Diet, physical activity and the obesogenic environment: are they related?

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Abstract

Obesity is a significant social problem which has reached pandemic levels. Prevention and treatment has focused on pharmacological, educational and behavioural interventions, with limited overall success. A novel and a longer term approach would be to investigate the environments which promote high energy intake and sedentary behaviour; this has not yet been fully understood.

This paper describes the piloting of an existing US developed questionnaire (Youth NEWS) [1] to assess the interaction between diet, physical activity and perceived environment in a sample of 25 (10 male, 15 female) 16-18 yr olds. Participants also completed a validated food frequency questionnaire.

This pilot provides a detailed description of the young people's environment and their dietary intake. Further development is required to fully understand the young peoples' perceptions of, and interaction with their environments.

Keywords – diet, physical activity, environment, obesogenic environment

1 Introduction

1.1 Obesity

Obesity prevalence in the UK has tripled over 20 years and continues to increase at an alarming rate [2]. The social costs of obesity are high; obesity accounts for approximately 30,000 premature deaths and the total estimated cost of obesity is £3.3 - 3.7 billion per year [3]. This paper focuses on an adolescent population. The incidence of obesity in children and young people is of great concern. In Canada, Australia and parts of Europe an additional 1% of all children are becoming overweight each year. It is estimated that 10 % of the world's school aged children are carrying excess body fat [4]. Recent Health Survey for England results [5] indicate that, between the ages of 11-19 years the prevalence of overweight in boys varied from 14.4% of 16 year old boys to 20.9% of 18 year old young men. While for girls at least 17.5% of girls were overweight at all ages. In addition to overweight, a further 5.1% to 9.1% of boys and 6.3% to 12.4 % of girls were obese.

The health consequences of overweight and obesity, especially for young people, are high. Body Mass Index (BMI) in childhood appears to have a stronger effect on adult BMI than birth weight and adult lifestyle factors [6]. Obesity in adolescence is strongly associated with obesity in adulthood [7, 8]. Obesity, once developed, is difficult to treat, and prevention programmes aimed at children and adolescents are considered a high priority [9].

No single theory has adequately explained all the factors which contribute to the current obesity epidemic [10]. Obesity is complex, the causes are multi-factorial and include biological, psychological, behavioural and social aspects [10]. It is acknowledged that the medical profession alone is unable to tackle the obesity epidemic [11]. Obesity is recognised as a broader environmental issue which includes physical, economic, political and socio-cultural factors [12].

The mechanisms by which the environment influences obesity include food intake and physical activity [13, 14]. In the developed world, our environment supplies an unlimited amount of convenient, energy dense foods [13] and also influences energy expenditure as our current lifestyles require relatively low levels of physical activity. Previous work has focused on the interactions between diet and physical activity, and also diet and the environment; however the relationship between all three factors is currently under researched. This link between the environment, diet, physical activity and obesity requires further exploration. The obesogenicity of an environment has been defined as 'the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations' [15]. Environments

which promote excessive food intake and discourage physical activity are seen as a contributing factor to the current obesity epidemic [13]. The majority of research on the obesogenic environment has been carried out in North America, Australia and New Zealand. The WHO [16] has reported that the obesogenic environment appears to be largely directed at the adolescent market, thereby making healthy choices for this age group more difficult. Research on the influence of the environment on obesity on adolescents is limited, although adult data does provide insight [17].

1.2 The Environment

The environment can be divided into two 'sizes'; 'micro-environments' (e.g. schools, workplace, home, neighbourhood, recreational facilities) which are influenced by broader 'macro-environments' (e.g. education, health and transport systems, government policy, society's attitudes and beliefs) [12]. These different types and levels of environments interact together and health related behaviour is determined by a combination of direct and indirect mechanisms [18].

One aspect of the environment which has attracted attention in relation to obesity is the built environment. Obesity has been related to the built environment through reduced opportunity for active travel and physical activity [19], and the location, proximity and availability of food and food outlets [20]. Investigating and tackling how the built environment influences public health and obesity requires professionals to cross disciplinary boundaries [21]. The built environment consists of three elements [22]:

1) Physical design.
2) Land use patterns (residential, commercial, office, industrial, and other activities).
3) Transportation systems.

Historically in the UK and US, modern town planning grew from a concern regarding the unsanitary conditions of industrialising cites in the 19th Century; health professionals and planners worked together in finding solutions [23]. However, as the health community became increasing focussed on treating diseases, so the planning profession became fixated on the aesthetic and economic aspects of planning and collaboration between the two professions dropped away [24]. Since the 1980s however there has been a growing recognition that in order to plan effectively there is a need to reinvigorate the historic collaborative link between public health and urban planning and together conduct informed science [25-27]

In 1987 the World Health Organisation Regional Office for Europe launched its 'Healthy Cities' Project. Taking a holistic approach to healthy urban environments, it states that healthy cities are ones where physical and social environments are continually improved and community resources strengthened to help people achieve their full potential [28]. In the USA corresponding programmes have also been initiated such as the Healthy Communities Movement and the Coalition of Healthier Cities and Communities [29]. The links between health and built environment have, therefore, been back on the research and policy agenda for some time. However, there is still a lack of understanding of how physical environments and social factors combine to create disparate environmental exposures and thus health inequalities among populations [30]. Moreover recent research though large in volume and mostly US based, has produced a disparate and often seemingly contradictory body of evidence in relation to this field.

Much of the literature points to a consistent link between urban design, walking and cycling. Research has suggested a number of factors within the built environment which appear to correlate with people's propensity to undertake walking and cycling and therefore have improved health outcomes. US work suggests than groups of neighbourhood characteristics will often be found together and these make neighbourhoods more, or less, 'walkable' [31]. Older (pre-WW II) traditional neighbourhoods display higher residential densities; high levels of connectivity between streets (e.g. gridiron patterns); high levels of land-use mix (residences, local shops and services mixed together); good levels of pavement prevision and; are often perceived to be aesthetically pleasing and safe; such built environment feature may encourage walking and cycling.

In contrast modern auto-dependant suburban neighbours, often labelled 'urban sprawl' in US literature, lack nearly all of these qualities. It is suggested the resultant large tracts of single use land patterns; few or no local shops, or services combined with housing; largely disconnected development i.e. 'cul-de-sac' layouts; poor levels of pavement provision and monotonous, uninteresting views, deter people from taking everyday (utilitarian) exercise, i.e. walking, or cycling to work, shops and services. This in turn is detrimental to peoples' health. A study in Atlanta, Georgia, for example found a significant correlation between the obesity of white males

and the residential density of where they lived; obesity decreased from 23 percent to 13 percent from the least to the most dense neighbourhoods [32]. Re-examining the data from this study and looking at age group 5-20, the researchers have further concluded that as well as household density, other urban factors including the availability of recreational space, land-use mix and street connectivity were all important as to whether this group regularly walked one –mile and/or if at all [33]. Previous studies have, however suggested that street connectivity was not correlated to children's propensity to walk to school [34].

Walking and/or cycling to school, its affects and barriers has been the focus of a number of studies. Bricker et al. [35] for example showed the direct correlation between the distance a child lives from school and the propensity to walk, or cycle to it. Other research has suggested that children living further from and therefore being driven to school lose 'free-time' (which might be physically active) commuting and this is not made up for other ways; moreover they are less able to stay for after school activities. This work has been particularly critical of modern trends in sitting large schools sites on the edge of large low density suburban locations [36]. Journey length to school may be only one factor however; work in Australia has suggested that micro urban design environments, such as the quality of pedestrian realm and public crossings can also be significant in whether parents allow their children to walk to school [37].

Another key aspect of the built environment related to children's activity patterns is the availability of play and recreational space; however this does not necessarily mean traditional parks and playgrounds. It has been argued that the streets near child's home are actually more important, since they are readily accessible and are more 'exciting' than specifically set aside play areas [38]. This said, for several decades it was thought that the suburban cul-de-sac also addressed this need and provided an ideal safe play space. Research is now challenging this assumption however, and suggests that only very young children may benefit. As soon as children become more adventurous i.e. wanting to explore beyond their immediate front garden and meet friends, cul-de-sac layouts with their disconnected networks actually hinder such exploration. Moreover the hierarchical nature of road networks, necessary for cul-de-sac designs to work often mean than traffic runs on high speed arterial roads on the edge of housing estates, which are highly dangerous for children to cycle along, or to cross [32].

Research has therefore correlated elements within the built environment to activity levels and there have been some tentative links to health outcomes. For the purposes of this study, however, there are a number of issues. Firstly as much of the work is US, or Australia based it is difficult to know how transferable the observations are to the UK. In the Atlanta study (above) for example the residential densities observed were much lower than would be typical in the UK. Moreover most studies in this field either focus on adults, or children. Studies which specifically look at adolescent behaviour are rare and yet this age group is important not least because it included the age at which people learn to drive.

1.3 Physical activity and the environment

A review has reported consistent associations between the physical environment and physical activity [39]. There is limited research on this interaction between the environment and physical activity in young people [1, 40]. Technological advances in transportation have resulted in a reduced need for physical activity in everyday life [13]. In children, an increase in sedentary behaviour has been associated with excessive television viewing, computer usage and availability of electronic games [41]. The amount of time spent watching television by children in the UK has doubled since the 1960s [42]. Adolescents now spend approximately 3 hours per day watching television or playing video games [43]. In addition to an increase in sedentary behaviour, young people's participation in physical activity is low [11].

Cutbacks in physical education programs have contributed to overall decline in children's physical activity levels [13]. The built environment has been seen to be associated with a decline in physical activity during recreational time, as areas with few facilities, safety concerns, hilly terrain or inadequate lighting has been found to discourage physical activity [44].

There is an association between a sedentary lifestyle and both individual [45] and neighbourhood socio-economic characteristics [19]. These have also been found to have wider implications in terms of health risk [46]. Neighbourhoods with low socio-economic status (SES) usually have fewer physical activity resources than medium to high SES neighbourhoods [47].

An American study found sidewalk characteristics to be positively associated with light-intensity physical activity, such as slow walking, and negatively associated with sedentary activity in adolescent males [40]. In adults, a European study objectively measured features of the

residential environment and found these to be closely related to physical activity and obesity [48]. High levels of incivilities, such as graffiti and litter, were associated with higher levels of physical inactivity and higher levels of obesity.

1.4 Nutrition and the environment

Research on nutrition environments is less advanced than that on physical activity environments [17]. Two food access pathways have been described in relation to the food environment; food for home consumption from supermarkets and grocery shops and ready-made food for home and out-of-home consumption from restaurants and take-aways [49].

In young people the school or college nutrition environment is important and has been found to significantly affect food choice and behaviour [50]. Adolescents spend a large amount of time in school [51] and about a third of all school-aged children eat a school meal during term time [52]. New-Zealand school environments were found not to be conducive to healthy eating, with less healthy options dominating the food sales [53]. In UK secondary schools, a large variety of unhealthy options were found to make it difficult for young people to choose a healthy diet even if they wanted to [54]. A contributing factor is the lack of regulations that are in place for alternative foods, such as those served at snack bars, tuck shops, or in vending machines [51]. Schools have been recognised as an important site for obesity prevention interventions, they provide opportunities to demonstrate health-promoting behaviours, and are an important environment that can shape the habits of young people [55].

Another important aspect of the food environment, for young people, is advertising and marketing of energy dense foods. Evidence exists which indicates that advertising to children does have an effect on their food knowledge, preferences and behaviour [56]. UK schools, in particular, have been subjected to heavy branding and marketing of foods through commercial sponsorship and the provision of vending machines [50].

As with physical activity, limited research exits on this topic in an adolescent age group. Good evidence exists of the link between the environment, food and obesity in the US, the UK picture is less clear [49] and further work is required to explore this relationship in the UK.

1.5 Measuring environmental influences

Measurement of the environmental influences on diet, physical activity and obesity presents methodological challenges. Current research has identified links between the environment and obesity risk. However, a variety of methods have been used to assess the obesity-related outcomes and the built environment. A combination of objective measurements (e.g. actual counts of traffic) and subjective measurements (e.g. an individual's self-reported perception of crime in their neighbourhood) are important in explaining the relationship between weight gain, obesity and the environment [18]. More consistent methods still need to be developed and applied in the field [10].

1.6 Aims and objectives

The aim of this study was to develop tools to assess the interaction between diet, physical activity and the environment in 16–18 year olds in the Newcastle area. The analyses in this paper seek to further the understanding of how food choice, lifestyle factors and the environment contribute towards obesity and how they can be measured.

The paper reports on the core aspects of this process:

1) The adaptation of an American designed diet, environment and physical activity questionnaire for use with 16-18 year olds in Newcastle.

2) The use of this adapted questionnaire and an adapted version of the European Prospective Investigation of Cancer (EPIC) Food Frequency Questionnaire (FFQ) to collect data.

3) Comparisons of food intake and food choice, lifestyle and neighbourhood environment in the sample.

4) The exploration of the interactions and relationships between diet, physical activity and the environment.

2 Methods

2.1 The questionnaire

The questionnaire used in this study was based on an extensively developed North American questionnaire known as "Youth NEWS" (Neighbourhood Environment Walkability Survey) [1]. This measures perception of the environment. It was developed from previous surveys and formative research, involving in-person interviews with children (12-17 year olds) and their parents in a variety of places where the environment might affect physical activity behaviour. The questionnaire included questions designed to assess several environmental characteristics, including types of residence, proximity and ease of access to, non-residential land uses, such as restaurants and retail stores, street connectivity, facilities for walking or cycling, neighbourhood aesthetics, traffic and crime safety issues [57].

With the exception of the residential density and non-residential land uses, items were scaled from 1 (strongly disagree) to 4 (strongly agree). Higher scores indicated a more favourable value of the environmental characteristic. Residential density items asked about the frequency of various types of neighbourhood residences, with a response range of 1 (none) to 5 (all). Non-residential land use was assessed by the walking proximity from home to various types of shops and facilities, with responses ranging from 1- to 5-minute walking distance to 31+ minute walking distance.

The Youth NEWS questionnaire was adapted for use in the North East of England and was renamed the Diet, Environment & Physical Activity Survey (DEPA). The questionnaire topics were targeted at the 16-18 year age group in the UK.

American to UK translations were made, some of the questions were removed and a number of new questions added. Socio-economic status was determined from the occupation of the highest earner in the household. Occupations were categorised according to the Standard Occupational Classification 2000 (SOC 2000) [58].

2.2 Pre-testing

Research that relies on self-reported data in surveys assumes that the respondent accurately recalls information and understands the questions and terminology in the same context as the investigator [59]. Cognitive methods were used to pre-test the questionnaire to ensure that questions were clear and comprehensive to the target age-group.

A sample of 11 16-18 year olds (6 male, 5 female) attending a local youth club took part in the pre-testing. They were asked to describe in their own words, what specific questions were asking, and their understanding of particular words or phrases. Participants were also asked whether there were any sections that they felt their peers would have difficulty understanding. Any difficulties in responding were noted.

2.3 Nutritional assessment

A number of questions within the DEPA questionnaire investigate the types of foods choices made however, apart from fruit and vegetables, it does not provide information regarding the frequency of food eaten. To further illustrate the eating habits of adolescents, an adapted version of the EPIC FFQ was used as an additional tool in conjunction with the DEPA survey. The EPIC FFQ was adapted from its original form for use in the Eating and Shopping in Newcastle Study [60]. This instrument will be referred to as the Food Frequency Questionnaire (FFQ).

The FFQ has 134 items and aims to assess diet over the past year. The FFQ asks how often they consume each item from a fixed set of responses, which range from 'never or less than once a month', to 'more than six times per day'. A factor is applied to these responses to produce an estimated mean daily frequency of intake. The mean daily frequency of each item reported by the subjects is then converted to nutrient intakes. Standard UK food composition tables were used to allocate the nutrient composition to each separate food contributing to each of the 134 items of the FFQ (The Supplements to McCance & Widdowson's Composition of Foods [61-69]).

2.4 Data collection and analysis

Interviews were conducted with consenting volunteers from a local sixth form college (Nov 05 – Jan 06). Many sections within the DEPA questionnaire required participants to answer the questions about their local neighbourhood. The term neighbourhood referred to the surrounding or nearby region in which a participant lives and is most active in. This was stated at the beginning of the questionnaire and respondents were asked to 'answer these questions thinking about the house and neighbourhood that you live in most'.

The data from the DEPA survey was manually entered onto an Excel spreadsheet. Information was divided into categories and responses coded. The data was transferred to SPSS Version 12 (SPSS Inc., Surrey England) for analysis. Most data from the DEPA questionnaire was in the form of categorical variables and chi-squared (χ^2) testing was used.

The food data collected from the FFQ was entered onto an ACCESS (Microsoft 2002) database and analysis completed in SPSS. Independent *t*-tests were used to compare the means of two different groups. Nutritional data were checked for normal distribution. Comparisons of reported dietary intakes between groups were carried out using either *t*-tests or, if there were more factors, an analysis of variance (ANOVA). Where appropriate, a Bonferroni post hoc test ($p < 0.05$) was carried out.

3 Results

3.1 Descriptives and demographics

Twenty-five students, (10 male (40%) and 15 female (60%)) mean age 16.8 years, completed both the DEPA questionnaire and the FFQ. All were in full time education, and 64% (n=16) had a part-time job. The majority of the highest wage earners fell into one of two categories 'skilled trades occupations' or 'sales and customer service occupations'. There were no significant differences between the numbers of participant's within each socio-economic classification.

The highest proportion of participants, 44% (n=11), were living in the same postal code area as the school. Other participants were living in four areas around the school and one participant lived approximately 12 miles from the school.

There were no significant differences between the reported main types of housing in the different areas. Respondents stated that the most common types of housing in their neighbourhood's were either terraced houses (36%, n=9) or semi-detached houses (32%, n=8). The majority (80%, n=20) stated there were no flats above 7-10 stories, or tower blocks 11-13 stories, in their neighbourhood.

3.2 Shops, other facilities and school

Respondents were asked to select from one of six categories which best represented the time taken to walk to the nearest shops and recreation places that were listed. There was no significant difference between the areas and the time each respondent perceived that it would take to walk from their home to the nearest shops, public places or recreation facilities.

Corner shops were perceived to be a shorter distance from home, compared to supermarkets ($\chi^2 = 9.48$, $p = 0.05$). Sixty-four percent (n=16) of respondents said that the nearest corner shop was a 1-5 minute walk from home, and 36% (n=9) had a 6-10 minute walk. Only 12% (n=3) of respondents said that there was a supermarket within 1-5 minutes walk from home, 44% (n=11) had to walk 6-10 minutes, 36% (n=9) had to walk 11-20 minutes, 4% (n=1) had to walk 21-30 minutes and 4% (n=1) had over a 31 minute walk to the nearest supermarket.

Forty percent of respondents (n=10) reported that the nearest fast food restaurant was 11-20 minutes walk from their home, and similarly for 44% of respondents the nearest non fast food restaurant (n=11), was also an 11-20 minute walk away.

For most (56%, n=14), the nearest public park was 6-10 minutes walk from home. A similar proportion (52%, n=13) reported that they were never active at a local park, and 24% (n=6) said that they were active there only once a month.

The majority (76%, n=19) of respondents reported that their school was within a 30 minute walk or cycle from their home. Fifty-two percent (n=13) reported that they did walk or cycle there on a regular basis. Respondents disagreed that there was a lack of pavements or cycle lanes (88%, n=22), and crime rate for many (88%, n=22) was not an issue. However, 84% (n=21) of

respondents either 'somewhat agreed' or 'strongly agreed' ((60%, n=15) and 24% (n=6) respectively) that the route was unsafe due to too much traffic. This result did not vary significantly with either postcode or gender.

3.3 Physical activity

The respondents were asked how many days, during a typical week, they were physically active for a total of at least 1 hour per day. Responses varied, with most respondents reporting that there were active for two (24%, n=6) or three (28%, n=7) days per week. The majority of respondents (80%, n=20) chose not to take part in physical education lessons at school. Sixty-four percent of respondents said that they never played any team sports, and 84% (n=21) said that they never took part in any physical activity classes such as dance, tennis, martial arts etc.

Respondents reported that the place that they were active most often was a friend or relative's house, of which 84% (n=21) said that they were active there once a week or more, and 16% (n=4) said that they were active there at least once every other week. Seventy-six percent (n=19) of respondents said that they would usually walk or cycle to get to a friend or relative's house. Another place that the respondents were frequently active was a shopping centre, with 68% (n=17) being active there once a week or more. Only 28% (n=7) of respondents said that they walked or cycled to a shopping centre.

Results showed that respondents were more likely to be active at a gym, with 36% (n=9) active there once a week or more, compared to activity at a leisure centre of which only 8% (n=2) were active there once a week or more. These results were not statistically significant. There was a significant difference between gender and reported activity at a leisure centre ($\chi^2 = 8.76$, $p = 0.033$). Males were active at a leisure centre once or every other week, while females tended to be active there less frequently, typically only once a month. A large proportion of respondents stated that they were never active at a beach, lake or river (64%, n=16), and 76% (n=19) said that they never made use of bike or hiking paths.

The respondents were asked about the availability of items that could be used for physical activity in the home or garden. There was no association between availability of equipment and SES. Only 12% (n=3) said that they did not have access to a bicycle. For the remaining 88% (n=22), half of the respondents (44%, n=11) said that even though a bike was available they never made use of it, and 36% (n=9) only used it once a month or less.

Eighty-four percent (n=21) of respondents had access to sports equipment (rackets, bats and balls) but 44% (n=11) never used them. Forty-four percent (n=11) had access to basketball or netball hoops but 28% (n=7) never used them.

There was a significant gender difference which indicated that females were more likely to have access to the use of exercise or yoga mats than boys ($\chi^2 = 10.00$, $p = 0.040$). However they did not make use of them. Although the results were not statistical significant, there was a pattern between males and the availability of weigh lifting equipment which they used once a week or more ($\chi^2 = 8.819$, $p = 0.066$).

3.4 Sedentary behaviour

Sedentary behaviour varied between weekdays and weekends. On a typical weekday, 44%, (n=11) reported that they watched approximately 2 hours of television. During a typical weekend, 44%, n=11 said that they watched on average 4 hours or more. Ninety-six percent (n=24) of respondents had their own television in their bedroom, and 80% (n=20) had at least one VCR or DVD machine in their bedroom.

The amount of time spent playing on the computer or using the internet was greater during the week, with 40% (n=10) of respondents using the computer for 1 hour on a weekday compared to just 24% (n=6) using the computer for 1 hour at the weekend. Thirty-two percent (n=8) of respondents also reported having a desktop computer with internet access in their bedroom.

Results indicated that there was a significant difference between the amount of time respondents spent doing homework during the week compared to the weekend ($\chi^2 = 15.019$, $p = 0.020$). Forty-four percent (n=11) spent one hour doing homework on a weekday, compared to 32% (n=8) who spent two hours at the weekend.

Results also showed that the amount of time spent talking on the telephone or hanging out with friends and family was significantly different on a weekday and weekend ($\chi^2 = 37.692$, $p =$

0.010). Thirty-two percent (n=8) of respondents spent one hour on this activity on a weekday, compared to 28% (n=7) who spent two hours at the weekend.

3.5 Nutrition results

The DEPA questionnaire asked respondents how many portions of fruit and vegetables they consumed on a typical day. The results varied, with the largest proportion of respondents (44%, n=11) eating only two portions of fruit per day and 40% (n=10) eating only two portions of vegetables per day. There were no significant differences between gender and the portions of fruit and vegetables consumed.

The FFQ data identified that the most frequently consumed drink in this sample was tea, with the average frequency being two cups per day. On average two teaspoons of sugar were added to tea or coffee. Other high frequency drinks included fruit squash and fizzy soft drinks. Packets of crisps and bars of confectionary were consumed on average once a day and white bread frequently consumed.

The majority of respondents said that they did not have to follow any parental rules about their eating patterns. Ninety-two percent (n=23) said that they did not have to have limited portion sizes at meal times, 76% (n=19) said that there fast food intake was not limited, and 92% (n=23) said that they were allowed to watch television while eating. Sixty-eight percent (n=17) of respondents said that they did not have to eat dinner with the family at home and 60% (n=15) said that they did not have to help with meal preparation.

All of the respondents (100%, n=25) reported that there were both food and drink vending machines at their school. The sixth-form common room in which participants were recruited had two vending machines, one selling carbonated drinks and another selling confectionary and crisps. Thirty-two percent (n=8) of respondents said that they never use the food vending machines, and 68% (n=17) use them on at least one day per week or more. Twenty-eight percent (n=7) of respondents never used the drink vending machines, compared to 72% (n=18) that use them at least once a week or more. Results indicated that there are no vending machines at the school which offer only 'healthy' foods or drinks.

Sixty-eight percent (n=17) of respondents never got lunch from the school canteen, while 48% (n=12) said that they never brought packed lunch from home. All respondents were permitted to go off-site at lunch time, of which 28% (n=7) got lunch at a fast food restaurant at least once a week or more, and 64% (n=16) got lunch at a corner shop at least once a week or more.

3.6 Physical activity and nutrition

There was a significant relationship between portions of fruit consumed and levels of activity reported for a typical week. Using an ANOVA test, differences emerged between fruit portion intake and levels of activity in a typical week. Participants who were physically active for at least one hour per day, most days per week, consumed on average more portions of fruit per day, compared to those who were less active ($p = 0.023$).

3.7 Type of food and where food is consumed at lunch time

Nutrient intakes varied depending on the type of food consumed during school lunch times. Thirty-two percent (n=8) of respondents reported that they ate their lunch in the school canteen at least once a week. The maximum number of days that lunch was eaten in the canteen was three days. ANOVA test indicated that there was a significant difference ($p = 0.028$) in the total amount of sugars consumed according to how often participants ate in the school canteen. Intake of total sugars ranged from 196.7g (SE=13.6) when lunch was not eaten in the school canteen, up to 285.6g (SE=0.9) if lunch was eaten in the canteen twice a week.

Fifty-two percent (n=13) of respondents consumed a packed-lunch from home at least once a week. Results indicated that there was a significant difference in the amount of energy ($p = 0.033$), according to how often packed-lunches were eaten. If a packed lunch was consumed only once a week, the mean amount of energy was 14286.6KJ (SE=1502.8), compared with a lower energy intake of 6063.3KJ (SE=2499.7) when a packed lunch was consumed five days per week. A Boneferroni post hoc test also showed that there was a significant difference ($p = 0.038$) between energy intake when a packed lunch was not consumed, compared to when a packed lunch was consumed five days per week.

Significant differences were also found between fat ($p = 0.017$) and percentage of energy from fat ($p = 0.001$) provided, according to how often packed-lunches were eaten. When a packed lunch was consumed only once a week, the mean intake of fat was 137.7g (SE=11.3), and percentage of energy from fat was 35.9% (SE=1.3). This decreased to a fat intake of 45.3g (SE=24.4), and percentage of energy from fat of 25.9% (SE=4.2) when a packed-lunch was consumed five days per week. A Boneferroni post hoc test also showed that there was a significant difference between fat intake ($p = 0.032$) and percentage energy from fat ($p = 0.007$) when a packed lunch was not consumed, compared to when a packed lunch was consumed five days per week.

Twenty-eight percent (n=7) of respondents reported eating their school lunch off-site at a fast food restaurant at least once a week. The maximum number of days per week that respondents ate at a fast food restaurant was four days. Results indicated a significant difference in the amount energy ($p = 0.044$) according to the number of days per week that fast food was consumed. If fast food was consumed once a week, the mean amount of energy was 13027.8KJ (SE=3035.0). This increased to 17977.3KJ (SE=6017.0) energy if fast food was consumed four days per week.

Results also showed that there was a significant difference in the amount of fat ($p = 0.029$) depending on the number of days per week that fast food was consumed. If fast food was consumed once a week, the mean amount of fat was 116.1g (SE=32.3), and this increased to 176.9g (SE=52.5) fat if fast food was consumed four days per week.

4 Discussion

4.1 Main findings of this study

This study has provided a detailed description of young peoples' (16-18 years old) perceptions of their environment, levels of physical activity and dietary intake. The participants attended the same school, however, they lived in a number of different areas.

Significant differences were found between portions of fruit consumed and levels of physical activity. Results indicated that levels of activity were greater in those who consumed more portions of fruit. Intakes of certain nutrients also varied depending on the type of food consumed during school lunch times. Mean intakes of total sugars were greater in those who consumed lunch in the school canteen. Intakes of fat and percentage energy from fat were lower in those who consumed a packed lunch, and level of fat intake increased in those who consumed their lunch off site at a fast food restaurant.

This study has also highlighted that the environment may have an influence on physical activity. Although no significant differences were found in this small sample, common barriers to the local neighbourhood which may have prevented walking or cycling included poor lighting and large volumes of traffic. Important safety features also arose, which included levels of crime and lack of safe locations to leave bicycles. Other characteristics that may be associated with the young people's use of pedestrian environments were also identified, and these included attractive architecture, well maintained pavements and trees lining the streets. The responses indicated that, on the whole, the young people had access to sports equipment and bicycles, but did not necessarily use them.

4.2 Limitations

While the sample size of this study is relatively small, this is the first UK study to explore the interaction between diet, physical activity and the environment in 16-18 year olds. The time scale for completing the study was a limiting factor. It was difficult to recruit and follow-up appointments with this age group, and more time would have allowed for a greater sample size. The participants in the study were largely a homogenous group of white English individuals with very little ethnic variation, however, this was representative of the area in which they lived in.

As the participants lived in different post code areas, and therefore lived in different neighbourhood environments, it is difficult to make comparisons within the sample. As this study has indicated, adolescents do different activities in a variety of locations and may have different perceptions of each environment. Clearer assumptions could have been made if the young people were all from the same area, or if there were an equal number of participants from each area. The study may have been able to draw more concise conclusions if it focussed on the school environment, rather than trying to incorporate the home environment as well.

Although this study provides a description of the environment and its possible relationship with diet and physical activity, it does not directly measure the environment. It used a self-reported questionnaire to measure young people's perceptions of their environment. Individual perceptions of the environment vary, and only fair to low agreement has been demonstrated between self-reports of neighbourhood environments and objective environmental audits [10]. However, perception is a vital factor, and therefore, a future work should include a combination of both perceptions and objective measures.

This study explored micro-environmental settings including the home, school, work place, recreational facilities, restaurants, supermarkets and neighbourhoods, it did not consider the macro environment in great detail. It did, however, explore some aspects of the macro environment including the built environment and transport infrastructure. Other wider features of the environment, such as the media and advertising were not fully taken into account. The FFQ is a self reported tool used in this study to assess dietary intake. This may lead to problems such as over reporting of food consumption, as the FFQ does not allow for variations in portion size [70].

The DEPA questionnaire gave an indication of the adolescents' levels of activity by asking the respondents questions including 'how many days were you physically active for a total of at least 1 hour per day'. However, the use of a questionnaire may not be the most accurate method for analysing physical activity, as it gives reported information rather than measurements.

4.3 What is already known on this topic

Obesity prevention interventions have been mainly educational, behavioural and pharmacological, and so far have shared limited success [12]. The majority of the population need to permanently alter their behaviour in order to prevent obesity [71]. There is an urgent need to create supportive environments to enable young people to make healthy choices and lead more active lifestyles. Although the relationship between the environment and obesity has been acknowledged, environmental strategies to tackle obesity remain undeveloped, and the influence of the environment on this age group is under researched.

4.4 Nutrition and physical activity

This study found that 80% of respondents chose not to take part in Physical Education lessons at school. This finding is not unexpected, as longitudinal studies have reported that the largest decrease in physical activity occurs during the adolescent years [72]. It has been suggested that today's generation of children will be the first for over a century, for whom life expectancy falls [3].

As indicated by previous work [53] the school food environment is not always conductive to healthy food choices. The National Diet and Nutrition Survey (NDNS) [73] examined the diet of British school children aged 4-18 years and found that adolescents consumed more than the recommended level of sugar, salt and saturated fat.

Results from this study found that participants consumed higher amounts of total sugars compared with this national data. The NDNS reported that the average intake of daily total sugars for males aged 15-18 years was 129g, compared to a mean intake of 202g in this sample. The average intake of daily total sugars intake in females aged 15-18 years was 92g compared to a mean intake of 225g in this sample.

Results also indicated that participants in this study had a mean daily energy intake that was much greater compared with national data. Results from the NDNS reported that average daily energy intake for males aged 15-18 years was 9600KJ, compared to a mean daily energy intake of 15263KJ in this sample. The average daily energy intake in females aged 15-18 years was 6820KJ compared to a mean daily energy intake of 13224KJ in this sample.

In this study, nutrients intakes were assessed using the FFQ. The FFQ was relatively straightforward to complete and was useful for large numbers of participants. However, the FFQ tends to over report nutrient intakes [74]. The dietary data from the NDNS were collected using a different method, a 7-day weighed food record. Use of this method has been related to under reporting, and it is also possible that respondents change their usual eating patterns to simplify the record [75].

A US study found fast food restaurants to be concentrated within a short walking distance from schools, thus school children are exposed to poor quality food environments when they are at school [76]. In the DEPA study 48% (n=12) of respondents reported that there was a fast food restaurant within a five minute walking distance from their school. Concentration of fast food

outlets has been investigated in the UK, where a positive association between neighbourhood deprivation and the mean number of McDonald's outlets per person was observed [77].

School children are often exposed to vending machines in their immediate school environment selling soft drinks and confectionary. As found here, the respondents could access two vending machines, none of which offered 'healthy' alternatives. Schools need to actively promote healthy behaviour, foods such as fruit and vegetables need to be made as accessible as the less healthy alternatives. Most of the DEPA sample were not consuming the recommended five portions per day. The young people's fruit and vegetable intake, in this study, was in line with national data of two portions of fruit and vegetables per day [73].

4.5 The environment and physical activity

Obesity is considered to be a multi-factorial disease [10], prevention of obesity, requires an understanding of the populations' eating patterns, their physical activity behaviours, and the determinants of these behaviours [78].

Results from the Health Survey for England [5] reported that 51% of young men, and 28% of young women, aged 16-24 years, were active for at least 30 minutes on 5 or more days per week. This study found that 16% of males, and 12% of females reported being moderately active for at least one hour, on 3 days per week.

Research on the built environment and physical activity has been conducted across several fields such as urban planning, architecture, recreation studies and public health, yet communication has been limited [79]. A review of studies of physical activity and health showed consistent associations of accessibility of recreational facilities and opportunities to be active, with physical activity in adults [39]. The sample size in this study was too small to be able to make clear assumptions regarding this. However, respondents did report that in general there was good access to recreational facilities and various opportunities to be active within their neighbourhood, and yet levels of reported physical activity were generally quite low.

Previous work has indicated that a reduction in time spent in sedentary behaviour, such as television viewing and playing computer games, can have a significant effect on weight loss in adolescents, regardless of increases in levels of physical activity [80]. The majority of respondents in this study spent at least 2 hours on a typical weekday, and 4 hours or more during the weekend, watching television or playing on the computer.

Research has indicated that people are more likely to walk and cycle when their neighbourhoods have a mixture of land use and a higher residential density [44]. Research on obesity and urban housing patterns has reported higher levels of obesity in neighbourhoods where the car is the dominant means of transportation [81]. Findings from this study showed that the adolescents did not report spending a great deal of time travelling in a car, with 64% (n=16) spending less than 30 minutes on a typical week day, and 84% (n=21) spending less than one hour during the weekend sitting in a car. The majority of respondents (76%, n=19) also reported that there was a public transport stop within a five minute walk from their house.

4.6 What this study adds

This is the first UK study which explores the interaction between diet, physical activity and the environment within an adolescent age group. This study provides a starting point for further work and tool development.

Self-reporting and direct observational tools to measure the environment in relation to diet, physical activity and obesity, have been developed in North America and Australia. These tools require piloting and adaptation for use in the U.K. This study adapted an existing questionnaire, 'Youth NEWS', which measures the perceived environment. The UK adapted version, The DEPA questionnaire, will be available on the IPEN website for future work (http://www.ipenproject.org/index.htm).

4.7 Future directions for research

This current study provides sufficient evidence to support the need for further research of the environmental interactions in this age group, which may contribute to the obesogenicity of the environment.

While the focus of this work has been perceptions, future work needs to address the objective measurements of the environment in addition to the perceived environment. Environmental

features can be measured through the use of geographic information systems (GIS) data [79]. An example of this is the Irvine Minnesota Inventory, which is an audit tool that can be used to measure built environment features linked to active living, through in-person observation and objective measurements [79].

The FFQ was used in this study to measure dietary intake, as it was a time efficient and un-intrusive method that could be used with young people. Planned future developments include using accelerometers to record physical activity.

Efforts to tackle obesity should focus on prevention rather than treatment. Findings from this study will be used as a basis for future work which will further explore the environmental impact of nutrition and physical activity.

This study has explored the interaction between eating behaviour, physical activity and the environment. The results, from this pilot, suggest that there may be some relationship and interaction between obesity in adolescence and these factors: the obesogenic environment. While this study provides a description of young peoples' environment, dietary intake, and levels of physical activity, further development is required to fully understand their perceptions of and interaction with the environment.

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