Walkable home neighbourhood food environment and children's overweight and obesity: Proximity, density or price?

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ABSTRACT

OBJECTIVES: To identify characteristics of the food environment associated with child overweight/obesity that could, if subjected to intervention, mitigate the risk of childhood overweight/obesity. We examined whether the proximity to or density of grocery and convenience stores or fast food restaurants, or the prices of healthy food options were more strongly associated with overweight/obesity risk in children.

METHODS: We collected geocoded data by residential addresses for 1,469 children aged 10–14 years and conducted a census of all food outlets in Saskatoon. The Nutrition Environment Measures Survey (NEMS)-Stores and the NEMS-Restaurants were used to measure availability, quality and relative price of healthy food items in stores and restaurants. Children's weight status was calculated on the basis of measured height and weight. Logistic regression was used to test the associations between overweight/obesity and food environment variables.

RESULTS: Within an 800 m walking distance from home, 76% of children did not have access to a grocery store; 58% and 32% had access to at least one convenience store or one fast-food restaurant respectively. A significantly lower odds of overweight/obesity was associated with lower price of healthy food items/options in grocery stores (odds ratio [OR] = 0.87, 95% confidence interval [CI] 0.77–0.99) and fast-food restaurants (OR = 0.97, 95% CI 0.95–0.99) within walking distance of home. Neither the distance to the closest food outlet nor the density of food outlets around children's homes was associated with odds of overweight/obesity.

CONCLUSIONS: Improving economic access to healthy food in food outlets or fast-food restaurants is one strategy to counter childhood overweight/obesity.

KEY WORDS: Environment; public health; child health; obesity

La traduction du résumé se trouve à la fin de l'article.

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With the increasing prevalence of overweight and obesity in Canada over the past few decades[1] and the minimal success of downstream interventions (educational, behavioural and pharmacological) that target the individual,[2] many have now turned to understanding the role of environments (neighbourhoods, schools, communities) to find solutions within them to stem the growing problem of overweight and obesity.[3–5] This paper focuses on one such environment – food environment closest to home – to understand its relationship with overweight and obesity in children, and to propose solutions for mitigation.

Broadly conceptualized, the food environment includes any opportunity to obtain food, such as accessibility to and availability of food stores, as well as marketing and advertising of food and food products.[6] Glanz and colleagues[6] have proposed a model of the food environment consisting of four interlinked components: the community nutrition environment (food sources available in a community at large), the consumer nutrition environment (typically food available within stores or establishments serving food), the organizational nutrition environment (food available in organizational settings such as schools, hospitals, workplaces) and the information environment (all information related to food typically through marketing or mass media channels).

Of these, researchers have argued that community and consumer nutrition environments are likely to have the broadest effects.[6,7] According to Holsten,[7] the research gaps that are most in need of filling include collecting primary data and conducting direct measures of the consumer and community nutrition environments. Additionally, all types of food outlets (grocery, convenience, restaurant) should be examined together to paint a more complete picture of the community and consumer nutrition environments in a particular locale.

The purpose of this study, then, is to identify factors within a walkable home neighbourhood food environment associated with overweight and obesity in young adolescents in Saskatoon, SK. Specifically, we studied three characteristics of the community and consumer food environments as they relate to child overweight and obesity, namely proximity to food outlets, density of available food outlets within a specified geographic area and costs of food or services available within food retailers or restaurants. We hypothesize that children who had convenient access (proximity) to more sources of healthy food, as compared with unhealthy food, at lower costs are less likely to be overweight or obese, and that

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these effects will be independent of selected dietary and socio-demographic factors related to children.

METHODS

The data used in this paper are from the Smart Cities, Healthy Kids: Food Environment study begun in 2011 in Saskatoon, SK. The design and methods of the Smart Cities, Healthy Kids study have been described in detail previously.[8] Briefly, this cross-sectional, multi-method study used data collected at multiple levels (children, neighbourhoods, food retail stores and services) and focused on 10–14-year-old children and their food environments. There were 1,469 students recruited from 43 of the 79 elementary schools in Saskatoon who agreed to a written request to participate. This sample of children accounted for 11.5% of the 10–14-year age group of the Saskatoon population according to the 2011 census. Since elementary schools are equally represented in all residential neighbourhoods in Saskatoon, the study sample was a good representation (socio-economically, geographically) of the population of children aged 10–14 years in Saskatoon.

The outcome measure, overweight or obese status vs. underweight and normal weight, was derived by measuring standing height without shoes to the nearest 0.1 cm and weight to the nearest 0.1 kg on a calibrated digital scale. The inputs for calculating the body mass index (BMI) were measured height and weight, and the instrument used was the age- and sex-specific BMI calculator from the World Health Organization (WHO) AnthroPlus version 3.1. Using the 2007 WHO reference standards,[9] we classified children as normal weight (±1 SD of the age-sex specific mean), overweight or obese (>1 SD) or obese (>2 SD).

Children's data were obtained from the Youth and Adolescent Food Frequency Questionnaire (YAQ),[10] anthropometric measurements and demographic data. YAQ was initially developed in the US[10] and has been adapted for Canadian use.[11] Detailed procedures for conducting dietary assessment in our study are given elsewhere.[8] For the purpose of this paper, we included as covariables derived nutrition-related factors such as food groups and macro- and micro-nutrient status, since earlier studies have found them to be related to BMI or weight status in children.[11,12] Since demographic characteristics and socio-economic status may influence children's weight status, we considered the following covariables as well: age in years, sex, Aboriginal status and self-reported family economic situation.[13]

A comprehensive database inventory of all restaurants, grocery stores, convenience stores and specialty food stores located within the city limits of Saskatoon was built, initially using the City of Saskatoon business licences database. This list was cross-checked with information from the phone book. The list of food outlets was later confirmed and completed in February 2011, when research assistants visited each neighbourhood in Saskatoon to conduct a census of the food environments. For the research reported here, we focused on all manner of grocery stores, convenience stores and fast-food restaurants. Grocery stores included both large supermarkets and small ones, as well as ethnic groceries, as long as they contained a full range of food items.[14] The convenience store category included gasoline stations and pharmacies where food items are sold.[14] The fast-food restaurants included all types of fast-food restaurant – burger and chicken, pita and sandwich, pizza and ethnic fast-food restaurants, as well as chain coffee shops, which are similar to fast-food restaurants in offering high-calorie foods and beverages (e.g., donuts, pastries) at lower price points and with minimal table service.[15]

The Nutrition Environment Measures Survey for Stores (NEMS-S)[14] and the Nutrition Environment Measures Survey for Restaurants (NEMS-R)[15] are structured observational tools that were used to characterize the nutrition environments of Saskatoon restaurants and retail food stores. The NEMS-S instrument measures the availability and pricing differences between healthier and less healthy options and the quality of fruit and vegetables (based on the percentage of acceptable ratings, and the total amount of varieties available). The scoring procedures for NEMS-S[14] involve positive scores for the availability of healthy food options in a store and the acceptability of fruit and vegetable quality, and negative scores for higher prices for healthy food options: the higher the score the better the consumer food environment. On the basis of the survey results, a total score (ranging from −9, least healthy, to 54, most healthy) was calculated by summing the scores for each NEMS-S item assessed.

The NEMS-R instrument measures the healthfulness of foods and beverages available on restaurants' menus, the main menu and children's, with a focus on availability of healthy entrées, side dishes and beverages; facilitators or supports for healthy eating; barriers to healthy eating; and relative pricing for healthy and less healthy choices. The scoring procedures for NEMS-R[15] involve positive scores for the availability of healthy options in the restaurant, nutrition information and facilitators encouraging healthful eating, and negative scores for barriers to healthy eating as well as extra costs for healthy food. On the basis of the survey results, a total quality score for restaurant food environments (ranging from −27, least healthy, to 63, most healthy) was calculated by summing the scores for each NEMS-R item assessed.

Children's walkable neighbourhood food environment was defined using a buffer zone area of a defined geographic distance from a child's residence. We considered distances of 500 m and 800 m from a child's home along the street network to be within walking distance, labeled "walkable neighbourhood from home". Most urban planners assume a half mile (805 m) to be walking distance.[16] Previous research has also used the half mile measure of proximity.[17,18]

Using ArcGIS 10.2 (Environmental Systems Research Institute Inc, Redlands, CA, 2010), the locations of food outlets were geocoded, along with the children's home addresses. Using these geocoded data we created the following walkable neighbourhood food environment indicators: 1) proximity to a food outlet (closest distance, via street network, from a student's home to each type of food outlet); 2) density of food outlets within the 500 and 800 m network buffer zones (counts of each type of food outlet); and 3) price of the overall quality of food consumable within restaurants and retail stores. Overall quality of food was calculated by summing two totals: the total of NEMS-S scores of each type of food stores (grocery, convenience) and the total of NEMS-R scores of fast-food restaurants within each defined neighbourhood.

Data analysis

After data entry was completed we omitted data for 103 children from further analysis. These non-retained respondents comprised

2 children whose data were incomplete, 59 who resided outside the Saskatoon city boundaries, 3 whose BMIs were either greater than 3 SD from the age- and sex-specific mean or were less than –3 SD,[19] and 39 who reported average energy intakes of less than 500 kcal or greater than 5000 kcal/day.[11,19] A further 145 students did not provide accurate address information, therefore the final sample remaining for logistic regression consisted of 1,221 students.

We used multivariable regression models to estimate associations between respondents' weight status and the variables of the walkable neighbourhood food environment. Variables were entered into multivariable logistic models in blocks. Block 1 consisted of socio-demographic variables such as sex, age, Aboriginal status, self-reported family economic situation; Block 2 dietary intake variables such as food group consumption, macro- and micro-nutrient intakes; and Block 3 the food environment indicators as described above, proximity to food outlets, availability of food outlets and relative price.

Odds ratios (OR) and 95% confidence intervals (CI) were calculated. The final model included only variables that were significant at a p value less than 0.05. SPSS version 18 was used for data analysis.

RESULTS

Of our sample of children aged 10–14 years, 55% were girls and 45% were boys; 15% of children self-identified as Aboriginal; 10.5% of the children reported their family economic situation as well-off, 68% as average and 5% as poor (17% had a missing value). In this sample 24.3% (95% CI 21.2–25.7) were classified as overweight, and 12.0% (95% CI 12.4–16.0) were obese (Table 1).

Table 1. Characteristics of the study participants*

Variable	Frequency (*n*)	Percentage (%)
Sex ($n=1408$)		
Female	776	55.1
Male	632	44.9
Age ($n=1408$)		
10	265	18.9
11	399	28.3
12	363	25.8
13	279	19.8
14	102	7.2
Aboriginal status ($n=1408$)		
Yes	208	14.8
No	1184	84.1
Missing	16	1.1
Self-rated family economic situation ($n=1408$)		
Well-off	148	10.5
Average	958	68.0
Poor	66	4.7
Missing	236	16.8
Body mass index ($n=1331$)		
Normal	678	51.0
Overweight	323	24.3
Obese	160	12.0
Underweight	170	12.7

* 1469 children agreed to participate; 59 cases were removed because they resided outside of Saskatoon, 2 cases were removed because of incomplete information. For calculation of BMI, an additional 43 cases were removed because of extreme or improbable values: 3 with BMI < –3 SD and BMI > 3 SD, and 39 with total calories consumed of <500/d and >5000/d.

Table 2 shows the mean, median, minimum and maximum closest distance (all measures in metres) to a grocery or a convenience store or a fast-food restaurant using road network distance. Overall, the mean closest network distance from children's residence to a grocery store was 1381 m, to a convenience store 803 m and to a fast-food restaurant 1236 m.

Table 3 presents the number and percentage of children who had 0, 1, or 2 or more of the food outlets and fast food-restaurants within walking distance from home. As shown, a large percentage of children (89% within 500 m or 76% within 800 m road network buffers) did not have access to a grocery store within walking distance from their homes; in contrast, 58% and 32% of children could access at least one convenience store or fast-food restaurant respectively within an 800 m walk of their home.

Table 4 presents the final multivariable logistic model showing significant covariables that were associated with overweight or obesity in the participants of this study. We found that a healthier consumer nutrition environment – i.e., healthy food options, at lower prices, in grocery stores or restaurants – was significantly associated with lower odds of overweight or obesity. Children who had access to higher quality and more affordable healthy food options in grocery and convenience stores in their home neighbourhoods had a significantly lower risk of being overweight or obese (OR = 0.87, 95% CI 0.77–0.99). Similarly, children whose walkable neighbourhoods offered more affordable prices and fewer barriers for healthy food options in fast-food restaurants had a lower risk of being overweight or obese (OR = 0.97, 95% CI 0.95–0.99). We did not find, however, statistically significant associations between distance to grocery stores or restaurants, or the density (number of retail or food services outlets within a given geographic area) of food outlets, and overweight and obesity in this study.

We found several other significant factors independently associated with overweight or obesity. The frequency of meat and meat-alternatives consumption increased the odds of being overweight or obese – the more the consumption the higher the odds of being overweight or obese. Children who reported the highest or moderate levels of meat consumption (3rd or 2nd tertiles), compared with those who consumed at the lowest level, had significantly increased odds of overweight or obesity: more than 2 times (OR = 2.14, 95% CI 1.33–3.45) or 77% greater odds (OR = 1.77, 95% CI 1.21–2.56) respectively. In contrast, high intake of monounsaturated fat or low intake of sodium was associated with lower odds of overweight or obesity (OR for monounsaturated fat 0.51, 95% CI 0.34–0.78, and OR for sodium 0.56, 95% CI 0.36–0.87). Significant associations were also found indicating increased odds of overweight and obesity for males, children 11, 12, 13 or 14 years of age compared with 10 years, and for children of Aboriginal status.

DISCUSSION

Prior to this not many studies have described the walkable community nutrition environment centred on children's place of residence (proximity to and density of food outlets and fast-food restaurants) and the consumer nutrition environment (pricing, quality of food items within the stores or restaurants) together. The results here suggest that young children in Saskatoon have greater access to potentially unhealthy food sources, compared with healthy food, within walking distance of 500–800 m from their

Table 2. Closest distance (all in metres) from children's residence to a food outlet or a fast food restaurant

		Mean distance (SD)	Median distance	Minimum distance	Maximum distance
Grocery store	Network distance	1381 (717)	1274	22	4014
Convenience store	Network distance	803 (483)	691	5	3556
Fast-food restaurant	Network distance	1236 (760)	1078	15	3804

Table 3. Density of food outlets or fast-food restaurants within walking distance from home (metres)

		Network buffer distance	
Food outlet	**Counts**	**500 m, *n* (%)**	**800 m, *n* (%)**
Grocery stores	0	1102 (89.2)	939 (76.0)
	1	110 (8.9)	204 (16.5)
	2	24 (1.9)	93 (7.5)
Convenience stores	0	872 (70.6)	517 (41.8)
	1	228 (18.4)	345 (27.9)
	2 or more	136 (11.0)	374 (30.3)
Fast-food restaurants	0	1037 (83.9)	846 (68.4)
	1	89 (7.2)	129 (10.4)
	2 or more	110 (8.9)	261 (21.1)
Retail food outlets (convenience and grocery stores)	0	839 (67.9)	489 (39.6)
	1	212 (17.2)	306 (24.8)
	2 or more	185 (15.0)	441 (35.7)

Table 4. Neighbourhood food environment factors (within an 800 m network buffer zone from home), nutrient intake and socio-demographic factors associated with overweight/obesity in children aged 10–14 years in Saskatoon

Associated factor	**Odds ratio (95% confidence interval)**	***p* value**
Higher quality and lower price (score) for healthier food options in grocery and convenience stores	0.87 (0.77–0.99)	0.032
Higher quality and lower price (score) for healthier food options in fast-food restaurants	0.97 (0.95–0.99)	0.014
Meat and meat alternatives (number of servings daily)		
Low (bottom third)	1.00	
Moderate (middle third)	1.77 (1.21–2.56)	0.003
High (top third)	2.14 (1.33–3.45)	0.002
Monounsaturated fats intake		
High (top half)	0.51 (0.34–0.78)	
Low (bottom half)	1.00	0.002
Sodium intake		
Low (equal to or less than 2000 mg/d)	0.56 (0.36–0.87)	
High (more than 2000 mg/d)	1.00	0.010
Sex		
Female	1.00	
Male	2.20 (1.66–2.93)	<0.001
Age in years		
10	1.00	
11	2.17 (1.34–3.50)	0.002
12	2.10 (1.30–3.41)	0.003
13	4.30 (2.63–7.03)	<0.001
14	4.13 (2.22–7.68)	<0.001
Aboriginal status		
Non-Aboriginal	1.00	
Aboriginal	2.92 (1.92–4.40)	<0.001
Family economic situation		
Well-off	1.00	
Average	1.27 (0.81–1.99)	0.294
Poor	1.99 (0.97–4.10)	0.061

home. The nearest grocery store was, on average, 1381 m from home, whereas the distance to a convenience store was 803 m and to a fast-food restaurant was 1236 m. A large percentage of children did not have access to a grocery store within walking distance from home (89% of children did not have access within 500 m of their home, and 76% children had no access within 800 m). It is normally assumed that grocery stores offer a fuller range of options, including healthy foods at an affordable cost,[20] and that convenience stores and fast-food restaurants sell mostly unhealthy food items.[21] The relevance of designating food stores in this manner for children has been questioned, however; furthermore, as reported here, proximity to food outlets or how many outlets are available within easy access may not be the primary factor of concern in terms of increased risk of overweight or obesity in children.[22,23]

This study reports that another type of accessibility – specifically the cost of food within the stores and meals within restaurants and their quality – around children's homes has a significant association with weight status, independent of factors such as the type of food children consume (i.e., meat and meat alternatives, fat or salt content in food) or key demographic factors such as age, sex, Aboriginal status or economic situation of the family. Children who had access to affordable healthy food options within walking distance from home (800 m) had a lower likelihood of being overweight or obese. These results agree with the findings from a review by Powell and Chaloupka, who found significant effects of food prices on weight outcomes.[24] Similarly, in a longitudinal study, Sturm and Datar showed that changes in children's weight were positively related to the price of fruits and vegetables.[25] In another study, in which Sturm and Datar followed children from kindergarten up to fifth grade, they confirmed their previous finding, that children's BMI was sensitive to changes in fruit and vegetable prices.[26] These results suggest that lower prices for healthy food options such as fruits and vegetables within a walkable distance from home may help to mitigate development of overweight or obesity in children.

Similar to An and Sturm,[22] we found no evidence, however, to support the hypotheses that improved access, i.e., proximity or distance to supermarkets, or decreased exposure to fast-food restaurants or convenience stores within walking distance, is associated with lower odds of overweight or obesity. This may be

due to several reasons. First, our study applied 500 and 800 m definitions of street network buffers around children's homes to operationally define a walkable neighbourhood food environment from home. However, these definitions assume that children, or indeed their parents, do in fact shop for food items closer to where they live. These assumptions need to be tested and measures incorporated in future studies to show that participants actually shop at food outlets closer to their home. Some studies have reported that most people do not shop for food primarily at stores near where they reside.[23] Drewnowski et al.'s study, on adults, reported that only 14% of the respondents in Seattle and 11.4% in Paris shopped for food either at the closest supermarket or in their own residential neighbourhood. They argued that shoppers seem to be willing to travel longer distances from home to arrive at the supermarket of their choice or that they use supermarkets on their daily activity routes rather than specifically near their home.[23]

Second, although it was normally assumed that grocery stores offer healthy foods at an affordable cost[20] and that convenience stores and fast-food restaurants sell mostly unhealthy food items,[21] Powell and Chaloupka argued that much of the revenue in supermarkets comes from the wider selection of soft drinks, sweets, salty snacks or frozen dinners, which are available at lower prices and in larger packaged sizes.[24] According to these arguments, one interpretation and implication of our data is that categorizing food outlets by general types, e.g., grocery stores, convenience stores, fast-food restaurants, is at best a crude and shorthand way of classifying a complex phenomenon and, at worst, would tend to produce uninformative or even misleading results. Future research on food environments should either break with or significantly improve on precedence when using broad classification systems to identify healthy and unhealthy food environments. As our study has shown, continuing to assume that healthy food at affordable prices is available on the basis simply of distance to or availability of broadly classified food outlets (grocery stores, convenience stores) or fast-food restaurants is no longer helpful in this field of study.

Strengths and limitations

Our study has a number of strengths. We conducted a census of food retail and food service establishments in one city, at one point in time, using direct observation and standardized tools. This allowed us to comprehensively document and describe, by direct observation, the neighbourhood food environment: location of food outlets, types, food quality and price. Second, we defined neighbourhood food environments in relation to participating children's homes and used two different distances (500 and 800 m) to define a walkable environment. We used children's actual home address for geocoding, which allows for the correct classification of the presence or absence of certain environmental features.[27,28] Third, our characterization of the local neighbourhood food environment was theoretically driven (i.e., Glanz et al.), and we specifically operationalized Glanz et al.'s food environment dimensions of community and consumer food environments.[6] This enabled us to focus on not only measures that are often used in other studies, such as availability of food establishments and closest distance to establishments,[21,29] but also the price and quality of food within these establishments. Fourth, we also directly measured height and weight, which allows for accurate classification of children's weight status. Socio-economic and demographic data and detailed dietary intake of children allow adjustment for potential confounders in the analyses.

The current study also has limitations. Its cross-sectional nature does not allow for the detection of any cause-and-effect relationship in the association observed. However, Hanibuchi et al. argued that even with longitudinal data the causal association between food outlets or dietary practices and BMI can be problematic because of residential selection and store location preferences.[30] Papas et al. argued that many "desirable" characteristics of neighbourhoods tend to cluster, therefore it is important to check that any putative influence of the food environment on obesity is not confounded by co-occurring built environment characteristics.[29] The measure of children's family socio-economic status from self-reported data likely has limitations (misclassification). Finally, generalizability issues need to be taken into account before applying the results of this study to other cities with similar characteristics of the food environment.

CONCLUSIONS

Guided by a theoretical understanding of the food environment – specifically, community and consumer food environments (Glanz et al.) – this study aimed to provide answers to the questions, Do children have greater (or lesser) access to healthy versus unhealthy food sources from their homes, and What characteristics of the neighbourhood food environment (proximity, density or costs of food and quality) are associated with overweight and obesity in children. A majority of children 10–14 years of age in Saskatoon do not have easy access to healthy food retail establishments. Most important, lower prices for healthy food options in grocery and convenience stores and fast-food restaurants are associated with decreased odds of overweight or obesity. Interventions to reduce food prices for healthy options in food outlets and restaurants in neighbourhoods may have favourable effects on children's weight outcomes.

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RÉSUMÉ

OBJECTIFS : Cerner les caractéristiques de l'environnement alimentaire associées au surpoids/à l'obésité des enfants qui pourraient, si elles étaient soumises à une intervention, atténuer le risque de surpoids/d'obésité juvénile. Nous avons cherché à déterminer si la proximité ou la densité des épiceries, des dépanneurs ou des restaurants rapides, ou les prix des choix alimentaires sains, étaient plus fortement associés au risque de surpoids/d'obésité chez les enfants.

MÉTHODE : Nous avons recueilli des données géocodées par adresse résidentielle pour 1,469 enfants de 10–14 ans et recensé tous les points de vente alimentaires de Saskatoon. Nous avons utilisé les sondages Nutrition Environment Measures Survey (NEMS)-Stores et NEMS-Restaurants pour mesurer la disponibilité, la qualité et le prix relatif des produits alimentaires dans les magasins et les restaurants, respectivement. Le statut pondéral des enfants a été calculé à partir de la taille et du poids mesurés. Nous avons procédé par régression logistique pour tester les associations entre le surpoids/l'obésité et les variables de l'environnement alimentaire.

RÉSULTATS : À distance de marche de 800 m de leur domicile, 75% des enfants n'avaient pas accès à une épicerie; 60% et 33% avaient accès à au moins un dépanneur ou un restaurant rapide, respectivement. Une probabilité significativement plus faible de surpoids/d'obésité était associée aux prix plus bas des produits ou des choix alimentaires sains dans les épiceries (rapport de cotes [RC] = 0.87, intervalle de confiance [IC] de 95%: 0.77–0.99) et les restaurants rapides (RC = 0.97, IC de 95%: 0.95–0.99) situés à distance de marche du domicile. Ni la distance du point de vente alimentaire le plus proche, ni la densité des points de vente alimentaires autour des domiciles des enfants n'était associée à la probabilité de surpoids/d'obésité.

CONCLUSIONS : Améliorer l'accès économique aux aliments sains dans les points de vente alimentaires ou les restaurants rapides est une stratégie pour contrer le surpoids/l'obésité juvénile.

MOTS CLÉS : environnement; santé publique; santé de l'enfant; obésité