Original Article

Association between Weight Status and the Built Environment around Schools in Greece Using Geographical Information Systems Technology

Anastasia Barbouni, PhD
Professor of Public Health, National School of Public Health, Department of Public Health & Administrative Health, Athens, Greece

Eirini Amanaki, PhD
Researcher, National School of Public Health, Department of Public Health & Administrative Health, Athens, Greece

Areti Lagiou, PhD
Professor of Epidemiology, Higher Technological Institute of Athens, Department of Public and Community Health, Athens, Greece

Dimitra Barbounis, PhD
Archeologist, National and Kapodistrian University, Athens, Greece

Sofia Kalogirou, MSc
Health Visitor, National School of Public Health, Department of Public Health & Administrative Health, Athens, Greece

Kyriakoula Merakou, PhD
Teaching and Research Associate, National School of Public Health, Department of Public Health & Administrative Health, Athens, Greece

Correspondence: Kyriakoula Merakou, Teaching and Research Associate, National School of Public Health, Department of Public Health & Administrative Health, 196 Alexandras Ave., Athens, 11521, Greece. E-mail: kmerakou@esdy.edu.gr

Abstract

Background: School environmental factors contributing to children obesity have not been thoroughly investigated. The Geographical Information System (GIS) mapping is a suitable instrument for detection of such factors outside schools.
Methods: The study group consisted of 940 students in grades 7 and 10 of all secondary schools (17 schools) in the city of Lamia, Greece, during the school year 2012-2013. Data analysis included students' BMI and spot checks within a 500m radius of each school for food shops and settings of physical activity through GIS mapping.
Results: The highest values of BMI were found at the 10^{th} grade [22.2 (±3.2) to 23.1 (±4.4)]. The lowest values of students' BMI were found at the 10^{th} grade of the Musical School [(19.7 (±2.8)]. The boys had a considerably higher BMI compared to the girls ($p<0.001$). Students from schools which were in close proximity of food shops had significantly higher BMI in comparison with students whose schools were not ($p=0.022$). The larger the school yard, the lower the students' BMI values ($p=0.022$).
Conclusions: Communities could support schools to fight students' obesity by setting limits regarding the distance of food shops, playing fields and larger yards.

Key words: Childhood obesity, physical activity, Geographical Information System, community, secondary school, health promotion.

Background

Obesity is a serious public health problem that is spectacularly difficult to define. A growing body of evidence has reported that obesity has increased at an "alarming rate" worldwide (James 2008, WHO 2000).

Surveys have shown the prevalence of overweight and obesity among school age children to be as high as 35% in parts of Europe (Branca et al 2007, Jackson-Leach & Lobstein 2006) especially in eastern and southern European countries (Livingstone 2000), and several countries have reported prevalence rates increasing year-on-year (Branca et al 2007, Jackson-Leach & Lobstein 2006). The findings from recently epidemiological surveys conducted in representative samples of children and adolescents in Greece are quite alarming (Georgiadis & Nassis 2007, Hassapidou et al 2009, Magkos et al 2006, Tzotzas et al 2008) and lead to the conclusion that the problem of overweight and obesity in Greek youth is very prevalent and takes the form of national epidemic (Roditis et al 2009). The high prevalence of obesity in Greek youth provides powerful justification for the development and implementation of preventive strategies which are population based rather than selectively targeted at high-risk youths (Branca et al 2007, Livingstone 2011).

Obesity is the result of an imbalance between energy expenditure and energy intake (Branca et al 2007, WHO 2000). The modern-day epidemic of obesity could be attributed to the contemporary environment, which discourages physical activity and encourages excessive food intake (Hill & Peters 1998). Our synchronous life-style requires limited levels of physical activity for subsistence, and is characterized by an unlimited supply of highly luscious, relatively cheap, convenient, energy-dense foods (Hills & Peters 1998, Hill et al 2003). Such an environment promotes obesity in such a degree that can be characterized as "obesogenic" (Golan & Crow 2004).

By adopting the view of Hill and Peters (1998), according to which in order to tackle and abolish the obesity epidemic we must first "cure" the obesogenic environment, the need for the best possible understanding and detailed description of the specific biophysical and manufactured environmental features, that are liable for obesity, could not be overlooked (Dunton et al 2009). Due to the considerable amount of time children spend in school settings, physical characteristics of the school environment are relevant intervention targets. Consequently, there is an obvious necessity for an elaborate and assiduous study and information collection of the broader school environment.

Lastly, it was determined that the need for reliable information about the community and health could not be satisfied using the tradition methods of collecting, recording and processing information. Therefore, Geographical Information Systems- G.I.S. technology developed greatly, and provides unique opportunities for epidemiologists to study associations between spatial distribution of epidemic and environmental exposures (Blatt 2011, Cromley 2011, Robinson 2000). The role of the G.I.S. in public health is very important. The G.I.S. as a means of investigating health problems and the discovery of ways to tackle them holds an important place in the methodological tools of Public Health Authorities (Cromley 2003, Goodchild 2009, Nykiforul & Flaman 2011). Especially during the last decade, there is an increase in the use of G.I.S. to analyze the relationship between obesity and the built environment (Black et al 2010, Jeffery et al 2006).

Therefore the research hypotheses of this study were whether:

- Food shops situated near schools have an effect on students BMI.
- Physical activity facilities situated near schools have an effect on students BMI.
- The size of the yard has an effect on students BMI.

The aim of the research is to examine the association among students' BMI, food shops and physical activity facilities around schools.

Methods

Participants

The total of 17 secondary schools (8 lower secondary schools and 9 higher secondary schools) situated at the city of Lamia (city population: 75,000), participated to the study. From each school the students who were attending at the 7th and 10th grades were selected

(aged 13 and 16 years). The reason for the selection of these grades was that the students had recently provided to schools their health records from their pediatricians. Students in 7th and 10th grade, according to Greek School System, are obliged to provide to school a health record from their pediatricians. In total 1120 students were attending at the schools but 180 of them had not brought their health records and therefore 940 students [499 boys (53.1%) and 441 girls (46.9%)] formed the final sample (participation rate 83.9%) The study was conducted during the school year 2012-2013.

Instruments

Anthropometry. Body Mass Index (BMI) was calculated by dividing the weight (kg) with the square of the height (m^2) and was used as an assessment indicator for obesity. Body weight and height of the participants were measured by students' pediatricians and were recorded on their health records. Participated students were classified as normal, overweight and obese, based on WHO Growth Reference Data for 5-19 years old children and adolescents (WHO 2007).

Built environment. GIS was used to link individual and built environment data. G.I.S. is an organized collection of mechanical equipment (hardware), software, spatial and descriptive data, with the aim of collecting, storing, updating, managing, analyzing and presenting every type of information, which refers to a geographic environment (Jennings et al 2011, Robinson 2000).

Procedure

Recent health records of the students were used for the collection of the anthropometric characteristics of participated students. Permission was asked and given by the director of the local authority of the Ministry of Education.

Spot checks were performed in a radius of 500m from every school for the collection of data which referred to food shops and settings of physical activity for students, following school routes to and from schools. The choice of zones was made based on school routes recommended by the G.I.S.

Statistical Analysis

Averages, standard deviations, medians and interquartile ranges were used for the description of the quantitative variables. Absolute (N) and relative (%) frequencies were used for the description of qualitative variables. Pearson's χ^2 test or Fisher's exact test were used for the proportionate comparison. For the comparison of quantitative variables between two groups, Student's t-test was used. For the control of the relativity of two quantitative variables, Pearson's correlation coefficient (r) was used. The levels of significance are bilateral and the statistical significance was set at 0.05. The Statistical programme SPSS 18.0 was used for the analysis.

The Geographical Information Software used is ArcGIS for Desktop Basic 10.1 by ERSI, for the final geographic image of the schools' positions as well as the data which resulted from the statistical analysis.

Results

The BMI of the students ranged from 22.2 ($\pm$3.2) to 23.1 ($\pm$4.4). The lowest rates of overweight/obese children were found at the Musical Secondary School (10th grade) (0%) and mean BMI 19.7 ($\pm$2.8). The average size of the school yards was 1467.6m² (±624.2m²). 52.9% of the schools had a playing field nearby and 35.3% a playground. In 88.2% of the schools there was some sort of shop nearby (newsagents, cafés, internet cafés, fast food, kiosks, etc) in a radius of 500m from the schools. More specifically, 50.0% of the schools were in close proximity of a newsagent's, 35.3% a café, 11.8% an internet café, 29.4% a fast food shop, 52.9% a kiosk and 41.2% another kind of shop, such as a baker's, a pastry shop, a grocer's etc. The average number of kinds of shops in close proximity of the sample schools was 2.1 (±1.7) while the average total number of all kinds of shops was 3.4 (±3.9).

By aggregating the number of kinds of shops (newsagent's, café, internet café) in close proximity of each school, the parameter "kind of shops" was obtained, while by aggregating the number of these shops in close proximity of each school, the parameter "Total number of shops" was obtained.

Table 1: Descriptive data of the study schools

		N	%
Size of yard in m², average±SD median (interquartile range)		1467,6±624,2	1500 (1000 - 1900)
Playing field (within 500m)	No	8	47,1
	Yes	9	52,9
Number of playing fields (within 500m), average±SD median (interquartile range)		0,65±0,7	1 (0 - 1)
Playground (within 500m)	No	11	64,7
	Yes	6	35,3
Newsagent's with prepared food and cigarettes (within 500m)	No	8	50,0
	Yes	8	50,0
Number of Newsagents' with prepared food and cigarettes (within 500m), average±SD median (interquartile range)		0,75±0,93	0,5 (0 - 1)
Cafe (within 500m)	No	11	64,7
	Yes	6	35,3
Number of Cafes (within 500m), average±SD median (interquartile range)		0,76±1,35	0 (0 - 1)
Internet cafe (within 500m)	No	15	88,2
	Yes	2	11,8
Number of Internet cafes (within 500m), average±SD median (interquartile range)		0,18±0,53	0 (0 - 0)
Fast food (within 500m)	No	12	70,6
	Yes	5	29,4
Number of Fast food (within 500m), aveage±SD median (interquartile range)		0,53±1,01	0 (0 - 1)
Other (within 500m)	No	10	58,8
	Yes	7	41,2
Number of Others (within 500m), average±SD median (interquartile range)		0,59±1	0 (0 - 1)
If Other, what	Baker's	3	17,6
	Dairy goods	2	11,8
	Toy shop (JUMBO)	2	11,8
Kiosk (within 500m)	No	8	47,1
	Yes	9	52,9
Number of Kiosks (within 500m), average±SD median (interquartile range)		0,76±0,9	1 (0 - 1)
Existence of newsagent's, café, internet café, fast food, kiosks and other kinds	No	2	11,8
	Yes	15	88,2
Types of shops, average±SD median (interquartile range)		2,1±1,7	1 (1 - 4)
Total number of shops, average±SD median (interquartile range)		3,4±3,9	1 (1 - 5)

Table 2: Comparison of BMI in boys and girls

		Sex				P
		Boys		Girls		
		N	%	N	%	
BMI		21,6±4,0		20,7±3,5		**<0,001**
BMI	Normal Weight	413,0	51,4	390,0	48,6	**0,013**
	Overweight/Obese	86,0	62,8	51,0	37,2	

Table 3: BMI of students compared with food shops and physical activity facilities

		BMI		P Student's t-test
		Average	SD	
Playing field within 500m	No	21,4	1,1	0,418
	Yes	21,0	1,0	
Playground within 500m	No	21,1	1,0	0,684
	Yes	21,3	1,2	
Newsagents' with prepared food and cigarettes within 500m	No	20,7	1,0	**0,026**
	Yes	21,8	0,9	
Café within 500m	No	20,9	1,0	0,070
	Yes	21,8	0,9	
Internet café within 500m	No	21,1	1,0	0,169
	Yes	22,2	1,3	
Fast food within 500m	No	20,9	1,0	0,065
	Yes	21,9	0,8	
Other food shops within 500m	No	21,3	1,1	0,745
	Yes	21,1	1,0	
Kiosk within 500m	No	20,8	1,0	0,165
	Yes	21,5	1,0	
Existence of newsagents', cafe, internet cafe, fast food, kiosk and other kind of shops	No	20,5	1,2	0,298
	Yes	21,3	1,0	

Table 4: BMI of students and the number of food shops and physical activity facilities

		BMI
Size of yard in m²	r	-0,73
	P	**0,001**
Number of playing fields (within 500m)	r	-0,07
	P	0,775
Number of Newsagents' with prepared food and cigarettes (within 500m)	r	0,69
	P	**0,003**
Number of Cafes (within 500m)	r	0,55
	P	**0,023**
Number of Internet cafes (within 500m)	r	0,22
	P	0,394
Number of Fast food shops (within 500m)	r	0,30
	P	0,242
Number of other food shops (within 500m) (baker's, pastry shop, grocer's, etc.	r	0,09
	P	0,745
Number of kiosks (within 500m)	r	0,36
	P	0,151
Kinds of shops	r	0,55
	P	**0,022**
Total number of shops	r	0,55
	P	**0,022**

An important finding of the study is that the boys had a considerably higher BMI in comparison with the girls ($p < 0.001$). Similarly, the rate of overweight/obese boys was significantly higher in comparison with the corresponding rate in girls ($p = 0.013$).

The results also pointed out that students of schools in close proximity of newsagents' had a significantly higher BMI in comparison with students whose schools were not ($p = 0.026$).

More specifically, the more kinds of shops (newsagent's, café, internet café) there were close to the schools, the higher the BMI of their students ($p = 0.022$). In contrast, the more shops there were close to the school, the higher the BMI of its students ($p = 0.022$). In addition, the larger the school's yard, the lower the values of its students' BMI ($p < 0.001$).

Discussion

The differences observed between the two sexes, in terms of BMI, are significant. Specifically, the boys had a considerably higher BMI in comparison with the girls. These findings are compatible with those have been found in Greek adolescents, showing that boys tend to have a higher risk of excess body weight than the girls have (Geordiadis & Nassis 2007, Hassapidou et al 2009, Tzotzas et al 2008), probably due to girls' greater concern about their body image. As it have been well documented in empirical

studies, girls are much more likely than boys to perceive themselves as overweight, highlight the importance of "not being overweight", engage in disordered eating, and frequently resort to exhausting diets in order to lose their excess weight (McCabe et al 2002, Neumark-Sztainer & Hannan 2000, Ricciardelli & McCabe 2002, Swanson et al 2011). The challenge facing health experts is how to implement interventions aimed at preventing youth obesity without leading to unhealthy weight control practices and immoderate weight preoccupation (Neumark-Sztainer & Hannan 2000).

School represents a suitable setting for the promotion of healthy physical activity levels in children and adolescents. It has been found that the length of recess, the school size, and the availability of game equipment in the playground (e.g. balls) have strong impact on the engagement of physical activity by children (Huberty et al 2011, Loucaides et al 2009, Ridgers et al 2007, Stratton 2000, Verstraete et al 2006, Zask et al 2001). The investigation of the positive effects of providing game equipment on children's physical activity levels during recess has shown that recess periods can contribute to reach the daily activity levels recommended for good health, making them an important school environmental factor for the promotion of healthy physical activity (Verstraete et al 2006). Also, a meta-analysis of forty-six studies revealed that self-determined (autonomous regulation) motivation had moderate, positive associations with physical activity, whereas controlled forms of motivation (other-determined, external regulation) had weak, negative associations with physical activity levels in children and adolescents (Owen et al 2014). On this basis, the finding of this research, according to which the size of the school yard was negatively associated with BMI, should not be surprising. Apparently, when the school yard is adequate in size, adolescents are more able to engage in non-organized, spontaneous play, which will be chosen by themselves and, at the same time, will be in agreement with the main developmental characteristics of adolescence, namely their tendency for independence (autonomy) and identity formation.

According to the results of the study, in 88.2% of the schools there were some kinds of shop - newsagent's, café, internet café, fast food, kiosk as well as other kinds nearby. Also, a similar study conducted in New Zealand pointed out that schools were characterised by a high density of fast food restaurants within walking distance, particularly in the more socially deprived areas. The outlets were concentrated within 800m from the schools and around secondary education (Day & Pearce 2011).

This study also reveals that the more shops there are close to the school, the higher the students' BMI and the more the increase in the rate of overweight/obese children. Easy access to food stores promotes the away-from-home food consumption among students, which has been associated with weight gain (Naska et al 2011). It has been known that the adoption of healthy dietary habits in adolescents is difficult to achieve, with the all-increasing consumption of snacks, since food outlets are concentrated around schools (Levin et al 2012). The assessment of the contribution of out-of-home energy and nutrient intake to total dietary intake conducted in 10 European countries, has revealed that eating outside the home is associated with increased sedentary behaviors and poor-quality food intake, especially in northern Europe (Orfanos et al 2009).

Convenience stores, which constitute a frequent part of the contemporary urban landscape, retail mainly energy dense, inexpensive, low-nutritive packaged foods including chips, candy, ice creams, chocolate bars, sugar-sweetened and artificially flavored beverages, etc. (Borradaile et al 2009, Laska et al 2010). This is in agreement with the findings of the present study, according to which the existence of shops with prepared food near schools is positively associated with increased students' BMI.

In relation to the perception of the control of physical activity, the results of this survey showed that difficult access to sports grounds constituted an obstacle to the increase in the children's physical activity. It has been found that children who have easy access to sports grounds, such as secure parks, public and private gyms and swimming pools, are more active compared to those who do not have access to such leisure facilities (Gordon-Larsen et al 2004).

Difficult access to sports grounds, which was revealed in this study, but also in previous ones (Gordon-Larsen et al 2004), in combination with the lack of free time, contribute to the promotion

of a sedentary lifestyle and these factors should constitute the primary objectives of intervention. Free entry to school facilities and school equipment after school hours would constitute an alternative solution in the improvement of access to secure sports grounds. The majority of schools in Greece (Manios et al 1999) as well as in other countries (Moody et al 2004) remain closed after school hours for security reasons.

A large part of the literature highlights a significant association between increased physical activity and the reduced risk of childhood obesity. Studies determined lower levels of physical activity in obese children compared to children of normal body weight (Ekelund 2002). However, in the present study, the rate of overweight/obese children did not differ according to the existence of playing fields close to their schools.

Obesity in childhood, especially in adolescence, is a key predictor for obesity in adulthood (Deckelbaum & Williams 2001) and is associated with increased rates of premature death from endogenous causes (Franks et al 2010). Further, it has been well documented that early obesity leads to an increased likelihood of obesity in later life (Freedman et al 2001, Reilly & Kelly 2011) as well as to an increased prevalence of obesity-related disorders (Austin et al 2005, Biro & Wien 2010). It is therefore important to establish healthy dietary and physical activity patterns early in the child's life. Consequently, the timely implementation of school programs to promote healthy lifestyles may be more effective than the anti-obesity preventive programs.

In order to ameliorate the dietary behaviors of children and adolescents, healthy food choices outside the home need to be disposable, affordable, and facile as the unhealthy ones are (Austin et al 2005, Hill et al 2003). Also, the physical activity of youths should be developmentally appropriate, enjoyable, and varied enough, taking under consideration their levels of biological maturation, physical growth, and behavioral development (Strong et al 2005), having in mind that when children move into adolescence they become more independent and they have to accommodate to great lifestyle, social, developmental, and environmental changes (Van Der Horst et al 2007). These changes in adolescent lives tend to be transmitted into their dietary intake patterns. Specifically, adolescent food intakes tend to be high in fat (especially saturated), salt, and sugar, and low in vegetables, fruits, fibres and calcium-rich foods (Branca et al 2007, Rolland-Cachera et al 2000).

In a digitalized world, the internet, particularly among adolescents, is observed to be "increasingly adopted as a readily accessible means for information retrieval, entertainment, and socialization" (Kormas et al 2011). Although longitudinal studies about the utilization of the new technologies in Greece are few and far between, we can support with confidence that the vast majority of Greek adolescents have access to the internet (Siomos et al 2008) and spend rapidly increasing amounts of time using computers and the internet (Tsitsika et al 2009). Also, a recent research found that approximately one fifth (19.4%) of Greek adolescents were identified with potential pathological internet use (Kormas et al 2011). Hence, it could be assumed that the digital 'revolution' increases even further the risk for sedentary behaviors among adolescents and this should be considered seriously for the successful planning and implementation of obesity prevention programs.

Changes in eating and physical activity behavior patterns, on the individual level, are at the heart of all strategies for reducing obesity (Brown & Summerbell 2009, Kamath et al 2008). However, successful efforts must not focus solely on the individual's behavior changes, but should take into account the effects exerted by the group (family, friends, peers), school, community, the media and public policy. Changes in dietary and physical behaviors of the individual can only be accomplished within a *supportive environment* that will provide accessible and affordable healthy food choices, and opportunities for physical activity/ exercise. Without this *multidisciplinary approach*, actions to reduce and prevent the obesity problem are doomed to fail.

Finally, we would like to point out the very interesting finding that none of the Musical Secondary School's students (10^{th} grade) was overweight or obese. A possible explanation could be that adolescents' engagement with something that interests them, such as music, prevents them from resorting to excessive eating for psychological reasons. This finding should be taken seriously by those responsible for the

planning and implementation of intervention and prevention programs against obesity in youths. Providing opportunities for adolescents within the school context to get involved with various forms of art may be curative, as highlighted by the findings of studies, according to which art therapy impacts on mood states and the subjective well-being of adolescents (Anderson et al 2014, Cobbett 2016, Esfandiari & Mansuri 2014, Kim et al 2014).

Limitations

This study has a number of limitations. For instance, the sample included schools situated only in one city; therefore the generalizability of the findings to the whole school and community system is limited. Moreover, socioeconomic and geographic variables were not studied.

Conclusions

Students' BMI positively correlates with existence of food shops nearby schools and negatively with size of school yard. Boys have higher BMI than girls.

Implications for school health

The findings of the present study may contribute to future research for researchers, policy makers, and municipality and community authorities for better understanding the importance of the environmental contribution to students' obesity. Teachers performing nutrition education in schools should analyze the "hidden" effect of the neighborhood food shops on overweight and obesity of their students.

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