BMI data (height and weight) are objectively measured but the physical activity outcome data in the New Zealand Health Survey are self report measures. Further limitations are the lack of differentiation by type of activity (e.g. leisure or transport, sport, non sporting) and activity location. Consequently an implicit assumption in the study hypotheses is that a proportion of the physical activity reported will have occurred in parks and on beaches (albeit an unmeasured proportion). Given the ready access New Zealanders have to both amenities this may be justified but it remains a lack of precision in the relationship between the exposure and outcome measures.

As others have concluded (Pikora et al., 2003; Humpel et al., 2002; van Lenthe et al., 2008), to tease out the impacts of access to public open spaces on physical activity, more comprehensive direct measures of access are needed that take account of the quality and safety attributes of specific amenities and their surrounding locales. Differentiation is also needed regarding the sites and purpose of physical activity as the contextual predictors of variation in levels of walking and cycling for active transport are likely to differ to those for leisure-based physical activity (Giles-Corti et al., 2005b; Pikora et al., 2006). Increased understanding of these factors is needed to maximise the health benefits of local government expenditure designed to increase population level physical activity.

Conclusions

This study found little evidence of an association between locational access to open spaces and physical activity. To substantially advance understanding on the topic, greater specificity is required in both access and outcome measures. Access measures are needed that incorporate dimensions such as amenity attractiveness and safety, as well as travel time access and greater differentiation of physical activity outcome measures in terms of leisure and transport-related activity and activity location (park, street, gym).

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