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1 **Associations between the combined physical activity environment, socioeconomic status, and**
2 **obesity: a cross-sectional study**
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4 [1,2]Hobbs, M., [1]Griffiths, C., [3]Green M., [4]Jordan, H., [5]Saunders, J., [1]McKenna, J.
5
6 [1]School of Sport, Carnegie, Leeds Beckett University, Leeds, LS6 3QT, UK.
7 [2] School of Social and Health Sciences, Leeds Trinity University, Leeds, UK.
8 [3] School of Environmental Sciences, University of Liverpool, Liverpool, UK.
9 [4] School of Health and Related Research (ScHARR), University of Sheffield, Sheffield, UK.
10 [5] Carnegie, Leeds Beckett University, Leeds, LS6 3QT, UK formerly, Public Health Team, Rotherham
11 Borough Council.
12
13 **Abstract**
14
15 **Aims:** This study investigates associations between the combined PA environment and obesity and
16 explores any sub-group effects by individual-level socioeconomic status.
17
18 **Methods:** In a large cross-sectional cohort (n=22,889) from the Yorkshire Health Study, body mass
19 index (BMI) was calculated using self-reported height and weight and obesity was defined as a BMI≥30.
20 The PA environment was split into "unfavourable PA", "moderately favourable PA" and, "favourable PA"
21 environments. This was based on the count of parks and PA facilities within a 2km radial buffer cantered
22 on home addresses. A favourable PA environment was defined as having ≥1 PA facility and ≥1 park,
23 unfavourable as having no PA facility and park and any other combinations, defined as moderately
24 favourable. Logistic regression (odds ratios (OR)) identified associations with obesity.
25
26 **Results:** Relative to "Unfavourable PA environments", individuals within favourable PA environments
27 were less likely to be obese (OR=0.90; 95%CI 0.82-0.97) yet there was no effect for moderately
28 favourable environment. Furthermore, once stratified by education level, this relationship was only
29 present for those of higher education.
30
31 **Conclusion:** Our findings provide novel UK evidence and is one of the first papers internationally that
32 highlights the importance of considering the interplay of individual-level socioeconomic factors when
33 investigating associations between the PA environment and obesity.
34
35 **Key words:** obesogenic environment; obesity; physical activity; parks;
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44 **Corresponding author**:
45 Matthew Hobbs
46 Email: m.hobbs@leedstrinity.ac.uk
47 Leeds Trinity University, LS18 5HD, Leeds, England.

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

57
58 Accounting for the co-location of features, by measuring both park and PA facility availability together
59 may better represent environmental influences on obesity. Unfavourable PA environments may lack
60 both PA facilities and parks. Furthermore, in developed countries, obesity prevalence is often lower in
61 those of higher socioeconomic status, relative to those of lower socioeconomic status (1). It is therefore
62 plausible that any effect of an unfavourable environment may be amplified by lower socioeconomic
63 status. This study will investigate associations between the combined PA environment and obesity, and
64 explore if associations differ by socioeconomic status.

65
66 Cross-sectional data were obtained from wave one [2010-2012] of the Yorkshire Health Study (YHS)
67 as outlined previously in detail (4). Briefly, 27,806 individuals (18-86 years) provided data from the
68 Yorkshire and Humber region, England. Participants were over-representative of older adults, females,
69 and non-white ethnicities relative to the actual population (4). Ethical clearance was granted in 2013 by
70 the Carnegie Faculty Ethics, Leeds Beckett University.

71
72 Body mass index (BMI) was calculated using self-reported height (cm) and weight (kg);
73 obesity=BMI≥30. Postcode, ethnicity (white/non-white), gender (male/female) education-level
74 (low=none, moderate=school, college and other, or high=university) and area-level deprivation (Index
75 of Multiple Deprivation 2010) were also provided. IMD 2010 provides a multidimensional measure of
76 area-level deprivation based on income; employment; health and disability; education, skills, and
77 training; crime; barriers to housing and services; living environment.

78
79 Data on the PA environment temporally matched (2013) individual-level data. The Ordnance Survey
80 (OS), a national mapping agency provided PA facility locations (easting, northing). The Point of Interest
81 (PoI) dataset is suggested as an accurate source of secondary data (5). Classifications were defined
82 based on 18 proprietary classifications related to PA i.e. "Athletics Facilities". Supplement 2 and 3
83 provide a full breakdown of classifications used in accordance with the Geo-FERN reporting framework
84 (6). Parks were sourced in 2013 from Open Street Map and defined as an open, green area for
85 recreation typically open to the public that is in a town or city.

86
87 To define availability, home addresses were geocoded based on postcode zone centroids.
88 Neighbourhood was then defined centred on geocoded home postcodes as a 2km radial buffer. This
89 gives an approximate measure of availability by car and previous analyses on the same sample have
90 shown little difference in associations when using 1600m radial buffers which may better reflect
91 availability when walking (7). PA facilities and park boundaries that were within or overlapped each 2km
92 buffer were then counted using a point in polygon analysis in ArcGIS V10.2.2 (ESRI Inc., Redlands,
93 CA). Thresholds for defining combined PA environments were deduced based on the count of PA
94 facilities and parks within home neighbourhoods. An environment "Favourable for PA" was defined as
95 having ≥1 PA facility and ≥1 park, "Unfavourable for PA" was defined as having no PA facility and no
96 park. Other combinations, for instance if only parks or PA facilities were available, were then defined
97 as "Moderately favourable for PA".

98
99 Adults living within the study area with complete data were included which resulted in 22,889
100 participants used for analysis. Supplementary Material 1 details the high statistical power in the dataset
101 and justifies the assumption that data were missing at random. Binary logistic regression (odds ratios
102 (OR) and 95% CI) with "Unfavourable PA environments" as the reference category estimated
103 associations with obesity. Age, gender, ethnicity, education-level, and IMD were included in all analyses
104 as covariates and sub-group effects were explored by education category. All statistical analysis was
105 performed using STATA IC V14.

106

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).
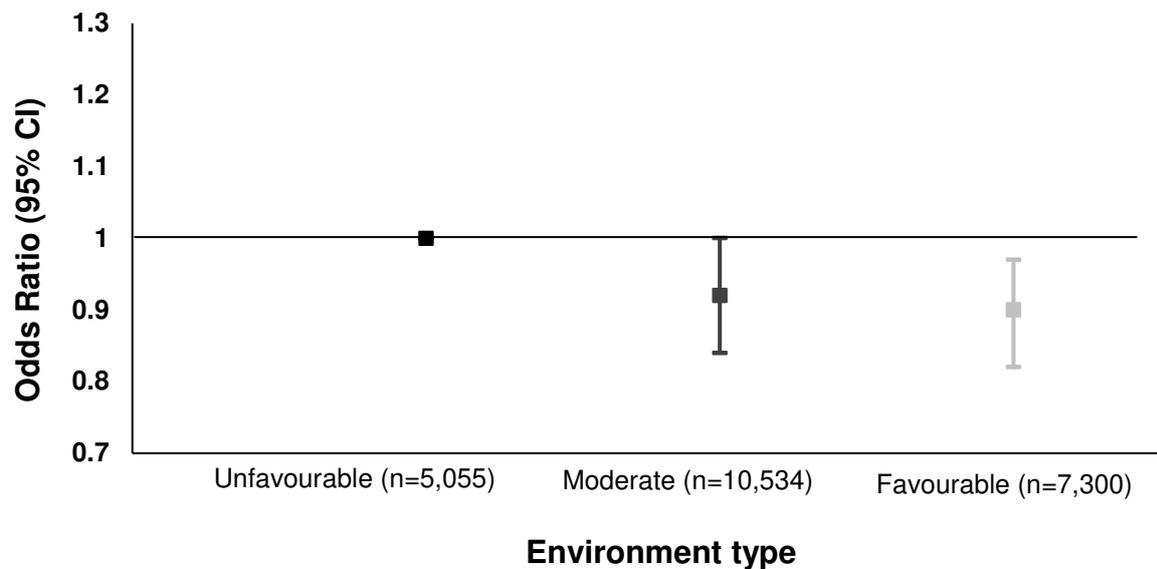
Figure 1A - Likelihood of obesity relative to those individuals residing within unfavourable environments
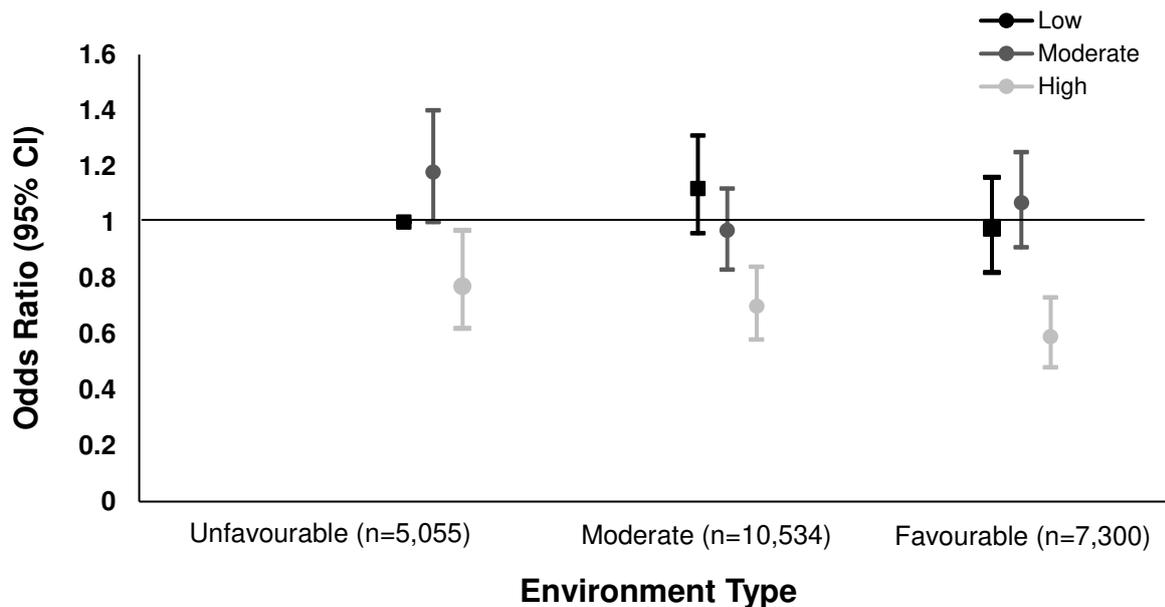
Figure 1B – Interaction between the favourability of PA environments education level (low, moderate and highly educated) and likelihood of obesity (OR [95% CI])

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

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

147 Despite this overall effect, little research investigates the interplay between individual-level
148 socioeconomic status, PA environments and obesity (10). While overall, favourable PA environments
149 were associated with lower odds of obesity, once stratified by education-level, this relationship was
150 present for the higher education category. Furthermore, there was no difference in odds of obesity by
151 PA environment within educational groups. These findings suggest that an effect of the PA environment
152 on risk of obesity may instead be detecting residual confounding through socioeconomic status. For
153 example, it is plausible that selection bias may be operating where individuals of higher socioeconomic
154 status are more likely to reside within favourable PA environments. This is therefore driving any
155 associations for PA environments as opposed to the environments having a direct influence themselves
156 (10).

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

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

184 **References**
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186 1.   Roberto CA, Swinburn B, Hawkes C, Huang TTK, Costa SA, Ashe M, et al. Patchy progress
187 on obesity prevention: emerging examples, entrenched barriers, and new thinking. The Lancet. 2015.
188 2.   Mackenbach JD, Rutter H, Compernolle S, Glonti K, Oppert J-M, Charreire H, et al.
189 Obesogenic environments: a systematic review of the association between the physical environment
190 and adult weight status, the SPOTLIGHT project. BMC Public Health. 2014;14(1):233.
191 3.   Picavet HSJ, Milder I, Kruize H, de Vries S, Hermans T, Wendel-Vos W. Greener living
192 environment healthier people?: Exploring green space, physical activity and health in the Doetinchem
193 Cohort Study. Preventive Medicine. 2016;89:7-14.
194 4.   Green M, Li J, Relton C, Strong M, Kearns B, Wu M, et al. Cohort Profile: The Yorkshire
195 Health Study. International Journal of Epidemiology. 2014:doi: 10.1093/ije/dyu121.
196 5.   Burgoine T, Harrison F. Comparing the accuracy of two secondary food environment data
197 sources in the UK across socio-economic and urban/rural divides. International Journal of Health
198 Geographics. 2013;12:2.
199 6.   Wilkins EL, Morris MA, Radley D, Griffiths C. Using Geographic Information Systems to
200 measure retail food environments: Discussion of methodological considerations and a proposed
201 reporting checklist (Geo-FERN). Health & place. 2017;44:110-7.
202 7.   Hobbs M, Green M, Griffiths C, Jordan H, Saunders J, McKenna J. How different data
203 sources and definitions of neighbourhood influence the association between food outlet availability
204 and body mass index: a cross-sectional study. Perspect Public Health. 2017;137(3):158-61.
205 8.   Charreire H, Weber C, Chaix B, Salze P, Casey R, Banos A, et al. Identifying built
206 environmental patterns using cluster analysis and GIS: Relationships with walking, cycling and body
207 mass index in French adults. International Journal of Behavioral Nutrition and Physical Activity.
208 2012;9(1):59.
209 9.   Todd M, Adams MA, Kurka J, Conway TL, Cain KL, Buman MP, et al. GIS-measured
210 walkability, transit, and recreation environments in relation to older Adults' physical activity: A latent
211 profile analysis. Prev Med. 2016;93:57-63.
212 10.   Boone-Heinonen J, Gordon-Larsen P, Guilkey DK, Jacobs DR, Popkin BM. Environment and
213 physical activity dynamics: The role of residential self-selection. Psychol Sport Exerc. 2011;12.

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