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Availability of local food outlets is associated with weight status and dietary intake in 9-10 year olds

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Abstract

Background—The rising rate of childhood obesity is a key public health issue worldwide. Limited evidence suggests that there may be interactions between environmental factors at a neighbourhood level and the development of obesity, with the availability and accessibility of foods outlets being potentially important.

Purpose—To examine how the weight status and dietary intake of 1669 9-10 year-olds was associated with neighbourhood food-outlets in a cross-sectional study.

Methods—Availability of food outlets was computed from GIS data for each child's unique neighbourhood. Outlets were grouped into BMI-healthy, BMI-unhealthy or BMI-intermediate categories according to food-type sold. Weight status measurements were objectively collected and food intake was recorded using four-day food-diaries. Data was collected in 2007 and analysed in 2009.

Results—Availability of BMI-healthy outlets in neighbourhoods was associated with lower body weight (1.3kg; $p=0.03$), BMI (0.5kg/m^2 ; $p=0.02$), BMI z-score (0.20; $p=0.02$), waist circumference (1.3cm; $p=0.02$), and percentage body fat (1.1%; $p=0.03$) compared to no availability. In contrast, neighbourhood availability of BMI-unhealthy outlets was inversely associated with body weight (1.3kg; $p=0.02$), BMI (0.4kg/m^2 ; $p=0.05$), BMI z-score (0.15; $p=0.05$), waist circumference (1.1cm; $p=0.04$), and percentage body fat (1.0%; $p=0.03$). Unhealthy food intake (fizzy drinks 15.3%; $p=0.04$, and non-carbonated 'fruit' drinks 11.8%; $p=0.03$) was also associated with availability of BMI-unhealthy food outlets.

Conclusions—This study suggests that features of the built environment relating to food purchasing opportunities are independent significant correlates of weight status in children.

Introduction

Childhood obesity rates are rising worldwide and it is now estimated that 10% of the world's school-aged children are overweight.¹ This is a major concern given there is evidence that obesity in childhood tracks to adulthood,² resulting in higher risks of diseases such as diabetes and cardiovascular disease.^{3,4}

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To date much research and many interventions aimed at reducing childhood obesity have focused on individual level factors, with the objective of improving dietary intakes and physical activity levels.⁵ Research, however, has also started to focus on associations between the neighbourhood environment and weight status.⁶ Most of these investigations have focused on the accessibility and availability of food outlets and weight status in adults; the evidence is equivocal. For example, good access to convenience stores and fast-food restaurants has been associated with higher weight status,⁷⁻⁹ and access to supermarkets with a lower prevalence of obesity.⁷ Conversely fast-food restaurants and take-away outlets have been found to be unrelated to obesity and BMI^{10,11} and supermarkets have been associated with higher BMI in a deprived neighbourhood.⁸

Studies amongst pre-school children in the US have found no associations between overweight or obesity and proximity or access to food outlets.^{12,13} Yet in older children in the US an increased distance between home and the nearest supermarket has been associated with an increased risk for overweight.¹⁴ Furthermore exposure to fast food outlets has shown to have little impact on obesity in children, or their parents.¹⁵ Neither less studies that have examined the association between availability of different food outlets and food intake suggest that location and proximity of food retail outlets are significantly associated with improved diet quality.¹⁶⁻¹⁹

Inconsistencies in previous findings may be explained by methodological limitations such as not considering the whole food environment and not controlling for characteristics of the built environment associated with obesity.²⁰ It is noteworthy that in a study in the US that aimed to address some of these limitations, densities of healthy-BMI outlets were collectively inversely associated with BMI in adults, whereas densities of outlets categorised as unhealthy, including fast-food restaurants and small grocery shops were not associated with BMI.²⁰

The aims of the current cross-sectional study were to assess if, in a well characterised population-based sample of 9-10 year old children, firstly, objectively and intensively measured parameters of children's neighbourhood environments were associated with their weight status independently of other characteristics of the built environment known to be potential influences on bodyweight, and secondly, if any observed associations might be attributable to differences in food intake. We hypothesised that children with availability of BMI-healthy food outlets in their neighbourhoods would have more favourable weight status and dietary intake than children with limited availability.

Materials and methods

The current analysis used data from the SPEEDY study (Sport, Physical activity and Eating behaviour: Environmental determinants in Young people). Participant recruitment procedures for this cross-sectional study have been described in detail previously.²¹ Briefly children aged 9-10 were recruited from 92 schools in Norfolk, UK during the summer term (April to July), the schools were purposively sampled to achieve maximum environmental heterogeneity. Ethical approval was obtained from the University of East Anglia local research ethics committee. All data was collected in 2007 and analysed during 2009.

As the majority of children's food is known to come from within the home,²² a neighbourhood was constructed around each child's home using the ArcGIS (ESRI inc.) Geographical Information System (GIS). As there is currently no consensus on how a neighbourhood should be defined for children we chose the definition of an 800m zone along pedestrian networks, based on evidence that parents report this as a safe walking distance for children.²³

Availability of food outlets in children's neighbourhoods were computed using the Ordnance Survey 'Points of Interest' database which provides data on the location of geographic and commercial facilities across Great Britain. The data for food outlets in the database is reported to be between 81-100% complete.²⁴ Food outlets were grouped based on the product's classifications as: supermarkets (supermarkets), fruit and vegetable stores (grocers, farm shops and pick-your-own), fast food outlets (fast food and takeaway outlets, fast food delivery services, and fish and chip shops), restaurants (all other restaurants), and other food outlets (all other food shops including butchers, bakers, and fish markets). For each outlet type information was generated on the number of units in the individual's neighbourhood (expressed as number of outlets per km²). In order to measure the quality of the local environment, food outlets were classified into BMI-healthy, BMI-unhealthy or BMI-intermediate categories, following similar procedures to a previous study which has shown this method to be associated with weight status in adults.²⁵ Supermarkets and fruit and vegetable stores were classified as BMI-healthy and take-away/fast-food outlets and convenience stores as BMI-unhealthy. Non fast-food restaurants and any other food shops were classified as BMI-intermediate as insufficient information was available to place them in one of the other two categories.

Due to the restricted distribution of the data dichotomous variables were created for each food outlet classification indicating whether or not any outlets were present in children's neighbourhoods. We chose to assess accessibility of food outlets using a measure of availability rather than distance due to the high environmental heterogeneity in this sample; it has previously been shown that distance measures in rural and more densely populated areas are not comparable.²⁶ Furthermore the use of an availability-based measure allowed us to examine the presence of multiple food outlets, which would not have been possible with a distance based measure.²⁷

Researchers measured children's height using portable Leicester height measures, waist circumference twice using a Seca 200 measuring tape and applying a 0.5 cm correction to account for clothing, and body weight and impedance using non-segmental bio-impedance scales (Tanita, type TBF-300A). Previously validated and published equations were used to calculate percentage body fat.²⁸ BMI was calculated as weight divided by height squared and transformed to standardised z-scores using the LMS method and the 1990 British Growth Reference data.²⁹ Obesity status (normal weight, overweight and obese) was determined using gender- and age-dependent cut points.³⁰

Food intake was recorded using a four-day food and drink diary where children, with assistance from their parents, were asked to record everything they ate and drank. Weights of portions were then estimated using published values, including those specific to children,³¹⁻³³ and mean intakes from key food groups estimated using the WISP nutritional analysis software version 3.0 (Tinuviel Software, Warrington, UK). using values from McCance and Widdowson's *The Composition of Foods*, 6th Edition.³⁴ Under-reporting of energy intake was assessed by calculating the ratio of reported energy intake (EI) to estimated energy requirements (EER), which were estimated using the FOA/WHO/UNU Expert Consultation Report on Human Energy Requirements.³⁵ A 95% confidence interval for the accuracy of EI:EER was calculated by taking into account the amount of variation inherent in the methods used to estimate EI and EER.³⁶ As excluding children who under-report can distort dietary intake data energy reporting quality was examined as a continuous variable in all statistical models.³⁷

Free living physical activity was assessed over one week with the ActiGraph activity monitor (GTIM, Actigraph LCC, Pensacola, US) using a recording epoch of 5 seconds. The outcome variables included total daily activity counts (counts·min⁻¹) which is an indicator

of overall physical activity intensity. Information on parent's educational attainment (in categories) was obtained by parental self-report.

Statistical analysis

Analysis of covariance (ANCOVA) was used to calculate adjusted means for weight status and food intake data and to establish the magnitude of any differences between groups of food-outlet availability. Prevalence ratios for overweight and obesity versus normal weight associated with food-outlet availability were estimated using Poisson regression with robust variance.³⁸ To take account of the hierarchical nature of the dataset (children nested within schools) multi-level models were used for all analyses with schools as the level two unit, and participants at level one. We assessed the possible confounding effects of area deprivation,³⁹ land-use mix,⁴⁰ population density, and density of bus stops and commercial buildings. Each model was also mutually adjusted for all other food outlet categories, gender, parental education, and physical activity. The food intake was further adjusted for under-reporting. All statistical analyses were performed using Stata/SE version 10.1 (StataCorp, College Station, TX).

Results

Of the 2064 children recruited to the study full data on GIS variables, anthropometric measurements, dietary intake, physical activity and parental education was available for 1669 (81%). The mean age was 10.2 years (SD 0.3) and 56% were girls. Twenty-three percent of children were found to be overweight or obese, according to cut-offs defined by the International Obesity Task Force³². Twenty-seven percent of the children lived in neighbourhoods with availability of BMI-healthy food outlets, 47% had availability of BMI-unhealthy outlets and 57% availability to BMI-intermediate outlets. Deprivation statistics for the children's neighbourhoods indicated that 44% and 21% of children were placed in the two highest quintiles of regional and national deprivation, respectively.²⁹

As highlighted in Table 2 body weight was 1.3kg lower ($p=0.03$ 95% CI -2.45 to -0.17) in children who had availability of BMI-healthy outlets compared to those with no availability, BMI was 0.5kg/m^2 lower ($p=0.02$ 95% CI -0.94 to -0.07), BMI z-score 0.20 lower ($p=0.02$ 95% CI -0.35 to -0.04) waist circumference 1.3cm lower ($p=0.02$ 95% CI -2.48 to -0.21) and percentage body fat 1.1% lower ($p=0.03$ 95% CI -2.13 to -0.10). For those with availability of BMI-unhealthy outlets body weight was 1.3kg higher ($p=0.02$ 95% CI 0.20 to 2.32), BMI 0.4kg/m^2 higher ($p=0.05$ 95% CI 0.01 to 0.81), BMI z-score 0.15 ($p=0.05$ 95% CI 0.00 to 0.29) waist circumference 1.1cm higher ($p=0.03$ 95% CI 0.08 to 2.19) and percentage body fat 1% higher ($p=0.03$ 95% CI 0.09 to 1.97). There were no significant associations between availability of BMI-healthy, unhealthy or intermediate outlets and prevalence of overweight or obesity in this sample.

Although similar differences in weight status, in opposing directions, were observed for availability of BMI-healthy and BMI-unhealthy categories, it is clear that this was not due to the way we stratified the groups as more children had availability of BMI-unhealthy outlets ($n=779$) than BMI-healthy outlets ($n=448$) in their neighbourhoods. Of interest only 24% of children ($n=394$) had availability of both BMI-healthy and BMI-unhealthy outlets in their neighbourhoods and there were no significant differences in weight status between the children with availability of both healthy and unhealthy outlets and those without. Examining the sub-group of children with no availability of BMI-unhealthy outlets revealed that those with availability of BMI-healthy outlets had more favourable weight status than those with no availability. The opposite was observed in the sub-group of children with no availability of BMI-healthy outlets (data not shown).

Differences in food intakes between children with and without availability of various food-outlets in their neighbourhoods are presented in Figure 1, adjusted for aspects of the neighbourhood environment, gender, parental education, under-reporting and the other two food-outlet categories. Children with availability of BMI-unhealthy outlets in their neighbourhoods had diets containing more fizzy drinks ($p=0.042$) and non carbonated 'fruit' drinks ($p=0.031$). Conversely children with availability of BMI-healthy outlets had diets containing fewer fizzy drinks ($p=0.043$). Adding dietary intake variables to the weight status model showed that inclusion of the food groups investigated did not attenuate the association between food outlet availability and weight status, suggesting there may be other pathways that need exploring.

Discussion

These results suggest there is an association between neighbourhood availability of food outlets and measures of weight status in this cross-sectional study. The availability of food outlets classified as BMI-healthy in a child's neighbourhood was associated with lower weight status, whereas the converse was found for children with unhealthy food outlets in their neighbourhood. These associations remained statistically significant after controlling for aspects of neighbourhood environments that are known to be associated with BMI and obesity. These current data also suggest there are aspects of the diet that are significantly associated with availability of food outlets, including the consumption of 'unhealthy' food products.

In agreement with the current findings a previous study in adults, using similar methods to define the food environment, reported that a higher density of BMI-healthy outlets was associated with lower weight status.²⁵ A study in children also suggested associations between proximity to supermarkets and lower prevalence of obesity,¹² which may reflect the availability of healthier foodstuffs from these outlets. Unlike the current study however, the study by Rundle and colleagues reported no differences by availability of unhealthy-food outlets.²⁵ As studies in children have also reported limited associations between fast food restaurants and obesity,¹² it may be that the relatively homogeneous access to fast-food outlets previously reported in the US was not as apparent in the areas we examined.¹¹ In regard to food intake the current study confirms the findings of previous studies that report how fast food outlets and convenience stores are associated with poorer diet quality,⁴¹ and supermarkets are associated with improved diet quality.¹⁷

The strengths of this study include the large sample size of children that were recruited using a population based sampling strategy. All statistical models removed the effects of relevant characteristics of the neighbourhood environment that have previously been shown to be significantly related to BMI. Reducing the number of food-outlets studied to three distinct categories, in line with previous research, makes it less likely that statistically significant results were due to chance, although it did mean we were unable to determine if differential associations may be found for specific types of food outlets. All data was collected using standardised techniques and the objective methods used to collect the environmental and anthropometry data reduce the possibility of measurement error. In addition, all the data were collected simultaneously so the measurement of neighbourhood characteristics was contemporary with the collection of anthropometry and dietary data.

The limitations of this study include the cross-sectional design that means we cannot establish causal relations but only generate hypotheses regarding childhood obesity and the built environment. Although the majority of these findings were significant at a 0.05 level, given the number of tests undertaken these findings need to be confirmed in future studies. In the current study we were interested in the associations between weight status and food

outlets around children's homes; we recognise however that food consumed at home might be brought in other settings. Future studies could look at other important contexts such as children's schools or parent's workplaces and collect more detailed information on parental food purchasing and transportation. Although parents are likely to provide most of the food a child consumes within their neighbourhoods there is evidence to suggest that children are assuming decision-making roles and are independent purchasers of food⁴² but further work is also needed to examine exactly how children interact with their local food environment.

Data on the location and classification of food outlets came from a national commercial database, and while the spatial coverage is reportedly high, little work has been done to ascertain whether there is any bias in coverage, as it has been suggested for similar datasets in the US²⁵. We were also unable to test the validity of the product's classification scheme, but the use of the three broad categories of food outlets reduces the potential for misclassification. In this study the limited variation in outlet availability meant that we were only able to study their presence or absence in neighbourhoods. Future studies are needed to examine whether higher densities of food outlets have stronger associations with children's weight status.

Conclusion

These findings show that availability of food outlets classified as BMI-healthy was favourably associated with measures of obesity and dietary intake in this sample of children. Conversely availability of outlets classified as BMI-unhealthy was adversely associated with the same measures. Hence knowledge of the food environment may be important in targeting policies and interventions to reduce childhood obesity not only at an individual level but also by identifying and overcoming neighbourhood barriers to choosing and purchasing healthier foods. Further work in this area is needed to determine what specific behaviours may be most strongly influenced by neighbourhood food environments.

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Figure 1.

The percentage differences in daily food intake between 1669 children with and without availability of different food outlets in their neighbourhoods

Table 1Characteristics of the study population and their neighbourhood environments ^a

Variables (n=1669)	Mean (SD) or %
Participant characteristics	
Gender (% girls)	56
Age (years)	10.2 (0.3)
Weight status - Normal weight (%)	77
Overweight (%)	18
Obese (%)	5
Parental education (%)	
None or school leaving certificate	7
GCSE or equivalent (exams normally taken at age 16)	51
A-level or equivalent (exams normally taken at age 18)	26
University	17
Food outlet availability (% yes)	
BMI-healthy	27
Supermarkets	22
Fruit and vegetable stores	11
BMI-unhealthy	47
Takeaway/fast-food	38
Convenience stores	38
BMI-intermediate	57
Restaurants	51
Other food shops	30
Neighbourhood characteristics	
IMD score	16.4 (9.8)
Population density (km ²)	1701 (1606)
Land use mix	3037 (1469)
Density of commercial buildings (km ²)	10003 (16702)
Density of bus stops (km ²)	10.0 (7.5)

^aNeighbourhoods defined as 800m along a road network from a child's residential location

Table 2

Adjusted means and standard errors for children's weight status measures by categories of food outlet availability (n=1669)

Weight status	BMI-healthy outlets			BMI-unhealthy outlets			BMI'-intermediate outlets		
	No availability	Availability	p-value	No availability	Availability	p-value	No availability	Availability	p-value
	(n=1221)	(n=448)		(n=890)	(n=779)		(n=712)	(n=957)	
Height (cm)	141.2 (0.21)	140.7 (0.38)	0.262	140.8 (0.27)	141.5 (0.29)	0.097	141.3 (0.28)	141.0 (0.24)	0.350
Weight (kg)	37.0 (0.26)	35.7 (0.47) *	0.025	36.0 (0.33)	37.3 (0.35) *	0.020	36.5 (0.34)	36.7 (0.29)	0.565
BMI (kg/m ²)	18.4 (0.10)	17.9 (0.18) *	0.022	18.1 (0.13)	18.5 (0.14) *	0.047	18.1 (0.13)	18.3 (0.11)	0.331
BMI (z-score)	0.46 (0.04)	0.26 (0.06) *	0.016	0.34 (0.04)	0.49 (0.05) *	0.049	0.37 (0.05)	0.44 (0.04)	0.241
Waist (cm)	64.5 (0.27)	63.2 (0.48) *	0.021	63.7 (0.33)	64.8 (0.36) *	0.035	63.9 (0.35)	64.4 (0.30)	0.326
Waist/height	0.46 (0.00)	0.45 (0.00) *	0.026	0.45 (0.00)	0.47(0.00)	0.091	0.45 (0.00)	0.46 (0.00)	0.138
Body fat (%)	31.0 (0.25)	29.9 (0.43) *	0.031	30.2 (0.30)	31.2 (0.33) *	0.032	30.5 (0.31)	30.8 (0.27)	0.494

* significant difference between groups (p<0.05, ANCOVA)

Means adjusted for: IMD, population density, land use mix, density of commercial buildings and bus stops, gender, parental education, physical activity and the other two food outlet categories