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Abstract

Background: Evidence suggests that many contemporary urban environments do not support healthy lifestyle choices and are implicated in the obesity pandemic. Middlesbrough, in the North East of England is one such environment and a prime target for investigation.

Methods: To measure physical activity (PA) levels in a sample of 28 adolescents (aged 11-14 years) and describe the environmental context of their activity and explore where they are *most* and *least* active over a seven-day period, accelerometry and Global Positioning System (GPS) technology were used. Twenty-five of these participants also took part in focus groups about their experiences and perceptions of PA engagement.

Results: Findings indicated that all participants were relatively inactive throughout the observed period although bouts of moderate-vigorous physical activity (MVPA) were identified in four contexts: school, home, street, and rural/urban green spaces, with MVPA levels highest in the school setting. Providing access to local facilities and services (such as leisure centres) is not in itself sufficient to engage adolescents in MVPA.

Conclusion: Factors influencing engagement in MVPA were identified within and across contexts, including 'time' as both a facilitator and barrier, perceptions of 'gendered' PA, and the social influences of peer groups and family members.

Background

Obesity rates in England have more than doubled since the mid-1980's with an increase in overweight and obesity in all age groups [1]. Overweight and obesity trends in young people have demonstrated a rapid increase during the previous fifteen years, with an estimated 10% of females and 8% of males younger than twenty years of age classified as obese, and a further 20% of males and 25% of females classified as overweight. Recent predictions indicate that by 2050, approximately 25% of all young people under twenty years of age are expected to be obese [1]. However, some reports indicate, in some countries, a stabilisation of the levels of obesity [2,3]. Obesity in young people is difficult to treat and there is a high risk of persistence into adulthood [4]. Obese adolescents are likely to have poorer health and reduced life expectancy [1]. Prevention of obesity in young people is a high priority [5,6].

A key driver for the rapid rise in obesity levels in adolescents over the last few decades is thought to be the increase in sedentary time in this age group [7]. Participation in both structured and non-structured activities is relatively low for adolescents (particularly girls), compared with younger children [8]. There is little evidence about the reasons why people (young and old) do or do not participate in physical activity [9]. A need has arisen to target adolescents and develop ways in which to engage them in various forms of activity, particularly that which reaches moderate to vigorous physical activity (MVPA) intensity levels. In addition to Body Mass Index (BMI), sedentary behaviours [10] track into adulthood [11]. Understanding physical activity and context of activity at life stage transitions is of great importance [12].

Policy makers and researchers alike have become increasingly interested in the role that the environment plays in influencing physical activity levels in both adults and young people. Societal, environmental and behaviour changes are deemed to play a pivotal role in the increasing levels of childhood obesity and inactivity, particularly in areas of high social deprivation [13]. Despite challenges around methodological issues [14], it is clear that those who have access to green space, fresh produce and reside in safe areas are more likely to adopt healthful behaviours [15].

Indeed data from a recent combined GPS-heart rate investigation in English adolescents [16] showed 'suburban youth' were more active than their 'rural' counterparts and made broader use of their immediate built environment, which could result from the greater range of recreational facilities (i.e. public parks, playing fields and playgrounds) available. In a combined GPS-accelerometer study of New Zealand adolescents, time in the school environment (within 1 km) was the largest contributor to daily MVPA, with the immediate home and neighbourhood (within 150 m of home) also key locations for physical activity[17]. There is however a distinct paucity of combined GPS-accelerometer data within adolescent populations.

Data on the environmental context of physical activity behaviours generated from studies such as the aforementioned has the potential to aid the development of behavioural change interventions and impact positively in the prevention of obesity. In tackling childhood and adolescent obesity, the government have placed emphasis upon increasing daily physical activity participation with the provision of a supportive built environment [1] in conjunction with such changes; the importance of targeting areas which are considered to be highly obesogenic is a priority.

The town of Middlesbrough has a population of approximately 138,000 and is located within one of the most deprived districts in England [18]. Thirteen of its 23 wards are placed in the most deprived 10% in England. Unemployment in the town is high, with worklessnes currently at a rate of 15.8% compared to the north-east regional average of 11.3% and the UK national average of 8.2% [19]. Crime rates are amongst the highest in the UK and educational attainment is below national average. Statistics indicate that 11.3% of children in the region were classified as being obese in 2008 [20].

Therefore we aimed to measure the levels and environmental context of MVPA that adolescents from a deprived urban area are involved with on a daily basis. Identifying specific environments where adolescents are at their *least* or *most* active may provide indicators for effective behaviour change interventions.

This exploratory study aimed to a) identify the environments in which adolescents participate in Moderate to Vigorous Physical Activity (MVPA) and b) discuss factors relating to physical activity and environmental context, and how they influence behaviour. Results from this research will provide direction as to which options need to be explored in order to increase levels of physical activity by manipulation of the environment, bringing about positive behavioural changes.

Methods

A two stage study was designed to explore adolescent's (ages 11-14 years) interactions with their environment in terms of physical activity intensity and the context (location) of this activity (Stage 1a and 1b). The second stage involved focus

group interviews with a subsample of participants to explore their activity and contextual data. Ethical approval was obtained by Durham University's School of Medicine and Health's ethics committee.

Participants

A voluntary sample (n=28: 11 boys; 17 girls) aged between 11-14 years old (mean = 11.8 years) were recruited from one school within Middlesbrough; GPS and accelerometer datasets were available for all 28 participants and 25 of the 28 participants took part in one of two focus groups. Participants with a physical disability that restricted their ability to walk were not eligible to participate in this study. The height, weight and BMI percentiles of participants were not recorded.

Instrumentation

Qstarz BT-Q1000XT Global Positioning System (GPS) technology was used to identify geographical locations in which participants were most and least active. In a recent multi-location (i.e. open sky, beacon, residential, mixed use, canopy and high-rise) static validity study the BT-Q1000XT was shown to have greatest accuracy and acceptable reliability compared to six other commercially available GPS monitors[21]. In addition, GPS monitoring has proven to be a promising tool for increasing understanding of the relationship between physical activity behaviours and the environment [22].

GT3X Actigraph Accelerometers were used to measure physical activity intensity throughout the data collection period. Accelerometry has shown to be an important tool for measuring physical activity patterns in obese children and adolescents [23-25].

Stage 1a: GPS/Accelerometer Data Collection

Adolescents (11-14 years) were recruited and monitored in October 2010. Informed consent was received from the parents or guardians of the invited adolescents. The study procedure and the monitors to be used for data collection were explained to potential participants before the study began; participants who completed and returned an appropriate consent form (n=28) were provided with an Actigraph accelerometer, QStarz GPS monitor, USB charger and plug adaptor. Participants were asked to wear the accelerometer and GPS monitor for seven days on an elasticated belt around their waist during waking hours, and were advised to charge the GPS monitor overnight when it was not being worn to ensure the battery remained charged throughout the data collection period. The accelerometer and GPS units were set to record data at five second epochs.

Stage 1b: GPS/Accelerometer Data Processing and Analysis

Intensity of activity was measured using accelerometry and location measured using GPS; using two distinct pieces of equipment. Matching this data in order to provide contextual information about location and intensity is challenging. The accelerometer and GPS data were downloaded and converted into XML format, storing information for each participant separately. Using the Accelerometer Analysis Software (a novel software program designed by Industrial Thinking Ltd, Wilton Centre, Redcar, UK), each participant's intensity and location data were matched at their corresponding time points. Using this software raw activity count data were reduced into minutes of MVPA using the cut-points of Freedson et al. (As published= ≥2220 cts.min^{-1}; Scaled= ≥185 cts.5sec^{-1}) as derived by Trost et al.from the original Freedson

regression equation. These 60 second cut-points were scaled to match the 5-second epoch data collected. Scaling of cut-points has been used in previously published accelerometer work[26]. Due to the exploratory nature of this study and the obvious requirement to maximise matched data, wear time criteria were not applied to the accelerometer data sets. In addition as MVPA was the PA outcome of interest, non-wear time (i.e. consecutive zero counts) was not excluded.

The software runs on any Microsoft Windows compatible PC running Windows XP and the Microsoft .Net Framework 2.0 (or higher) and can analyse data for single participants as well as group datasets and generates an Excel file with GPS links that can be opened in Google Maps for times when bouts of three minutes (or more) of moderate-vigorous physical activity were identified for each participant.

GPS data points were recorded for four points during each identified bout of moderate-vigorous physical activity (at 0 minutes, 1 minute, 2 minutes and 3 minutes). Where consecutive three-minute bouts were found, these were combined to ascertain both starting and ending points. Using these geographical data points, the novel software allowed the researcher to open up a webpage in Google Maps via a single mouse click. The researcher could then examine the environment *where* participants had engaged in MVPA. Using Google Maps, one of four context descriptors was assigned to each activity bout: ‘home’, ‘school’, ‘street’ and ‘rural/urban green space’. This process was carried out for each of the 28 participants, and the information generated was used as a basis for the questions for Stage 2, the focus groups.

Stage 2: Focus Group Procedure and Participants

Focus groups were conducted to gain individual's perceptions of the environmental influences on physical activity. The adolescents that participated in Stage 1 of the study were invited to take part in Stage 2 to elicit more detailed information and enable/direct further analysis of the data available.

Informed consent was received from the parents or guardians of 89% (n=25: 10 boys; 15 girls) of the invited students. Two focus groups were conducted on the same day in May 2011, with 12 students in group one: (all Year 7 students aged 11 to 12 years), and 13 students in group two: (four Year 7 students and nine Year 9 students aged 13 to 14 years).[i] Students were white British (n = 23) and Asian (n = 2).

Questions generated

Trends emerging from the Stage 1 analysis were used to inform the development of focus group questions. Questions were constructed around the topic of physical activity (i) within school, (ii) outside school, and (iii) at weekends and on weekdays.

Two researchers facilitated the focus groups. CN began with a brief overview of the research study prompting participants to recall their involvement in the first stage. Graphs generated from the output data analysis were presented to the participants by WD who explained the levels of activity reached by the student groups over a one week period. The participants were asked to comment on the graphs of physical activity produced from the accelerometers. Individual questions written on slips of paper were folded into an envelope and handed around the group to involve the students in both asking and answering questions as a group. Questions about the student's experiences of wearing the monitors were also included to assess any feasibility issues.

Data Analysis

The procedure for asking and answering questions as a group generated discussion around the topics of physical activity both within and outside of school and differences between physical activity at weekends and on weekdays. Data from focus group discussions were recorded and transcribed. We were particularly interested in the students' access to and engagement in school based activities and activities out of school to identify perceived facilitators and barriers to moderate to vigorous physical activities. Qualitative data were analysed using a qualitative content analysis approach [27] which lends itself to an inductive and deductive interpretation of the data. A categorization matrix was developed through the collaboration of two researchers (CN, AL) and data from the focus groups were coded according to the 'context' categories identified in the mapping analysis, to address the second aim of our investigation. Discrepancies in initial categorization of the data were resolved through further discussion with a third researcher (CS) to reach a consensus of agreement on the coding framework. In addition to the contexts identified in the mapping analysis, coding was also guided by the social-ecological model [28]: students' comments were coded in relation to personal, social and environmental factors influencing their access to and engagement in physical activities, within and across contexts. Common themes emerging from the data were incorporated into the coding framework and the categories developed provide the headings under which we present our findings.

Results

Context of physical activity

Following the collection and analysis of the GPS and accelerometer data (as described in the methods section), schools were identified as being the primary locations where young people engaged in MVPA during the week in which they wore the monitors. Other contexts identified from the mapping analysis in which the young people also engaged in MVPA were 'home', 'street' and 'rural areas/urban green spaces'.

Table 1 here

School Context

The group means and (SD) for MVPA within the school context are presented in Tables 1 and 2 (split by the day of the week and the time of the day).[ii] All but one participant reached MVPA within the school context during the monitored period. The participants from two year groups indicated they had structured compulsory physical education (P.E.) sessions for three hours each week over two sessions, on Wednesday and Thursday (Year 9) and Tuesday and Friday (Year 7). The P.E. sessions can explain the two highest MVPA mean scores on Tuesday and Wednesday PM in Table 2 below although it is unclear why there are not similar peaks in MVPA on Thursday and Friday.

Table 2 here

P.E. Sessions

'You get three hours (each week) across two sessions, we do ours on Wednesday and Thursday' (Year 9)

'We do ours Tuesdays and Fridays' (Year 7)

'Most schools only do two hours a week but here you have three'

'We're doing athletics and rounders at the moment (Summer), it depends on the terms'

'In other seasons… we do trampolining, gymnastics, hockey, cricket, netball, football, rounders, watersports'

Enrichment

'Enrichment you can do every day apart from Fridays, and it is after school'

'we get enrichments after school and we can choose which ones'

'last half-term there was football and rugby and hockey and now it's like changed so like athletics, golf and […] like summer sports it's like seasons'

'I've chosen to do an enrichment where you go to Sunderland to do rock-climbing, so you can choose physical stuff as well'

In their discussion of compulsory physical education in school, the participants were keen to highlight the wide range of structured activities available to them both within the P.E. sessions, and as part of their enrichment options[iii]. Time was an important factor which influenced the young people's engagement in physical activities in the school context.

Break-time

'Break is 15 minutes and you've got to think about getting to your next lesson'

'They provide activities but you never really have time to do it'

'Lunch is only 40 minutes and by the time you've queued and had you lunch, there isn't really time'

'When we were playing (at lunch time) we'd only have like ten minutes because I got in the (dinner) queue first and the rest of my friends didn't'

Compulsory Physical Education was scheduled for three hours each week, over two sessions. Also, at least one enrichment session per week was compulsory for all Year 7, 8 and 9 students in the participating school. In addition to the young people's enthusiastic comments regarding the range of activities available to them in school, the 'extra' P.E. time and enrichment opportunities were reported positively. It is worth noting that a majority of enrichment activities took place within the school context although there were a few exceptions to this such as using climbing walls and playing golf at external venues. The young people also highlighted that games and sports were available to them at break-times although it was evident that time constraints made break-time physical activity difficult for many.

Gender and engagement

'Maybe boys do more vigorous activity, like football where girls may not play'(boy)

'Well (football) is seen as more of a boys' thing' (girl)

'If there's girls' football we play' (girl)

'Sometimes on a Tuesday for boys there's table-tennis' (girl)

'It's for all people not just boys, it's for girls as well' (boy)

'Some boys and some girls do football at break' (boy)

Some of the participants' comments also highlighted how beliefs about gender might shape access to and engagement in physical activities within the context of school. When they were asked about the graphs showing that the boys were engaged in physical activity more than the girls, one girl highlighted how some sports were more

accessible to boys, although this observation was quickly challenged by some of the boys.

Home Context

The group means and (SD) for MVPA within the home context are presented in Table 3 below. Nineteen of the 28 participants reached MVPA within the home context during the monitored period. Within the school context the highest mean MVPA score reached within the monitored period was 11.5 minutes (SD 18.9) on Wednesday afternoon (12.00pm to 5.00pm) (see table 2). In contrast, within the home context (table 3) the highest mean MVPA score reached throughout the monitored period was 2.7 minutes (SD 6.5) on Wednesday evening (5.00pm to 9.00pm).

Table 3 here

There was a low level of MVPA within the home context over the entire 7-day period including weekends and it was evident from the focus group data that the home appeared synonymous with *not* engaging in physical activities. Young people engaged in sedentary activities within the home context, including watching television, playing computer games and doing homework. Physical activities were viewed by the young people as something that took place outside the home and that were often compromised by competing home-based activities.

Sedentary activities

'When I get home I have to do my homework and by the time I finish my homework it'll be about 7 o'clock and by the time I've got dressed to go out it'll be about 8 o'clock and then I've got an hour to play out so..'

'It's not that I don't choose to, (be physically active) I do, but it's getting out of the house and doing it… (it's) not difficult, it's just you could be doing other things like (computer) games and stuff'

For young people who were engaged in physical activities with their family, these also tended to be outside the home and at the weekend.

Weekend activities

There was a consensus among the young people that they were typically more active during week days than on weekends. Environmental and social influences were evident in their comments, where the school and the home environments were seen as obvious explanations for more and less physical activity respectively. One participant's response highlights the taken-for-granted assumptions about physical activity in different social contexts: '*during the week that's when you see your friends and (the) weekend is when you're with your family*'.

Weekends vs. Weekdays

'Sometimes you hang about with your mates and play footy but sometimes you sit in or something'

'I probably do more (PA) on a weekday'

'You'll be active for longer during weekdays'

'We all go to school middle of the week and we're walking round to our lessons and on a weekend we just normally sit down and watch telly'

'I stay in and watch TV'

Mean scores for MVPA at the weekend in both the home, street and rural/urban green contexts indicate low levels of physical activity in these contexts. These findings are supported in part by some of the comments made by the young people, and although many participants also claimed to spend time at the weekend engaged in physical activities it is possible that MVPA was either not reached or not sustained for bouts that were long enough to be included in the analysis.

'I do a lot of football on a weekend'

'I do like rock-climbing on a weekend'

'I play for my football team on a weekend'

'I do dancing on a weekend'

'We go to (a local leisure centre) and things and go swimming and things like that'

'I do swimming every Saturday'

'I go swimming every Sunday with my dad'

A further consideration regarding numerous reports of physical activity at weekends and the contrary findings of low MVPA in all contexts at the weekend is that the young people were not able to wear the monitors when swimming, and many were concerned about damaging them when playing games and contact sports: bouts of MVPA which reached the cut-off may not have been recorded.

The street context[iv] and rural/urban green spaces

The group means and (SD) for MVPA within the street context are presented in Table 4 below. Twenty-one of the 28 participants reached MVPA within the street context during the monitored period.

Table 4 here

Only five of the 28 participants reached the cut-off for MVPA in rural or urban green spaces throughout the 7 day period. Contexts included a golf course (Wednesday PM) a football pitch (Friday evening), two urban parks (Thursday night and Saturday PM), a sports pitch/play area (Thursday evening) and a National Park within the North York Moors (Tuesday AM and PM).

From the GPS data it was evident that morning MVPA was often reached during the participants' active travel to school. Several participants commented that they walked or rode their bicycle to and from school. However, the mean MVPA scores were relatively low, and this can be explained by the larger number of young people who said they travelled to and from school by car or by bus.

As highlighted earlier, the way in which physical activities in the school context were perceived as gendered was evident in comments from some of the girls. Two girls' comments on active travel (above) also highlight the relevance of gender in engagement in physical activities. It seems that a lack of engagement in active travel from their peers has a knock-on effect. It may be that some girls do not or cannot walk/cycle to school alone and simply want a friend to go with, or it may be that *knowing* other girls do not walk/cycle to school is enough to dissuade the girls from doing so.

Active Travel

I get the car from my house to school and sometimes I walk back to my house

My dad drops me at school 'coz it's like on his way to work, but then some days I get the bus and some days I walk

I usually get the bus but if it's like nice weather then I'll walk

I wouldn't bike 'coz I live too far away

'I would (cycle to school) but no other girls do so'

'I would walk but no other girls do so I just don't'

Physical activities after school and at the weekend

A majority of the young people reported at least one physical activity that they engaged in regularly either as part of their enrichment session, or after-school club, or with family or friends on weekday evenings or weekends, including swimming, football, rounders, hockey, cricket, rugby, athletics, walking (the dog), dancing and skating. It was also evident that others' engagement in various activities had a direct impact on the young people's motivation and continued participation.

All but two of the participants were allowed unstructured independent 'leisure-time' after school: their parents set a time by which they must return home (ranging from 7.00pm to 10.00pm). Two young people reported that they were not allowed out of their home independently after school.

Overall, the findings from the analysis of the 'street' context data (see table 4) suggest that the young people engaged in more physical activity on weekday evenings than on weekend evenings. A comment from one participant highlights how weekend entertainment may be more sedentary such as going out for a meal or to the cinema: '*On a weekend you might go into town, but on a school night you might just go out and play football'.*

Although a majority of the young people reported engaging in many structured activities throughout the monitored period, it is evident from the analysis that other than the 'home' and 'school' settings (see above), the cut-off for MVPA was identified in only two other contexts: the 'street' and 'rural/urban green spaces'.

Despite participants' frequent reports of cycling after school, at weekends and during holidays, it is noted that cycling activity is not effectively recorded using accelerometry; which may be a contributing factor in discrepancies between participants' subjective reports of physical activity and MVPA data collected. Also, many sports and other structured activities that are likely to have taken place within a gym or leisure centre/swimming pool were not identified. Participants reported being concerned about damaging the monitors and as such, monitors may have been removed before engaging in MVPA (this was required prior to swimming), or MVPA was not reached during the physical activity sessions.

Cycling

'I usually go on my bike with my friends, I don't think it's much fun just going on my own'

'I go on my bike about twice a week'

'I use my bike a lot in the summer'

'I used to go on it all the time because my dad used to have a bike, but he doesn't have one now so I don't go'

'I always go up in the hills where there's loads of jumps'

Monitors

'I was a bit scared (I would) break them'

'I didn't wear it when I went biking in case it fell off and got broken'

'I didn't wear it when I went swimming'

'I took it off in case- because I was play-fighting'

A further possibility is that a leisure-complex was not easily identifiable from the Google maps and MVPA was coded as taking place in the 'street' context.

Discussion

Attempts to increase levels of physical activity in young people have been the focus of successive government health policies [29]. Resonant with existing research [30], the present study illustrates a low level of physical activity in a sample of 11 – 14 year olds in Middlesbrough throughout a 7-day period; in addition, this work provides further detail of the geographical locations in which MVPA was reached and examines potential facilitators and barriers to physical activities within the settings identified. In relation to the first aim of this study, our analysis of GPS and accelerometry data led to the identification of four contexts in which young people engaged in Moderate to Vigorous Physical Activity (MVPA): school, home, street and rural/urban green spaces. Factors relating to physical activity and environmental context, and how they influence behaviour are discussed below.

It is evident from the GPS and accelerometry data analysis that levels of MVPA reached during the monitored period ranged widely between participants (see Table 1). Mean MVPA for the participants (n=28) was highest in the school context and lowest in the rural/urban green context within the monitored period. Further analysis of each context enabled us to identify times of the day in which levels of MVPA were reached.

Within the school context the highest levels of MVPA were recorded in the afternoon on Tuesday and Wednesday, during which time participants were engaged in compulsory P.E. sessions. Existing studies have identified a similar finding [8]. It is also important to note that many of the students' enrichment sessions took place after-school but within the school setting and may have contributed to the relatively higher level of MVPA within the 'PM' (12.00pm to 5.00pm) time frame. P.E. sessions and enrichment sessions were compulsory and students were engaged in structured

activities for set periods of time. The findings from this study suggest that without some degree of structure (which the school context provides), young people are less likely to engage long enough and hard enough to reach MVPA.

Engagement in MVPA outside the school environment was identified in the contexts of home, street and rural/urban green spaces. During the focus groups participants claimed to be taking part in many after-school activities, most often with family members and friends, however activity levels spent out of school hours remained very low for both year groups. This could indicate that although a student was present at a particular activity, they were not necessarily being active enough to reach MVPA while taking part.

One would expect that living closer to opportunities for physical activity (e.g. leisure centres) has positive associations with increased physical activity levels. However the literature shows that this association is only seen in very young children rather than adolescents [15], and this was confirmed in our study with the interrogation of the GPS data: leisure centres, gyms and swimming baths within the locality were not identified from the GPS data for the monitored 7-day period. A small number of rural/urban green spaces in which MVPA was reached were recorded, including parks, sports pitches and a golf course, although only five of the 28 participants reached MVPA in these contexts. A number of studies have found that having recreational facilities which are easily accessible are necessary to create a supportive environment for physical activity, but accessibility alone is insufficient to increase physical activity levels [31].

Boys were found to be more active than girls in both year groups; findings that correlate with a number of recent studies [23,30,32]. Findings from the focus groups support previous research suggesting that girls may be reluctant to engage in

physical activities (e.g. football) that hold gender stereotypes [33], where they may be perceived as 'overly masculine' [9] or are perceived as "uncool" by peers [34]. Such findings warrant further investigation and consideration by both researchers and policy makers. Also, two girls in the present study reported how travelling to and from school was shaped by their peers; it would be useful in future research to explore this further to ascertain how active travel is shaped by gender and/or distances between school and home for individual participants. Additional information about the weather at specific times within the day or evening could also be collected to support conclusions about participants' decision-making regarding active travel, and outdoor physical activity more generally.

Limitations and future developments

Use of GPS is increasingly popular in health research, however there are currently no best-practice guidelines for collecting, processing, and analysing GPS data [35]. Global Positioning Systems can provide limited coverage in built up urban areas and devices often lose signal indoors. However in this work, logging the GPS with the accelerometery data in addition to the adolescent's school schedule allowed for interpretation of the data.

Neither wear time criteria (i.e. minimum minutes of wear time and valid days), nor removal of non-wear time (i.e. minutes of consecutive zeros) was applied to the accelerometer datasets. This decision was made to maximise the volume of matched GPS and accelerometer data. The caveat being that the levels of MVPA reported may underestimate 'true' values due to the inclusion of incomplete wear days. However, our data still provides important information on the distribution and

environmental context of MVPA, of which there is a paucity of data in adolescent populations.

Focus group data demonstrated contradiction in the young people's claims that they were both *most* active on week days, *and* engaged in a wide range of sports, games and activities at the weekend. Furthermore, we must also consider some of the discrepancies between the young people's verbal reports and the data from the GPS and accelerometers. It is possible that the monitors were not worn during some physical activities, certainly this is the case for swimming, and several participants removed the monitors to prevent any breakages. Also, MVPA may not have been reached or sustained during the reported activities. Alternatively, it may be that the young people perceived that they engaged in more MVPA than they actually did during the monitored period. We know that this type of reporting issue is common in adults, and suggest that the young people's reports of engagement in moderate to vigorous physical activities may have been overstated, particularly within a peer group context.

Obesogenic environments such as Middlesbrough, which promote overconsumption, are not to be underestimated in taking some responsibility for the increase in obesity in young people within deprived areas [36]. Previous research within the same region found that pre-adolescent children living in highly obesogenic environments such as the North East of England typically exhibit low levels of MVPA [37]. It is clear that environmental factors play a larger role than first anticipated but establishing the extent to which they are responsible remains unclear until further research has been conducted to explore barriers to PA within the adolescent community.

In the present study, an important factor shaping the young people's engagement in physical activities was time. At home, time was given to sedentary activities such as watching television, playing computer games and completing homework, purportedly leaving less time for physical activities both inside and outside the home. Within the school day, time was often structured, for example, in P.E. and enrichment sessions, although it was evident from participants comments that the free time available during the school day to play/be active (during lunch and break times) was limited. In the school involved in this study, only one morning break of fifteen minutes and one lunch break of forty minutes were included in the school day. The adolescents unanimously reported that they didn't have time during these breaks to play or be active, and their lunch times were primarily spent queuing for food. This scenario is very different to the school day of ten years ago when there was sufficient time in the school break times for children to engage in physical activities. A further analysis of the disadvantages of shorter school breaks on MVPA is recommended.

Conclusions

In summary, this study demonstrates the utility of combining accelerometry and GPS mapping to identify contexts for physical activity in adolescents. The findings presented here illustrate a low level of physical activity in a sample of 11 – 14 year olds in Middlesbrough throughout a 7-day period. Mean MVPA for the group was highest in the school context and lowest in the rural/urban green context within the monitored period. Within the school context the highest levels of MVPA were recorded in the afternoon on Tuesday and Wednesday, during which time participants were engaged in compulsory P.E. sessions, a finding that is supported

elsewhere [8]. In focus groups, participants' reported high levels of engagement in numerous physical activities outside the school at the weekends and on weekday evenings, however this was not reflected in the findings from the analysis of MVPA in home, street and rural/urban green contexts. Further investigation is needed to address methodological limitations and discrepancies between self- reported physical activity and recorded MVPA identified in this study. Factors influencing engagement in MVPA were identified within and across contexts, including 'time' as both a facilitator and barrier, perceptions of 'gendered' physical activities, and the social influences of peer groups and family members. We suggest further research should be conducted to identify barriers and facilitators to MVPA in this age group which can then inform the development of successful interventions.

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Table 1. Mean MVPA (in minutes) in four contexts during a 7-day period using Accelerometers and GPS monitors in 28 adolescents (aged 11-14 years).

Context	N	Mean (SD)	Minimum	Maximum	Range
School	28	40.2 (35.1)	0.0	174.0	174.0
Streets	28	28.1 (43.8)	0.0	198.0	198.0
Home	28	11.8 (18.2)	0.0	87.0	87.0
Rural/Urban green	28	4.8 (14.5)	0.0	72.0	72.0

Table 2. Mean MVPA (in minutes) in the school context (by day of week and time of day) in 28 adolescents (aged 11-14 years).

Time	Monday	Tuesday	Wednesday	Thursday	Friday
AM	1.2 (1.7)	0.2 (0.8)	0.4 (1.1)	0.8 (1.8)	3.2 (6.4)
PM	4.1 (8.2)	**10.6 (12.3)***	**11.5 (18.9)***	3.2 (8.8)	3.5 (5.8)
EVE	0.9 (1.8)	0.1 (0.6)	0.1 (0.6)	0.0 (0.0)	0.0 (0.0)

*Highest mean MVPA was recorded during afternoon Physical Education sessions in the school context

Table 3. Mean MVPA (in minutes) in the home context (by day of week and time of day) in 28 adolescents (aged 11-14 years).

Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
AM	0.4 (1.3)	0.5 (1.4)	1.3 (5.2)	0.9 (2.9)	0.8 (2.4)	0.3 (1.2)	0.0 (0.0)
PM	0.0 (0.0)	0.0 (0.0)	0.5 (2.0)	0.0 (0.0)	0.0 (0.0)	0.3 (1.7)	0.5 (2.8)
EVE	1.0 (2.8)	0.0 (0.0)	**2.7 (6.5)***	0.1 (0.6)	1.3 (5.7)	0.2 (0.8)	0.3 (1.7)
NIGHT	0.5 (2.8)	0.2 (1.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)

* Highest mean MVPA was recorded during Wednesday evening in the home context

Table 4. Mean MVPA (in minutes) in the street context (by day of week and time of day) in 28 adolescents (aged 11-14 years).

Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
AM	1.5 (5.7)	1.8 (5.6)	2.0 (6.4)	0.1 (0.6)	2.4 (6.1)	0.1 (0.6)	0.3 (1.2)
PM	1.2 (4.6)	0.2 (0.8)	1.7 (4.1)	0.5 (1.4)	2.1 (7.3)	1.0 (2.7)	0.2 (1.1)
EVE	1.7 (4.0)	1.7 (5.3)	**3.2 (7.5)***	2.4 (5.8)	0.2 (1.1)	0.8 (2.9)	0.1 (0.6)
NIGHT	0.0 (0.0)	0.6 (2.3)	0.0 (0.0)	1.1 (4.6)	0.5 (2.3)	0.0 (0.0)	0.0 (0.0)

* Highest mean MVPA was recorded during Wednesday evening in the street context

NOTES

[i] Student groups were arranged by a member of school staff to minimise disruption to their schedule

[ii] Times of day are categorised as: AM = 06:00 to 12:00 / PM = 12:00 to 17:00 / EVE = 17:00 to 21:00 / Night = 21:00 to 06:00

[iii] Focus group students attended the same secondary school which offers students an enrichment programme of more than 70 'after school' activities – including classroom-based and physical activities. Physical activity choices include athletics, basket ball, hockey, cricket, dance, fitness, golf, trampolining, mini-fencing, netball, rounders, running, table tennis, rugby, volleyball and football. It is compulsory for all students in Years 7, 8 and 9 to attend at least one enrichment per week

[iv] Google maps (in street view) were examined to identify the area around the GPS coordinates. Residential areas that were not the participants' home addresses were coded as 'street'