# Associations between the combined physical activity environment, socioeconomic status, and obesity: a cross-sectional study

[1,2]Hobbs, M., [1]Griffiths, C., [3]Green M., [4]Jordan, H., [5]Saunders, J., [1]McKenna, J.

[1]School of Sport, Carnegie, Leeds Beckett University, Leeds, LS6 3QT, UK.
[2] School of Social and Health Sciences, Leeds Trinity University, Leeds, UK.
[3] School of Environmental Sciences, University of Liverpool, Liverpool, UK.
[4] School of Health and Related Research (ScHARR), University of Sheffield, Sheffield, UK.
[5] Carnegie, Leeds Beckett University, Leeds, LS6 3QT, UK formerly, Public Health Team, Rotherham Borough Council.

## Abstract

**Aims:** This study investigates associations between the combined PA environment and obesity and explores any sub-group effects by individual-level socioeconomic status.

**Methods:** In a large cross-sectional cohort (n=22,889) from the Yorkshire Health Study, body mass index (BMI) was calculated using self-reported height and weight and obesity was defined as a BMI≥30. The PA environment was split into “unfavourable PA”, “moderately favourable PA” and, “favourable PA” environments. This was based on the count of parks and PA facilities within a 2km radial buffer cantered on home addresses. A favourable PA environment was defined as having ≥1 PA facility and ≥1 park, unfavourable as having no PA facility and park and any other combinations, defined as moderately favourable. Logistic regression (odds ratios (OR)) identified associations with obesity.

**Results:** Relative to “Unfavourable PA environments”, individuals within favourable PA environments were less likely to be obese (OR=0.90; 95%CI 0.82-0.97) yet there was no effect for moderately favourable environment. Furthermore, once stratified by education level, this relationship was only present for those of higher education.

**Conclusion:** Our findings provide novel UK evidence and is one of the first papers internationally that highlights the importance of considering the interplay of individual-level socioeconomic factors when investigating associations between the PA environment and obesity.

**Key words:** obesogenic environment; obesity; physical activity; parks;

**Acknowledgements**:
We acknowledge the Ordnance Survey who provided the Points of Interest dataset for the PA environment. We would also like to acknowledge that The Yorkshire Health Study was funded by the NIHR Collaboration for Leadership in Applied Health Research and Care Yorkshire and Humber (NIHR CLAHRC YH). www.clahrc-yh.nihr.ac.uk. The views and opinions expressed are those of the author(s), and not necessarily those of the NHS, the NIHR or the Department of Health.

**Corresponding author**:
Matthew Hobbs
Email: m.hobbs@leedstrinity.ac.uk
Leeds Trinity University, LS18 5HD, Leeds, England.

Elevated obesity prevalence remains a global public health priority due to its association with chronic diseases (1). While genetic factors may predispose obesity susceptibility, the rapid increase in prevalence suggests environmental influences may be important (1). Environmental influences can relate to what is available within the local physical activity (PA) environment, for instance, how many parks are available. Importantly, PA environments with a greater availability of such features are hypothesised to promote PA and thus a healthy weight. However, consistent associations in terms of both scale and direction remain elusive (2). For example, a longitudinal study within the Netherlands demonstrated that increased green space within 125m of the home, was associated with increased odds of obesity (OR=1.04_95% CI_1.01-1.07) (3).

Accounting for the co-location of features, by measuring both park and PA facility availability together may better represent environmental influences on obesity. Unfavourable PA environments may lack both PA facilities and parks. Furthermore, in developed countries, obesity prevalence is often lower in those of higher socioeconomic status, relative to those of lower socioeconomic status (1). It is therefore plausible that any effect of an unfavourable environment may be amplified by lower socioeconomic status. This study will investigate associations between the combined PA environment and obesity, and explore if associations differ by socioeconomic status.

Cross-sectional data were obtained from wave one [2010-2012] of the Yorkshire Health Study (YHS) as outlined previously in detail (4). Briefly, 27,806 individuals (18-86 years) provided data from the Yorkshire and Humber region, England. Participants were over-representative of older adults, females, and non-white ethnicities relative to the actual population (4). Ethical clearance was granted in 2013 by the Carnegie Faculty Ethics, Leeds Beckett University.

Body mass index (BMI) was calculated using self-reported height (cm) and weight (kg); obesity=BMI≥30. Postcode, ethnicity (white/non-white), gender (male/female) education-level (low=none, moderate=school, college and other, or high=university) and area-level deprivation (Index of Multiple Deprivation 2010) were also provided. IMD 2010 provides a multidimensional measure of area-level deprivation based on income; employment; health and disability; education, skills, and training; crime; barriers to housing and services; living environment.

Data on the PA environment temporally matched (2013) individual-level data. The Ordnance Survey (OS), a national mapping agency provided PA facility locations (easting, northing). The Point of Interest (PoI) dataset is suggested as an accurate source of secondary data (5). Classifications were defined based on 18 proprietary classifications related to PA i.e. "Athletics Facilities". Supplement 2 and 3 provide a full breakdown of classifications used in accordance with the Geo-FERN reporting framework (6). Parks were sourced in 2013 from Open Street Map and defined as an open, green area for recreation typically open to the public that is in a town or city.

To define availability, home addresses were geocoded based on postcode zone centroids. Neighbourhood was then defined centred on geocoded home postcodes as a 2km radial buffer. This gives an approximate measure of availability by car and previous analyses on the same sample have shown little difference in associations when using 1600m radial buffers which may better reflect availability when walking (7). PA facilities and park boundaries that were within or overlapped each 2km buffer were then counted using a point in polygon analysis in ArcGIS V10.2.2 (ESRI Inc., Redlands, CA). Thresholds for defining combined PA environments were deduced based on the count of PA facilities and parks within home neighbourhoods. An environment “Favourable for PA” was defined as having ≥1 PA facility and ≥1 park, “Unfavourable for PA” was defined as having no PA facility and no park. Other combinations, for instance if only parks or PA facilities were available, were then defined as “Moderately favourable for PA”.

Adults living within the study area with complete data were included which resulted in 22,889 participants used for analysis. Supplementary Material 1 details the high statistical power in the dataset and justifies the assumption that data were missing at random. Binary logistic regression (odds ratios (OR) and 95% CI) with “Unfavourable PA environments” as the reference category estimated associations with obesity. Age, gender, ethnicity, education-level, and IMD were included in all analyses as covariates and sub-group effects were explored by education category. All statistical analysis was performed using STATA IC V14.

Overall, 5,055 participants (22.1%) resided within an environment defined as “Unfavourable for PA”, 7,300 (31.9%) within “Favourable for PA” environments, and 10,534 (46.0%) within “Moderately favourable for PA” environments. Relative to residing within an environment “Unfavourable for PA”, residing within a “Moderately favourable for PA” environment was unrelated to obesity (OR=0.92 [95% CI 0.84, 1.00]). However, residing within a “Favourable for PA” environment was associated with lower odds of obesity (OR=0.90, [0.82, 0.97]) (Figure 1A). When examined by socioeconomic status, there was no substantive association with obesity for those classified as low- or moderate-education, relative to those residing within an unfavourable PA environment and low-education. For those classified as highly educated, residing within a “Favourable for PA” environment was associated with lower odds of obesity (Figure 1B).

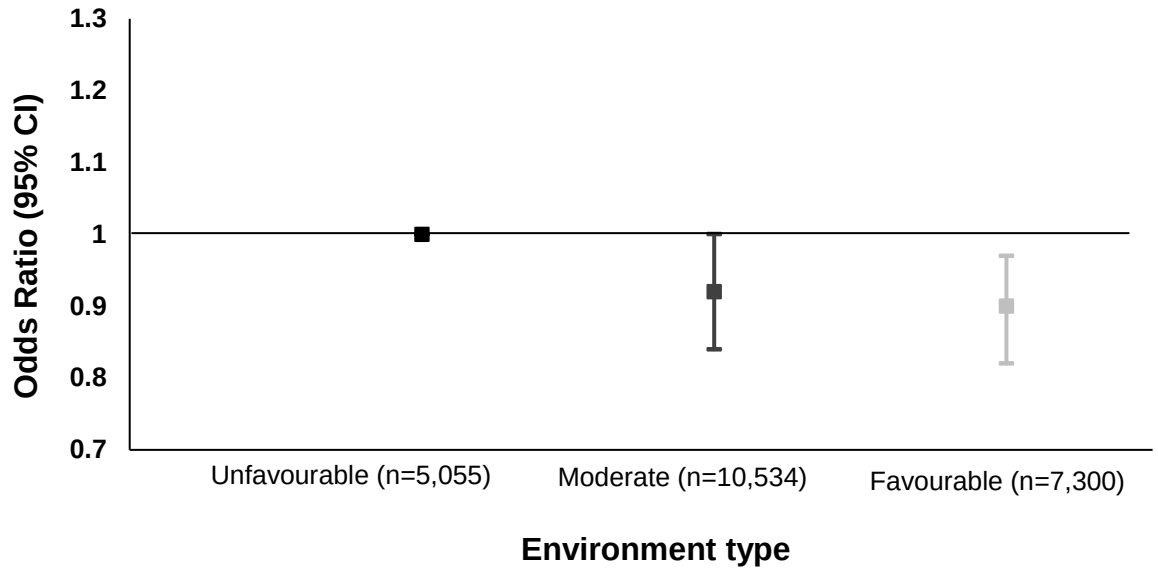


**Figure 1A** - Likelihood of obesity relative to those individuals residing within unfavourable environments

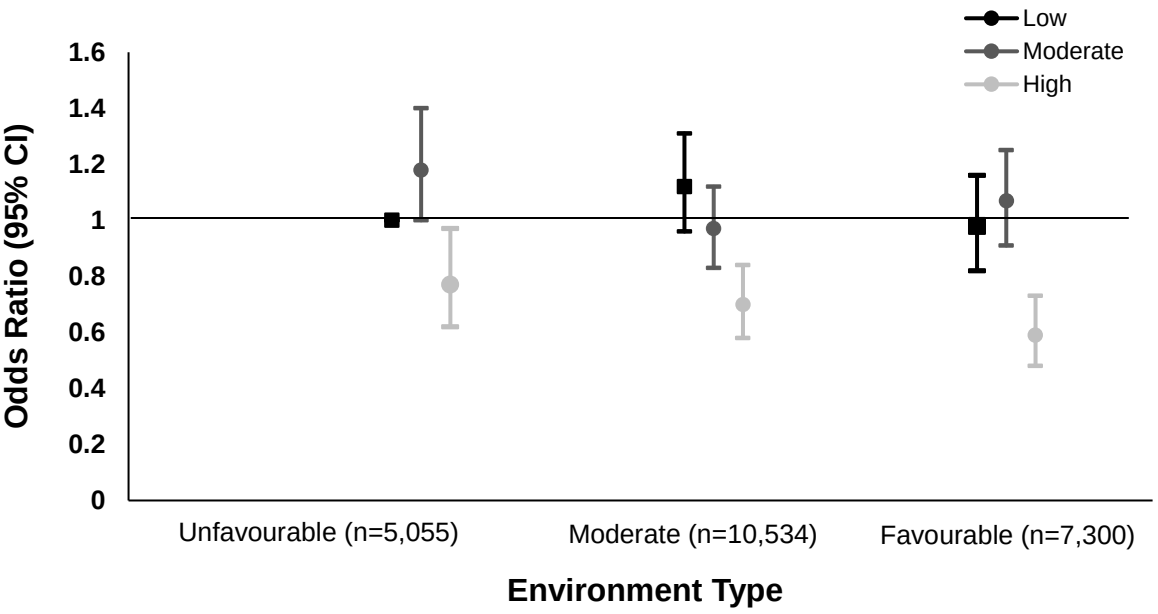


**Figure 1B** – Interaction between the favourability of PA environments education level (low, moderate and highly educated) and likelihood of obesity (OR [95% CI])

This study contributes to evidence by examining associations between the combined PA environment and obesity in large UK dataset. Environments that include places to be active are hypothesised to promote PA and help control weight and our overall finding was that residing within a home neighbourhood classified as "Favourable for PA" was related to lower odds of obesity. It also contributes significantly to evidence by investigating any differences by socioeconomic status. However, when examined by socioeconomic status, lower odds of obesity were only present for those classified as highly educated.

Consistent associations between the PA environment and obesity continue to be elusive however, few studies use a combined measure of the PA environment (2). Parks and PA facilities combined may also be a particularly influential combination of factors within the PA environment that uncover meaningful associations with obesity. In two notable studies that have considered associations between the combined PA environment and BMI, both found substantively no association (8, 9). Research in Paris used cluster analyses based on green spaces, proximity to facilities such as drugstores or bookstores and the availability of cycle paths (8). Similarly, US research using latent profile analysis split environments into unfavourable, moderate, and favourable PA environments based on walkability, transit, and recreation PA (9). In both studies, although associations with PA outcomes were demonstrated, these environments were unrelated to BMI. In contrast to the current study, different definitions of neighbourhood, secondary environmental data and/or extraction methods, may have contributed to the disparities in associations relative to the findings within this study (6).

Despite this overall effect, little research investigates the interplay between individual-level socioeconomic status, PA environments and obesity (10). While overall, favourable PA environments were associated with lower odds of obesity, once stratified by education-level, this relationship was present for the higher education category. Furthermore, there was no difference in odds of obesity by PA environment within educational groups. These findings suggest that an effect of the PA environment on risk of obesity may instead be detecting residual confounding through socioeconomic status. For example, it is plausible that selection bias may be operating where individuals of higher socioeconomic status are more likely to reside within favourable PA environments. This is therefore driving any associations for PA environments as opposed to the environments having a direct influence themselves (10).

Findings should be interpreted considering this study's strengths and weaknesses. First, data were cross-sectional, availability for individuals across their life course may be more influential, and self-selection bias where individuals self-select into environments cannot be ruled out (10). Second, this study's definition of neighbourhood is subject to the uncertain geographic context problem where it is assumed that participants use parks and PA facilities within 2km of their home. Third, although research suggests that POI is an accurate source of environmental data this was only focused on food environment and in one geographical area (5). Fourth, participants in the YHS were over-representative of older adults, females, and non-white ethnicities relative to the actual population (4). Finally, our definition of a combined environment was limited, as we only used two markers of the PA environment. In future research, this could include other aspects such as the quality of the PA environment.

In conclusion, this study used a large and unique UK dataset, containing both individual-level socioeconomic data, and an innovative combined measure of the favourability of a PA neighbourhood to examine associations with obesity. The overall finding supports initiatives currently being considered by planning officers, public health, and local governments to create healthy physical environments with places to be active, for instance maintaining sufficient park availability. Despite this, once stratified by education-level, this relationship was present only for those of higher education. Our results provide novel UK evidence and is one of the first papers internationally that highlights the importance of considering the interplay of individual-level socioeconomic status when investigating associations between the PA environment and obesity.

**Funding**: None
**Competing interests**: None
**Ethical approval**: Approved by Leeds Beckett University Research Ethics.
**Authorship**: all authors made a significant contribution to this paper.

## References


1. Roberto CA, Swinburn B, Hawkes C, Huang TTK, Costa SA, Ashe M, et al. Patchy progress on obesity prevention: emerging examples, entrenched barriers, and new thinking. The Lancet. 2015.
2. Mackenbach JD, Rutter H, Compernolle S, Glonti K, Oppert J-M, Charreire H, et al. Obesogenic environments: a systematic review of the association between the physical environment and adult weight status, the SPOTLIGHT project. BMC Public Health. 2014;14(1):233.
3. Picavet HSJ, Milder I, Kruize H, de Vries S, Hermans T, Wendel-Vos W. Greener living environment healthier people?: Exploring green space, physical activity and health in the Doetinchem Cohort Study. Preventive Medicine. 2016;89:7-14.
4. Green M, Li J, Relton C, Strong M, Kearns B, Wu M, et al. Cohort Profile: The Yorkshire Health Study. International Journal of Epidemiology. 2014:doi: 10.1093/ije/dyu121.
5. Burgoine T, Harrison F. Comparing the accuracy of two secondary food environment data sources in the UK across socio-economic and urban/rural divides. International Journal of Health Geographics. 2013;12:2.
6. Wilkins EL, Morris MA, Radley D, Griffiths C. Using Geographic Information Systems to measure retail food environments: Discussion of methodological considerations and a proposed reporting checklist (Geo-FERN). Health & place. 2017;44:110-7.
7. Hobbs M, Green M, Griffiths C, Jordan H, Saunders J, McKenna J. How different data sources and definitions of neighbourhood influence the association between food outlet availability and body mass index: a cross-sectional study. Perspect Public Health. 2017;137(3):158-61.
8. Charreire H, Weber C, Chaix B, Salze P, Casey R, Banos A, et al. Identifying built environmental patterns using cluster analysis and GIS: Relationships with walking, cycling and body mass index in French adults. International Journal of Behavioral Nutrition and Physical Activity. 2012;9(1):59.
9. Todd M, Adams MA, Kurka J, Conway TL, Cain KL, Buman MP, et al. GIS-measured walkability, transit, and recreation environments in relation to older Adults' physical activity: A latent profile analysis. Prev Med. 2016;93:57-63.
10. Boone-Heinonen J, Gordon-Larsen P, Guilkey DK, Jacobs DR, Popkin BM. Environment and physical activity dynamics: The role of residential self-selection. Psychol Sport Exerc. 2011;12.