Associations between school and neighbourhood ethnic density and physical activity in adolescents: evidence from the Olympic Regeneration in East London (ORiEL) study

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Abstract

While most adolescents do not achieve the recommended level of physical activity in the UK, the risk of physical inactivity varies across ethnic groups. We investigated whether own-group school and neighbourhood ethnic density can explain ethnic differences in adolescent physical activity. We used longitudinal data from the Olympic Regeneration in East London (ORiEL) study. In 2012, 3,106 adolescents aged 11-12 were recruited from 25 schools in East London, UK. Adolescents were followed-up in 2013 and 2014. Own-group ethnic density was measured in 2012-2014 at school-level and in 2011 at neighbourhood-level, and calculated as the percentage of pupils/residents who were of the same ethnic group. Analyses were restricted to White British (n=382), White Mixed (n=190), Bangladeshi (n=337), and Black African groups (n=251). We estimated adjusted logistic regression models with generalised estimating equations for self-reported walking to school, walking for leisure, and outdoor physical activity. At school-level, there was consistent evidence that own-group ethnic density amplifies ethnic differences in walking to school. For each 10 percentage point increase in own-group ethnic density, there was evidence of increased probability of walking to school in Bangladeshi adolescents (OR=1.20; 95% CI 1.09-1.31) and decreased probability of walking to school in Black African (OR=0.58; 95% CI 0.45-0.75) and White Mixed adolescents (OR=0.51; 95%CI 0.35-0.76). Associations with walking for leisure and outdoor physical activity were in expected directions but not consistently observed in all ethnic groups. At neighbourhood-level, evidence was more restricted. Amplification of ethnic differences was found for walking to school in Bangladeshi adolescents (OR=1.31; 95% CI 1.14-1.51) and for outdoor physical activity in White British adolescents (OR=0.85; 95% CI 0.76-0.94). Our results suggest that own-group ethnic density contributes to explaining differences in physical activity by amplifying ethnic differences in some forms of physical activity.

Keywords

ethnicity; race; ethnic density; place; health behaviour; walking; England; UK

Introduction

Most adolescents do not achieve the recommended level of physical activity in the UK (Health and Social Care Information Centre, 2017). Recent research, although limited, suggests that differences exist in children's activity levels between ethnic groups in the UK. For example, data from the Child Heart and Health Study in England and the Millennium Cohort Study show that South Asian children were less active than the European White and Black African-Caribbean children (Griffiths et al., 2013; Owen et al., 2009). One of the very few studies investigating ethnic differences by type of activity reported that White European children were more likely to walk or cycle to school than ethnic minority groups (Owen et al., 2012).

One explanation for ethnic differences in physical activity behaviour is ethnic-specific attitudes to different types of activities. Different ethnic groups might have differing norms with respect to socially acceptable health behaviours and activities, such as walking to school and playing outside (Bécares et al., 2011). These ethnic differences in physical activity norms might be reinforced for people living in areas with higher proportions of people of the same ethnicity, that is, areas with higher own-group ethnic density. Ethnic density has been hypothesised to influence other health behaviours by increasing civic engagement, increasing social capital and social support, and reducing exposure to racism and discrimination (Bécares and Nazroo, 2013; Shaw et al., 2012). A handful of studies have investigated associations between ethnic density and health behaviours in the UK, finding some protective effect for alcohol consumption in ethnic minorities (Bécares et al., 2011), and differential effects for smoking, which appear to vary depending on the prevalence of smoking in the ethnic group in question (Mathur et al., 2017).

However, empirical research on other health behaviours remains limited. There are very few studies that have investigated the association between ethnic density and physical activity, and none in UK adolescents. Exploring the ethnic density hypothesis in adolescent health behaviours may help shed light on the relative importance of ethnic density in the residential and school settings (Astell-Burt et al., 2012). Teasing out the independent contributions of neighbourhood deprivation and ethnic density also remains an issue, given the correlation between the processes of ethnic and economic segregations (Karlsen and Nazroo, 2002). Focusing on homogeneously deprived but ethnically diverse areas might help better capture the ethnic density 'effect' itself (Uphoff et al., 2016).

In this study we undertook a longitudinal analysis of a deprived adolescent population to address whether exposure to higher own-group density would be associated with physical activity, after adjusting for a number of potential confounders. Effects in residential and school settings were examined for four ethnic groups – White British, White Mixed, Bangladeshi and Black African – and for three physical activity outcomes – walking to school, walking for leisure and outdoor physical activity.

Methods

Study design and participants

We analysed data from the ORiEL study, a prospective cohort study, a prospective cohort study aimed at assessing the health impact of urban regeneration following the London 2012 Olympic and Paralympic Games. Participants were recruited from 25 schools in four London boroughs: Tower Hamlets, Hackney, Barking and Dagenham, and Newham. The boroughs have highly ethnically diverse populations and higher levels of social, economic and environmental deprivation than the England average (McLennan et al., 2011; Office for National Statistics, 2013). Six schools per borough in Newham, Hackney and Barking & Dagenham, and seven schools in Tower Hamlets were selected using simple randomisation with refusals replaced by eligible schools from the same borough. Special-needs schools, pupil referral units and independent schools were excluded from the sampling frame. The sample consisted of both single and mixed-sex faith and non-denominational schools. Faith schools were affiliated to a range of religious denominations. Full details on study recruitment and data collection are described elsewhere (Smith et al., 2012).

The participants, in year 7 at baseline (age 11-12 years: Jan-June 2012), were first followed-up in year 8 (wave 2, age 12-13 years: Jan-June 2013) and again in year 9 (wave 3, age 13-14 years: Jan-June 2014). Timing of follow-up for each school was matched by month to reduce seasonality effects. The longitudinal cohort comprised 2,260 adolescents who participated in all three waves, representing an overall retention rate of 73% (Figure 1).

Measures

Ethnicity

Ethnicity was assessed by asking participants: "Which ONE category best describes you - this is your race or ethnic group?", with 24 pre-defined categories available for selection. The question was adapted from the 2011 Census for England and Wales (Office for National Statistics, 2013). If the relevant category was not available respondents could write in free text their self-identified race/ethnicity. Due to statistical power issues, only the four largest ethnic groups were included in the analyses: "White British" (n=382), "White Mixed" (White and any other background; n=190), "Bangladeshi" (n=337) and "Black African" (n=251) (Figure 1).

Own-group ethnic density exposures

Ethnic density in school and residential settings were computed for each ethnic group and assigned to adolescents based on their self-reported ethnicity. The data sources used definitions of ethnicity compatible with the one used in this study. School-level prevalence of each ethnic group (i.e. ethnic density) was calculated in participating schools using ethnicity statistics from the Department for Education for the period 2012-2014 (Department for Education, 2014). Neighbourhood-level ethnic density was measured at the lower layer super output area (LSOA) using ethnic composition data from the 2011 UK Census Population. The LSOA has been suggested to be the best administrative area with available routine data to characterise ethnic density effects (Stafford et al., 2009). LSOA data were geo-coded to the home-address of the participants for each of the waves. Amongst adolescents belonging to one of the four main ethnic groups who reported a home address, some moved primary place of residence. As a result, 5.2% changed LSOA at wave 2, and another 5.9% changed LSOA wave 3. The neighbourhood-level ethnic density variable is therefore time-varying to account for changes in exposure due to residential mobility. Exposure variables were treated as continuous in the analyses, in the absence of established cut-off values in the literature (Shaw et al., 2012).

Physical activity outcomes

Physical activity was assessed using the Youth Activity Questionnaire (Y-PAQ). Y-PAQ is a validated self-reported tool that captures the frequency and duration of a range of physical and sedentary activities over the past 7 days (Corder et al., 2009). Three forms of physical activity expected to be differentially associated with the exposure variables were computed: walking to school, walking for leisure and outdoor physical activity. Outdoor physical activity aims to group physical activities that are mainly performed in open recreation areas such as parks, sport fields and other open spaces, which are usually located in the residential neighbourhood of the adolescents (D'Haese et al., 2015; Esteban-Cornejo et al., 2016). It combines basketball/volleyball (with the expectation that basketball is mainly reported in an outdoor court), (roller)blading, cricket, football, rounders, rugby and roller skating. Running was not included due to under-reporting which reflects that the activity was likely to have been understood as 'running around' by adolescents and not understood as a formal sporting activity. Owing to their non-normal distributions and to the fact that no adequate transformation could be found, the three outcome variables measuring forms of physical activity were dichotomised (e.g. activity reported at least once vs. not).

Covariates

Potential confounders available at baseline and for both follow-up surveys were identified a priori from existing literature. They were included in adjusted models if there was evidence of associations with physical activity and ethnic density. Gender; time lived in neighbourhood (≤ 5 years vs. > 5);

household composition (both parents vs. none); family affluence score from the revised Family Affluence Scale II (low=0-2; medium=3-5; high=6-9) (Boyce et al. 2006); free-school meal status at baseline; health condition (none vs. 1+); and distance to school (for walking to school only) were selected. Country of birth was not associated with any of the physical activity outcomes and therefore omitted from analyses. Unlike previous studies, we were unable to adjust for area of deprivation because the study population was homogeneously deprived: 87% of adolescents' residential LSOAs were classified below the 1st quintile of the Income Deprivation Affecting Children Index (IDACI) and 98% were below the 1st or 2nd quintiles. The full ORiEL questionnaire is available elsewhere (Cummins et al., 2018).

Statistical analyses

Prevalence of missing data for the outcomes and covariates were examined; missing values ranged from 0.0% to 13.7%. We explored both predictors of the probability of missingness and predictors partially observed variables through logistic regression modelling. Analyses suggested that data were not missing completely at random and that the missing at random assumption was plausible. Data were imputed using multilevel multiple imputation with the 'jomo' package in R, which uses a joint multivariate normal modelling approach through the Markov Chain Monte Carlo method (Quartagno et al., 2018). We imputed with 2 levels (first, adolescent; second, school) with all the outcomes and covariates as fixed effects using the data in the wide format, so that each measurement occasion was represented by a separate variable. Interaction terms between ethnicity and the ethnic density variables were handled by imputing the data separately for each ethnic group. The imputation model was chosen to be compatible with the most saturated model of interest; auxiliary variables were included to strengthen the missing at random assumption (Carpenter and Kenward, 2012). We used a 'burn in' period of 35,050 iterations and 5,000 between-imputation iterations to produce 20 imputed datasets. The Markov Chain Monte Carlo chains were examined to check for convergence.

Unadjusted and adjusted logistic regression models were estimated using generalised estimating equations (GEE) in Stata 15 with the command “mi estimate: xtgee”. GEE methods were used to account for the hierarchical structure of the data at individual level (measurements nested within individuals), and have a convenient population-average interpretation of the parameters (Fitzmaurice et al., 2011). We were unable to specifically examine the effect of within-individual changes in ethnic density because of the restricted extent of change in residential LSOA over the study period. Preliminary analyses indicated no evidence of clustering at school- or neighbourhood-level, so that these additional levels of hierarchy were not taken into account in the final models. Lowess smoothers were used to explore the functional shape of the association between the logit of physical activity and the measures of ethnic density (Cleveland, 1979). For each outcome, separate logistic models were specified to test school-level and neighbourhood-level ethnic density effects by ethnic group. For each ethnic density variable, unadjusted models included time, exposure, ethnicity and ethnicity*exposure interaction terms. Partially adjusted models further included potential confounders. Finally, the fully adjusted models included time, ethnicity, potential confounders, the two exposures and their interaction with ethnicity.

For sensitivity analyses purposes, models were also stratified by ethnic group instead of using interaction terms to allow confounding to differ by ethnic group; the exposure variables were modelled as tertiles to allow deviation from linearity; and an alternative working correlation structure was used to initiate the GEE models using exchangeable as opposed to unstructured correlation matrices (Molenberghs and Verbeke, 2005).

Results

Ethnic differences in physical activity prevalence differed by form of physical activity (Table 1). The prevalence of walking to school was highest in Bangladeshi (84.4%) and White British (80.8%) groups, and lowest in White Mixed (72.4%) and Black African (71.4%) groups. Walking for leisure was highest in the White British group (48.3%), intermediate in the White Mixed group (39.8%), and lowest in the Black African (28.5%) and Bangladeshi (24.4%) groups. Outdoor physical activity was highest in the Black African group (80.1%), intermediate in the White Mixed (75.1%) and Bangladeshi (74.8%) groups, and lowest in the White British group (71.4%).

The vast majority of adolescents (96%) attended a local school located outside their residential LSOA (median distance to school was 1.6km). Own-group ethnic densities were highest for White British and Bangladeshi adolescents at both school- and neighbourhood-levels, and lowest for White Mixed and Black African adolescents (Table 1). Table 1 describes the key socio-demographic characteristics of the sample. In general, White British adolescents were less disadvantaged and were more likely to have lived in their neighbourhood for more than 5 years.

Walking to school

School-level own-group ethnic density (school-level ethnic density hereafter) is associated with walking to school, after adjustment for potential confounders (Table 2). A positive association is observed for the Bangladeshi group, indicating that a 10% increase in school-level ethnic density increases the odds of walking to school by 1.20 (95% CI: 1.09-1.31). In adjusted models, negative associations are observed for the White Mixed (OR: 0.51; 95% CI: 0.35-0.76) and Black African (OR: 0.58; 95% CI: 0.45-0.75) groups. The model using exposure tertiles (Supplementary Table 7) indicates a U-shaped relationship for the White British group such that the lowest odds of walking to school are observed for the 2nd tertile of ethnic density.

Table 2 shows evidence of associations between neighbourhood-level own-group ethnic density (neighbourhood-level ethnic density hereafter) and walking to school. Compared to school-level measures, coefficients have the same signs but are mostly lower in magnitude. The strongest association is observed in the Bangladeshi group, where an increase in neighbourhood-level ethnic density by 10% increases the odds of walking to school by 1.31 (95% CI: 1.14-1.51).

In fully adjusted model, which includes the two ethnic density exposures and potential confounders, school-level ethnic density remains a predictor of walking to school, whereas neighbourhood-level ethnic density coefficients are no longer statistically significant (Table 2). An increase in school-level ethnic density by 10% would decrease the odds of walking to school by a factor of 2.27 (=1/0.44, 95% CI: 1.43-3.57) for the White Mixed group and by 1.67 (=1/0.60, 95% CI: 1.43-3.57) for the Black African group. In the Bangladeshi group, coefficients of school-level and neighbourhood-level ethnic densities are attenuated in the fully adjusted model (ORs=1.13 and 1.15, respectively) and are no longer significant, which reflects an overlap between the two ethnic density measures for that group and the incapacity of the model to differentiate school-level from neighbourhood-level effects in this context.

Walking for leisure

There was no evidence of log-linear associations between ethnic density measures and walking for leisure for any ethnic group, before and after adjustment for potential confounders (Table 3). Results by tertile (Supplementary Table 8) confirm the lack of association with school-level ethnic density, with one possible exception. Tertile analysis indicates weak evidence of a negative dose-response relationship in the Bangladeshi group: as school-level ethnic density tertile increases, the odds of walking for leisure decreases. However, the fully adjusted model indicates that, in the presence of the two exposures and potential confounders, there is no evidence of association between ethnic density measures and walking for leisure (Supplementary Table 8).

Outdoor physical activity

Table 4 provides some evidence that school-level ethnic density is associated with outdoor physical activity in some ethnic groups, after adjustment for potential confounders. In particular, a negative association is observed for the White British group, indicating that an increase in school-level ethnic density by 10% decreases the odds of outdoor physical activity by 1.16 (=1/0.86; 95% CI: 1.03-1.30). The models using exposure tertiles suggest the presence of a bell-shaped relationship for the Black

African group, such that estimated odds of outdoor physical activity are highest in the 2nd tertile of school-level ethnic density, and lowest in the 3rd tertile (Supplementary Table 9).

There is evidence that school-level ethnic density is associated with outdoor physical activity in the White British group, such that an increase in neighbourhood-level ethnic density by 10% decreases the outdoor physical activity by 1.17 (=1/0.85; 95% CI: 1.06-1.32), after adjustment for potential confounders (Table 4). The fully adjusted model shows that, in the White British group, associations are attenuated but remain statistically significant at neighbourhood-level, but not at school-level (ORs are 0.87 (95% CI: 0.77-0.98) and 0.94 (95% CI: 0.82-1.08), respectively).

Sensitivity analyses

Additional analyses stratified by ethnic group and those based on different specifications of the working correlation structure in the GEE process indicated no differences in the interpretation of the results (Supplementary Tables 1-6). Analyses using ethnic density tertiles, as opposed to continuous scores, allowed us to obtain more correct estimates in the presence of non-linear relationships, as reported above. Non-linear relationship were observed between school-level ethnic density and walking to school in the White British group (Supplementary Table 7) and between school-level ethnic density and outdoor physical activity in the Black African group (Supplementary Table 9). Interpretations of other parameters remained unchanged (Supplementary Tables 7-9).

Discussion

We explored whether own-group ethnic density was associated with physical activity in an ethnically diverse and relatively deprived adolescent population, after controlling for individual socio-demographic characteristics. We found consistent evidence that school-level ethnic density is associated with walking to school. The direction of the associations are ethnic-specific but indicate that higher ethnic density amplifies the underlying ethnic-specific propensity to walk to school. A higher ethnic density appears to increase the propensity to walk to school in the Bangladeshi adolescents; conversely, it seems to decrease it in the White Mixed and Black African groups, which are groups with a lower prevalence of walking to school.

No prior study has examined the association between ethnic density and physical activity in the UK (Bécares et al., 2012), but some studies on smoking have reported comparable results. In particular, a large study conducted using electronic health records of adults from the boroughs of Hackney, Lambeth, Newham and Tower Hamlets showed that the negative association between smoking and ethnic density was greater in ethnic minority groups where smoking was less socially accepted (Mathur et al., 2017). Another study conducted in a deprived population indicated that a higher South Asian density was associated with a lower probability of smoking during pregnancy in the Pakistani women, a group in which smoking is uncommon, whereas no protective effect was found amongst the White British women (Uphoff et al., 2016).

There are three main theoretical pathways by which ethnic density might influence health and health-related behaviours (Bécares et al., 2009; Bécares and Nazroo, 2013; Das-Munshi et al., 2010; Halpern and Nazroo, 2000; Karlsen et al., 2012; Pickett and Wilkinson, 2008). Own-group ethnic density might increase civic engagement; increase social capital and social support; and reduce exposure to racism and discrimination. With respect to walking to school, the latter two processes are likely to be more salient. An increase in neighbourhood social capital and social support might in addition provide resources to cope better with experiences of racism and discrimination. As a result, experience of racism might not translate into a change in health behaviours. The three hypothesised pathways imply that higher ethnic density might provide greater opportunities to conduct ethnic-specific preferred health behaviours, which can lead to an amplification of ethnic differences if these cultural norms differ by ethnic group.

Explaining observed associations in terms of amplification of ethnic-specific cultural norms seems plausible in this context. Previous studies have shown differences of knowledge, norms and expectations about health behaviours across ethnic minority groups (Koshoedo et al., 2015; Rawlins et al., 2013). In addition, studies have shown that 'homophily' or the tendency for friendships to form between those who are alike, is more frequent amongst ethnic minority groups, and that adolescents tend to adopt health behaviours that are similar to their friends' behaviours (Lorant et al., 2016). These behaviours have been recognised as being both potentially positive and negative for health.

Alternative explanations have been offered in the literature to explain ethnic differences (Nazroo, 2014) but these seem less consistent with the amplification phenomenon observed here. One of those alternative explanations is that observed associations might reflect the degree of acculturation, or the fact that ethnic minorities shift their behaviour over time and become more westernised so that health-related cultural differences between minority groups and the majority diminish (Bécares et al., 2011; Pickett et al., 2009). Acculturation might indeed confound the amplification phenomenon. In this study, however, we have found no evidence of association between the physical activity outcomes and either country of birth or language spoken at home in the ethnic group studied. Although acculturation might not be fully captured by the two variables (Bécares et al., 2011), these should at least have displayed some indication of an association if acculturation was playing a major role. Another alternative explanation for the results observed might come from differences in racism and discrimination across ethnic groups. Racism is considered as having a central role in the development of ethnic inequalities in health, and might affect perceived safety, fear of crime and health behaviours (Foster et al., 2014; Karlsen et al., 2012; Lorant et al., 2016; Rawlins et al., 2013). However, the experience of racism alone would not be enough to explain why the association with ethnic density is positive for some ethnic groups and negative for others. Therefore, it is plausible to explain these results in terms of amplification of ethnic-specific cultural norms, which might themselves, but not necessarily, have been the result of broader contextual and structural socio-economic inequalities (Karlsen and Nazroo, 2002; Nazroo, 1998).

The associations observed for walking to school should be interpreted cautiously for the following reasons. First, despite being in the expected direction, associations are modest and not statistically significant in all ethnic groups. The strength of the association indicates that a 10 percent increase in ethnic density is estimated to increase the odds of walking to school by 0.44 to 1.10. Second, no clear associations were found with the other physical activity outcomes. The only other consistent evidence of an association was for the White British group, for whom a higher ethnic density decreases the odds of outdoor physical activity, which is less popular in that ethnic group compared to others. The reasons for inconsistent results relating to walking to school and outdoor physical activity are not clear. A possible explanation for outdoor physical activity might be the composite nature of the measure, which pools a series of activities with different levels of popularity across ethnic groups, and therefore dampens differences.

We also compared the relative importance of school-level and neighbourhood-level ethnic density in explaining differences in physical activity. As expected, school-level density appears to matter more for walking to school, and neighbourhood-level ethnic density for outdoor physical activity. Where associations were observed, they were usually for both measures in partially adjusted models. However, in models adjusted for both ethnic density measures, only one of the measures would usually remain significant. A notable exception are Bangladeshi adolescents, for whom stronger associations between neighbourhood-level ethnic density and walking to school were observed, but no significant associations were found in the fully adjusted model. These results can be explained by the overlap between school-level and neighbourhood-level density measures in that group (r=0.69), and the fact that the ethnic density of Bangladeshi adolescents was very high in some schools (up to 80%), reaching a potential threshold above which an increase in ethnic density might not have any further effect. Astell-Burt et al. (2012) have also investigated the influences of neighbourhood and school-level densities in adolescents and reported negative associations with perception of racism, but the authors did not compare the relative influence of the two measures.

Strengths and limitations of this study

To our knowledge this is the first study to examine the association of ethnic density with physical activity in the UK, using validated instruments and appropriate statistical methods to account for non-independence of observations and item non-response. The Y-PAQ questionnaire allowed for the study of three common types of physical activity, and thus explored how different aspects of physical activity were associated with ethnic density.

A further advantage of the current study was in the use of large-scale data of a representative sample of the ethnic diversity of East London, providing evidence from populations less studied in the physical activity research. Unlike previous studies of ethnic density, our study population was homogeneously deprived, which helped better capture the ethnic density 'effect' itself due to the absence of correlation between ethnic density and deprivation in our context (Uphoff et al., 2016). Results might nonetheless not be generalizable to other settings. The study had a high response rate (87% at baseline) and retention rate (71%), which is consistent with best practice in other school-based cohorts (Booker et al., 2011).

This research also has limitations. Physical activity measured by the Y-PAQ is self-reported and might therefore be subject to recall and social desirability biases (Prince et al., 2008). However, the use of an objective physical activity measure was not practically possible given the size of the study. The Y-PAQ questionnaire does not have situational reference (Giles-Corti et al., 2005) and did not capture where the reported activity was taking place (e.g. garden, neighbourhood, parks). Such information would be valuable to better understand the relative contribution of school- and neighbourhood-level ethnic densities on more specific types of activities.

As large-scale studies of ethnic minorities are rare in the field, especially in the UK, the ethnic diversity of the ORiEL study is a major strength. However, the super-diversity of the sample was a limiting factor because over 200 ethnic categories were self-reported for minor groups. Nonetheless, ethnic differences in the ethnic density could be analysed for four main ethnic groups and some promising results were found despite low statistical power.

Although the ORiEL study is one of the few large longitudinal studies to investigate the determinants of physical activity, its short period of follow-up (3 waves; 2 years) restricted the ability to test the influence of time-change in ethnic density on physical activity, given the limited extent of residential mobility of the participants and the slow pace of change in the ethnic composition of their school and neighbourhood over time.

Another weakness of this study is that we were unable to assess causal relationships. Reverse causality could have accounted for findings; it is plausible that families with preferences for certain lifestyles may choose to send their children to a school or live in a neighbourhood with a greater proportion of people of the same ethnic group.

Conclusion

This study suggests that own-group ethnic density contributes to explaining differences in physical activity in adolescents by amplifying ethnic differences, in particular for walking to school. Further research is needed to confirm these results in different populations and for different health behaviours.

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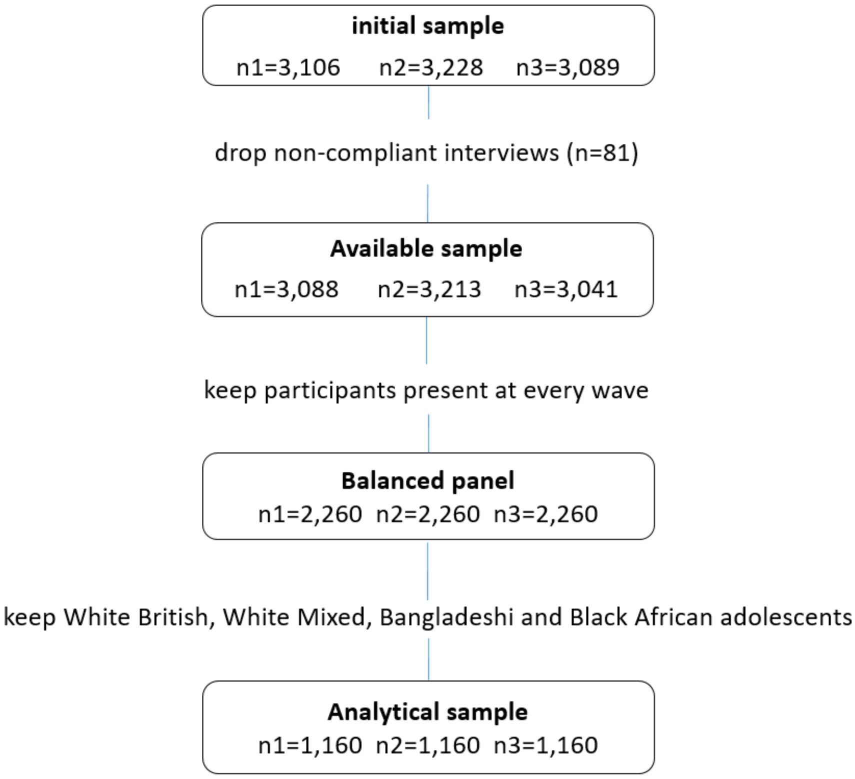

Figure 1 Data flowchart

Table 1 Characteristics of the study participants by ethnic group, 2012-2014

	White British (N=382)	White Mixed (N=190)	Bangladeshi (N=337)	Black African (N=251)	% Missing
Exposure					
Median school-level ethnic density (10^{th}- 90^{th} percentiles)	22.7 (13.2-57.6)	14.2 (4.4-21.7)	63.3 (7.5-80.6)	19.3 (9.5-24.8)	0.0
Median neighbourhood-level ethnic density (10^{th}- 90^{th} percentiles)	40.5 (19.7-63.1)	12.8 (6.3-22.2)	22.3 (4.5-53.2)	13.6 (4.0-23.5)	8.2
Outcome Measures					
% walking to school	80.8	72.4	84.5	71.4	4.4
% walking for leisure	48.3	39.8	24.4	28.5	9.5
% reporting outdoor physical activity	71.1	75.1	74.8	80.1	13.7
Covariates					
% Girls	44.8	50.0	36.5	40.2	0.0
% with health condition	44.3	51.8	43.1	33.1	10.4
Family affluence					3.7
% Low	8.3	10.2	9.7	6.2	
% Medium	43.0	48.5	62.9	57.4	
% High	48.7	41.3	27.4	36.5	
% receiving free school meals at baseline	29.2	44.2	45.3	41.4	1.7
% not living with both parents	33.1	50.2	13.8	33.3	2.7
% living in the neighbourhood > 5y	76.1	65.3	67.1	50.2	8.1
Median distance to school in km (10^{th}- 90^{th} percentiles)	1.6 (0.5-4.0)	2.1 (0.6-4.2)	1.2 (0.6-3.5)	2.2 (0.7-5.9)	8.5

Results are pooled across the 3 waves of data collection and obtained from 20 imputed datasets.

Table 2 Association of increasing own-group ethnic density with walking to school. Values are odds ratios (95% confidence interval)

	Unadjusted		Confounders Adjusted[1]		Fully Adjusted[2]	
School-level ethnic density*						
White British	1.08	(0.96 to 1.21)	1.08	(0.96 to 1.21)	1.10	(0.94 to 1.30)
White Mixed	0.53	(0.36 to 0.77)	0.51	(0.35 to 0.76)	0.44	(0.28 to 0.70)
Bangladeshi	1.19	(1.09 to 1.31)	1.20	(1.09 to 1.31)	1.13	(0.96 to 1.32)
Black African	0.58	(0.45 to 0.75)	0.58	(0.45 to 0.75)	0.60	(0.45 to 0.79)
Neighbourhood-level ethnic density*						
White British	1.01	(0.88 to 1.17)	1.01	(0.88 to 1.16)	0.97	(0.81 to 1.15)
White Mixed	0.95	(0.62 to 1.44)	0.94	(0.62 to 1.43)	1.33	(0.81 to 2.18)
Bangladeshi	1.32	(1.14 to 1.52)	1.31	(1.14 to 1.51)	1.15	(0.91 to 1.46)
Black African	0.80	(0.60 to 1.06)	0.80	(0.60 to 1.06)	0.91	(0.67 to 1.25)

Results are from logistic regression models estimated with Generalised Estimating Equations to account for the dependency across repeated measurements. Missing data were handled using multilevel multiple imputation (20 datasets).

* Assessed as change per 10 percentage points.

[1] Adjusted for time, gender, health condition, family affluence, baseline free school meal status, household composition, time lived in the neighbourhood and distance to school.

[2] Adjusted for time, gender, health condition, family affluence, baseline free school meal status, household composition, time lived in the neighbourhood, distance to school, the two ethnic density variables and their interaction with ethnicity.

Table 3 Association of increasing own-group ethnic density with walking for leisure. Values are odds ratios (95% confidence interval)

	Unadjusted		Confounders Adjusted[1]		Fully Adjusted[2]	
School-level ethnic density*						
White British	0.99	(0.90 to 1.09)	0.99	(0.89 to 1.10)	0.96	(0.86 to 1.08)
White Mixed	0.92	(0.66 to 1.29)	0.88	(0.62 to 1.25)	0.96	(0.65 to 1.40)
Bangladeshi	0.94	(0.89 to 1.00)	0.95	(0.90 to 1.01)	0.97	(0.89 to 1.06)
Black African	1.11	(0.83 to 1.49)	1.14	(0.86 to 1.51)	1.07	(0.78 to 1.47)
Neighbourhood-level ethnic density*						
White British	1.03	(0.95 to 1.13)	1.02	(0.94 to 1.12)	1.04	(0.94 to 1.15)
White Mixed	0.83	(0.57 to 1.19)	0.82	(0.57 to 1.18)	0.84	(0.56 to 1.25)
Bangladeshi	0.92	(0.83 to 1.01)	0.93	(0.85 to 1.03)	0.97	(0.84 to 1.11)
Black African	1.17	(0.90 to 1.52)	1.18	(0.91 to 1.54)	1.16	(0.86 to 1.55)

Results are from logistic regression models estimated with Generalised Estimating Equations to account for the dependency across repeated measurements. Missing data were handled using multilevel multiple imputation (20 datasets).

* Assessed as change per 10 percentage points.

[1] Adjusted for time, gender, health condition, family affluence, baseline free school meal status, household composition, time lived in the neighbourhood.

[2] Adjusted for time, gender, health condition, family affluence, baseline free school meal status, household composition, time lived in the neighbourhood, the two ethnic density variables and their interaction with ethnicity

Table 4 Association of increasing own-group ethnic density with outdoor physical activity. Values are odds ratios (95% confidence interval)

	Unadjusted		Confounders Adjusted[1]		Fully Adjusted[2]	
School-level ethnic density*						
White British	0.86	(0.77 to 0.96)	0.86	(0.77 to 0.97)	0.94	(0.82 to 1.08)
White Mixed	0.97	(0.66 to 1.43)	1.05	(0.68 to 1.62)	1.04	(0.65 to 1.67)
Bangladeshi	1.05	(0.98 to 1.12)	1.02	(0.95 to 1.10)	1.04	(0.94 to 1.14)
Black African	0.78	(0.57 to 1.08)	0.77	(0.58 to 1.04)	0.78	(0.56 to 1.09)
Neighbourhood-level ethnic density*						
White British	0.84	(0.76 to 0.92)	0.85	(0.76 to 0.94)	0.87	(0.77 to 0.98)
White Mixed	1.07	(0.73 to 1.57)	1.05	(0.70 to 1.57)	1.03	(0.66 to 1.61)
Bangladeshi	1.03	(0.93 to 1.15)	1.01	(0.91 to 1.12)	0.97	(0.84 to 1.12)
Black African	0.91	(0.66 to 1.22)	0.89	(0.67 to 1.18)	0.97	(0.71 to 1.32)

Results are from logistic regression models estimated with Generalised Estimating Equations to account for the dependency across repeated measurements. Missing data were handled using multilevel multiple imputation (20 datasets).

* Assessed as change per 10 percentage points.

[1] Adjusted for time, gender, health condition, family affluence, baseline free school meal status, household composition, time lived in the neighbourhood.

[2] Adjusted for time, gender, health condition, family affluence, baseline free school meal status, household composition, time lived in the neighbourhood, the two ethnic density variables and their interaction with ethnicity.