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Energy expenditure on recreational visits to different natural environments

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ABSTRACT

Physical inactivity poses a significant challenge to physical and mental health. Environmental approaches to tackle physical inactivity have identified natural environments as potentially important public health resources. Despite this, little is known about characteristics of the activity involved when individuals visit different types of natural environment.

Using Natural England's Monitor of Engagement with the Natural Environment Survey, we examined 71,603 English respondents' recreational visits to natural environments in the past week. Specifically, we examined the intensity of the activities they undertook on the visits (METs), the duration of their visit, and the associated total energy expenditure (MET minutes).

Visits to countryside and urban greenspace environments were associated with more intense activities than visits to coastal environments. However, visits to coastal environments were associated with the most energy expenditure overall due to their relatively long duration. Results differed by the urbanity or rurality of the respondent's residence and also how far respondents travelled to their destination.

Knowledge of what types of natural environment afford the highest volumes and intensities of physical activity could inform landscape architecture and exercise prescriptions. Isolating activity-supporting characteristics of natural environments that can be translated into urban design is important in providing physical activity opportunities for those less able to access expansive environments.

1. Introduction

Despite widespread evidence that physical activity (PA) can reduce the risk of coronary heart disease, cancers, diabetes, and obesity (The National Institute for Health and Care Excellence, 2008), and enhance mental well-being (Downward and Dawson, 2015; Ekkekakis, 2015), physical inactivity is one of the leading risk factors for death worldwide (World Health Organization, 2009). Economically, inactivity is estimated to cost the UK National Health Service almost £1 billion each year (Scarborough et al., 2011). The scale of the issue warrants ecological approaches concerning environmental supports for PA (Hunter et al., 2015). Natural environments have been identified as having much potential for promoting and eliciting recreational PA (Hartig et al., 2014; Ward Thompson, 2013).

One way this has been investigated is through examining access to natural environments and corresponding PA levels. Lachowycz and Jones (2014) found that people living in greener areas of England report more days per week of walking for at least 30 min. Conversely, residents from an English city demonstrated no relationship between living distance from a park and whether or not they did five or more sessions of walking or aerobic PA in the last week (Panter and Jones, 2008). As Hillsdon et al. (2006) note, inconsistency in such studies is rife and this may be because studies can often only account for the presence and proximity of greenspace, and not whether it is actually visited. However, some cross-sectional studies do address this omission. For example, Coombes et al. (2010) found a positive association between visiting greenspace at least once in the last week and the likelihood of achieving recommended PA guidelines. Nonetheless, from this type of evidence, it is still not possible to discern whether health-enhancing

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PA is performed in greenspace. This needs to be established if natural environments are to be considered public health resources as opposed to a preferred visit destination of more active people.

Studies now examine PA in situ using global positioning systems and are often conducted with children (e.g. Wheeler et al., 2010). However, one study observing parent–child pairs found that both the parent and child spent around 20% of their time jointly engaged in moderate-to-vigorous PA (MVPA; ≥3 METs for adults, ≥4 METs for children) in open spaces such as parks, gardens and beaches (Dunton et al., 2013). Additionally, in a sample of American adults, only 8.2% of all moderate and 9.4% of all vigorous activity took place in parks (Evenson et al., 2013). Whilst the former study shows that diverse natural environments can promote MVPA, it cannot determine what environments are associated with what activities. The latter study shows modest associations, but only examines one type of environment (parks). Public health policymakers interested in environmental supports for PA may need to know which types of environment are most beneficial for supporting physical activity (Lee and Maheswaran, 2011) but the above literature is not able to inform on this. Some studies suggest that more expansive environments such as forests (Mitchell, 2013) and coasts (White et al., 2014) are used specifically for physical activity, but the type and duration of this activity is still unknown.

1.1. Present study

The present study addresses limitations with the above literature using the Monitor of Engagement with the Natural Environment Survey (MENE; Natural England, 2015); a dataset concerning recreational visits to natural environments. Using this, it is possible to determine the type and quantity of PA conducted in different environments using estimates of energy cost (METs) and duration, the absence of which has formed an important limitation previously (Mitchell, 2013). The central research question for this study was what types of natural environment are associated with recreational visits involving higher intensity activities, longer visit durations, and higher energy expenditure? Considering that relationships between greenspace and health are moderated by urbanity (Mitchell and Popham, 2007), a subsidiary question was how do the relationships between environments and energy expenditure differ between individuals from rural and urban areas? Lastly, considering recent research suggesting that coastal residents directly use the coastline in order to achieve higher levels of PA (White et al., 2014), the final research question was how does the relationship between environments and energy expenditure vary with the distance travelled to the destination?

2. Methodology

2.1. Sample

MENE is an ongoing survey using a cross-sectional, representative sample of English adults (aged 16 and over) that concerns recreational visits to natural environments (Natural England, 2015). Data is collected throughout the year via in-home interviews with a weekly quota sampling method and respondents report details concerning their visits to natural environments in the last week. All responses were recorded using a Computer Assisted Personal Interviewing (CAPI) device. Once respondents had provided brief details of all visits made in the last week, the CAPI device randomly selected one visit for the interviewer to ask more detailed questions about. The aim of random selection at the point of interview was to reduce potential biases such as recency effects for recall. The data used in the current paper concern this randomly selected visit. Individual-level variables such as self-reported PA, age and gender are also surveyed. Several inclusion criteria existed for this study (consult Supplementary Table A for details). Data from 2009 to 2014 were used and the overall sample size was 71,603.

2.2. Outcomes

2.2.1. Activity intensity

The first outcome variable was the *intensity* of the activity reported. Every respondent chooses an activity that they did on their visit from a predefined list. MET rates were ascribed to each activity. One MET is equivalent to a standard resting metabolic rate (RMR) of 3.5 ml O_2 kg^{-1} min^{-1} (3.5 mL of oxygen consumption per kilogram of body weight of the individual per minute engaged in the activity). METs are then a ratio of the work metabolic rate to this standard RMR. MET scores were derived from the compendium of physical activities (Ainsworth et al., 2011) and have been used frequently in cross-sectional analyses of recreational PA (e.g. Yu et al., 2011). Where multiple activities in the compendium could relate to the activity in the survey, an average MET score was used. For example the activity ‘walking with a dog’ is 3.0 METs and derived from one activity in the compendium (walking the dog), whereas the activity ‘beach, sunbathing or paddling’ is 1.9 METs and averaged across two activities in the compendium (lying quietly, doing nothing; water walking, light effort, slow pace).

2.2.2. Duration of visit

The survey records the duration of all visits using the following question:

> *“How long did this visit last altogether –that is from the time you left to when you returned?”*

It is clear that respondents could interpret this question in different ways. Firstly, they could report, as asked, the duration of their entire visit including travel to and from their start point. It could be that the respondents only travelled one-way before moving elsewhere. However, we argue that most respondents interpreted this question as the amount of time spent *in* the natural environment, excluding *all* travel time. This is because in many cases, respondent's reported travel distance and visit duration are incompatible (e.g. travelling 80–100 miles, but only reporting a duration of an hour). Nevertheless, as different interpretations are possible, we separate the findings into different models: Model 1 assumes the respondents reported duration as intended, potentially including travel time. Model 2 subtracts an estimate of the duration spent travelling to and from the destination and omits respondents who report incompatible travel times and durations. Model 3 subtracts a one-way estimate of travel time, again omitting respondents with incompatible travel times and durations. Additionally, a model is presented whereby only respondents who walked to their destination within 5 miles of their start point, and who undertook walking (or walking with a dog) as their chosen activity, were included. As well as representing the most common visit, it would not be of concern that duration included travel time, as this also represents time being physically active. In this sense, it acts as a robustness check and is henceforth referred to as the “walkers only” model. For further details as to how these models were constructed, consult Supplementary Table B.

2.2.3. Energy expenditure

The final outcome variable concerned total energy expenditure. Following earlier work (e.g. Rind and Jones, 2011), MET minutes were calculated by multiplying the MET rate by the duration of the visit (using all models detailed above).

2.3. Predictors

2.3.1. Environment visited

Every respondent reports the environment that they visited. Respondents can select one of: In a town or city (hereafter referred to as urban greenspace; 47% of visits); in the countryside (countryside; 43% of visits); a seaside resort or town (seaside resort; 7% of visits); or other seaside coastline (other coast; 3% of visits). These were used as the environments in this study and urban greenspaces, where most visits were taken, represented the reference category.

2.3.2. Individual-level

For descriptions and reference categories pertaining to all other predictors, consult Supplementary Table C. Firstly, the possibility that more and less active people use environments differently for recreation was controlled for by examining self-reported PA. Previous research has shown that regular exercisers use indoor exercise settings more frequently than outdoor for PA (Hug et al., 2009). Gender and age were adjusted for as women have been found to engage in less vigorous PA in parks than men (Cohen et al., 2007) and the relationship between recreational walking and greenspace quantity may be moderated by age (Maas et al., 2008). Socio-economic status (SES) was controlled for as low SES groups may be less likely to use beaches for recreational walking (Giles-Corti and Donovan, 2002). We additionally adjusted for work and marital status, ethnicity, and disability which have all been associated with the active use of parks (Bedimo-Rung et al., 2005).

2.3.3. Visit characteristics

Different types of visits could explain the relationship between environments and the outcome variables, so visit characteristics were also controlled for. Firstly, the presence of other adults, children and dogs on the visit were adjusted for. Greenspaces afford social activity (Coley et al., 1997; Kweon et al., 1998) and coastlines promote PA for families (Ashbullby et al., 2013). Beaches in England can forbid dog-walking so urban greenspaces and countryside may better support this activity and thus cause differences in METs.

Whether the visit was taken on a weekend or weekday was also controlled for as certain leisure opportunities may be more feasible at weekends (e.g. coastal watersports); and thus be responsible for different levels of energy expenditure in separate environments. Respondents who made just one visit in the past week were compared with those who reported multiple visits. Frequent greenspace users have been found to be more active (Coombes et al., 2010), therefore frequent visitors may have used certain environments for activities of higher METs.

The start point of the visit was also adjusted for as visits starting from, for example, holiday accommodation, may have distinct characteristics (e.g. long durations) which could moderate the relationship between different environments and the outcome variables. The distance travelled to the destination was also controlled for. A higher proportion of people may have to travel longer distances to reach environments such as the coastline, so the distance travelled may moderate any relationships between environments and duration or energy expenditure. The travel mode used for the visit was also accounted for as ownership and use of a car may foster better access to some activities (e.g. watersports). Seasonality was adjusted for as individuals may favour certain environments in some seasons as opposed to others (Badland et al., 2011). Lastly, the year of the survey was controlled for to examine annual differences in the outcome variables.

2.4. Analysis strategy

A series of regression models were constructed. In each model the first step included only the visited environment. In the second step, the self-reported PA variable was entered. The third step added the remaining individual-level variables and the final step included visit characteristics. The results are presented using each model listed in 2.2.2. Any resultant systematic differences between the environments and the outcome variables can then be examined. As a sensitivity analysis, we excluded dog-walking visits as research has found that features such as the presence of dog fouling receptacles and perceived safety, affect the likelihood of dog-walking (Cutt et al., 2007). These features may be more abundant in certain environments. The energy expenditure model was stratified both by urbanity/rurality of residence and then by travel distance (see 1.1). This dichotomy is defined in line with the 2001 Office for National Statistics classification where urban areas comprise urbanised settlements only, and rural areas comprise villages, town and fringe settlements, and hamlets or isolated dwellings.

3. Results

3.1. Descriptive statistics

Frequencies of respondents undertaking different activities are displayed in Table 1.

This shows that nearly 70% of respondents undertook some form of walking on their visit. The most popular vigorous-intensity activity (>6 METs) was running, accounting for nearly 3% of visits and the most popular light intensity activity (<3 METs) was eating or drinking out, accounting for nearly 4% of all visits.

Table 2 displays descriptive statistics on how the three outcome variables differ by visit location.

For all models, activities undertaken in coastal environments are lower in METs. However, coastal visits are longer in duration and consequently incur more expended MET minutes than visits to countryside or urban greenspaces.

3.2. Transformations

Distributions of all outcome variables were positively skewed. Whilst transformations did not improve model fit for METs and

Table 1
Frequency and proportion of respondents undertaking different visit activities.

Activity (MET rate of activity)	N	%
Eating or drinking out (1.75)	2761	3.9
Fieldsports (6.39)	390	0.5
Fishing (3.50)	512	0.7
Horse riding (5.50)	473	0.7
Off road cycling or mountain biking (8.50)	699	1.0
Off road driving or motorcycling (4.00)	118	0.2
Picnicking (1.75)	602	0.8
Playing with children (3.58)	6542	9.1
Road cycling (7.50)	1520	2.1
Running (7.00)	2092	2.9
Appreciating scenery from a car (1.30)	492	0.7
Swimming outdoors (6.00)	213	0.3
Beach, sunbathing or paddling (1.90)	696	1.0
Visiting an attraction (3.50)	2093	2.9
Walking without a dog (3.50)	25,791	36.0
Walking with a dog (3.00)	23,094	32.3
Watersports (5.78)	310	0.4
Wildlife watching (2.50)	510	0.7
Informal games and sport (e.g. frisbee or golf) (4.43)	2695	3.8

Table 2
Means and standard deviations (in parentheses) of the three outcome variables by visit location and model.

Model	Visit location	Activity intensity (METs)	Duration (minutes)	Energy expenditure (MET minutes)
Model 1 (n = 71,603)	Urban greenspaces	3.54 (1.16)	109.87 (91.35)	382.54 (349.64)
	Seaside resort	3.33 (1.10)	162.17 (123.50)	527.02 (446.34)
	Other coast	3.43 (1.18)	147.63 (115.01)	506.19 (461.66)
	Countryside	3.59 (1.20)	121.91 (103.17)	450.22 (444.62)
Model 2 (n = 56,568)	Urban greenspaces	3.52 (1.14)	96.62 (87.65)	333.53 (330.49)
	Seaside resort	3.31 (1.08)	130.91 (103.79)	423.56 (375.00)
	Other coast	3.40 (1.17)	122.39 (101.01)	417.84 (404.34)
	Countryside	3.59 (1.18)	106.27 (96.64)	391.68 (405.27)
Model 3 (n = 66,153)	Urban greenspaces	3.52 (1.14)	98.88 (88.98)	342.24 (336.21)
	Seaside resort	3.32 (1.07)	140.37 (112.24)	454.41 (403.22)
	Other coast	3.41 (1.16)	127.17 (107.19)	434.56 (426.06)
	Countryside	3.58 (1.18)	106.99 (99.14)	394.11 (416.64)
Walkers only (n = 33,408)[a]	Urban greenspaces	3.27 (0.25)	73.32 (56.76)	242.91 (195.19)
	Seaside resort	3.28 (0.25)	88.22 (66.80)	293.88 (231.63)
	Other coast	3.26 (0.25)	91.58 (65.41)	302.82 (228.53)
	Countryside	3.19 (0.24)	72.50 (51.52)	234.41 (175.14)

[n.b]Model 1 includes the whole sample and assumes respondents report visit durations as intended. Model 2 subtracts a one-way, and model 3 a two-way, estimate of travel time. The "walkers only" model includes only respondents who walked to their destination, within 5 miles and undertook walking (with or without a dog) on their visit.
[a] Small standard deviations and mean differences are a result of restricting this model to two activities (walking and walking with a dog) with a MET range of 3–3.5.

duration, log-transforming MET minutes did result in better model fit, so this transformation was used in the analysis.

3.3. Model fit

Table 3 displays results for all model permutations; consult Supplementary Tables D–G for complete models. Dependent on model, 0.3–2.4% of the variance in METs was explained by visited environment alone compared to 31.3–35.4% when controlling for all predictors. For visit duration, 0.6–2% of the variance was explained by visited environment alone compared to 10.4–36.1% in fully-adjusted models. Lastly, 0.7–1.2% of the variance in log-transformed MET minutes was explained by visited environment alone, compared to 12.5–32.7% in fully-adjusted models. In all models and for all outcomes, visit characteristics explained substantially more variance than other predictors.

3.4. Intensity, duration and energy expenditure in different environments

3.4.1. METs

For model 1, unadjusted coefficients revealed that visits to the countryside were associated with higher METs than visits to urban greenspaces whereas visits to the two coastal categories were associated with lower METs. These differences remained after adjustments: countryside visits ($b = 0.04$, 95% CI 0.03, 0.06); seaside resorts ($b = -0.17$, 95% CI −0.20, −0.14); other coastline ($b = -0.09$, 95% CI −0.13, −0.05). Being male, younger, of higher SES, in education, unmarried, of black or minority ethnicity, and without a disability were associated with higher METs. Also, being with children or other adults on the visit; not being with a dog on the visit; visiting on weekdays; travelling 6–20 miles to the destination; travelling by bicycle; and visiting in summer were associated with higher METs.

None of the associations between environments and METs changed using models 2 or 3. In the "walkers only" model, adjusted results revealed that visits to the countryside were associated with lower METs than visits to urban greenspaces ($b = -0.03$, 95% CI −0.04, −0.03) and visits to seaside resorts with higher METs ($b = 0.01$, 95% CI 0.00, 0.02). However, as this model was restricted to respondents undertaking walking or walking with a dog, this reflects the fact that countryside environments were more often used for dog-walking than seaside resorts and urban greenspaces (dog-walking is lower in METs than walking without a dog).

3.4.2. Duration

Using model 1, visits to seaside resorts, other coast, and the countryside were associated with longer durations than visits to urban greenspaces. These differences remained after adjustments: countryside visits ($b = 3.39$, 95% CI 2.05, 4.74); seaside resort visits ($b = 14.87$, 95% CI 12.41, 17.34); other coastline visits ($b = 9.80$, 95% CI 6.31, 13.30). Being male, younger, of *lower* SES, in education, unmarried, of black or minority ethnicity, without a disability, and reporting meeting PA guidelines were associated with longer visit durations. Additionally, being with children or other adults on the visit; not having a dog on the visit; visiting at weekends; only making one leisure visit to a natural environment in the past week; beginning the visit from holiday accommodation; travelling over 20 miles to the destination; travelling by public transport; and visiting in summer were associated with longer visit durations.

No associations between environments and visit duration changed systematically using model 2. Using model 3 and the "walkers only" model, after adjustments, visits to the countryside were not significantly longer than visits to urban greenspaces (model 3; $b = 1.30$, 95% CI −0.09, 2.69; walkers only; $b = 0.95$, 95% CI −0.29, 2.19), although visits to the two coastal categories remained significantly longer.

3.4.3. MET minutes

In model 1, unadjusted coefficients revealed that visits to seaside resorts, other coast, and the countryside were associated with more MET minutes than visits to urban greenspaces. These associations remained after adjustments: countryside visits ($b = 0.02$, 95% CI 0.02, 0.03); seaside resorts ($b = 0.03$, 95% CI 0.02, 0.04); other coastline ($b = 0.03$, 95% CI 0.02, 0.05). These associations along with subsequent stratifications are displayed in Fig. 1. Reporting meeting PA guidelines; being male; younger; in education; unmarried; of black or minority ethnicity; and without a disability were associated with more MET minutes. Having children or other adults on the visit; not having a dog on the visit; visiting at the weekend; only visiting a natural environment once in the past week; beginning the visit from holiday accommodation; travelling more than 20 miles; travelling by bicycle; and visiting in summer were also associated with more MET minutes.

The relationships between environments and MET minutes did not change using model 2. In model 3, although all environments

Table 3
Regression coefficients and 95% confidence intervals for each of the outcome variables by the type of environment visited.

Model		METs			Duration			Log-transformed MET minutes		
		b	LB	UB	*b*	LB	UB	*b*	LB	UB
Model 1	*Unadjusted*									
	Constant	3.54	3.53	3.55	109.87	108.80	110.94	2.44	2.44	2.44
	Visit location (urban greenspaces = ref)									
	Countryside	0.05***	0.03	0.07	12.04***	10.49	13.58	0.05***	0.04	0.06
	Seaside resort	−0.21***	−0.24	−0.17	52.30***	49.34	55.26	0.14***	0.13	0.15
	Other coast	−0.11***	−0.16	−0.06	37.76***	33.50	42.03	0.12***	0.11	0.14
	R^2	0.003			0.020			0.012		
	Fully-adjusted[a]									
	Constant	2.61	2.54	2.68	92.14	86.29	97.98	2.29	2.27	2.31
	Visit location (urban greenspaces = ref)									
	Countryside	0.04***	0.03	0.06	3.39***	2.05	4.74	0.02***	0.02	0.03
	Seaside resort	−0.17***	−0.20	−0.14	14.87***	12.41	17.34	0.03***	0.02	0.04
	Other coast	−0.09***	−0.13	−0.05	9.80***	6.31	13.30	0.03***	0.02	0.05
	R^2	0.320			0.361			0.327		
	N = 71,603									
Model 2	*Fully-adjusted*[a]									
	Constant	2.78	2.70	2.86	84.29	77.71	90.87	2.23	2.20	2.26
	Visit location (urban greenspaces = ref)									
	Countryside	0.07***	0.06	0.09	1.68*	0.16	3.20	0.02***	0.01	0.02
	Seaside resort	−0.17***	−0.20	−0.14	7.57***	4.88	10.26	0.02**	0.01	0.03
	Other coast	−0.09***	−0.14	−0.04	4.20*	0.36	8.03	0.03**	0.01	0.05
	R^2	0.313			0.273			0.276		
	N = 56,568									
Model 3	*Fully-adjusted*[a]									
	Constant	2.75	2.68	2.82	99.42	32.36	93.40	2.35	2.32	2.37
	Visit location (urban greenspaces = ref)									
	Countryside	0.05***	0.04	0.07	1.30n.s	−0.09	2.69	0.01**	0.00	0.02
	Seaside resort	−0.17***	−0.20	−0.14	10.94***	8.43	13.45	0.03***	0.02	0.04
	Other coast	−0.08***	−0.13	−0.04	5.56**	2.01	9.10	0.02**	0.01	0.04
	R^2	0.332			0.321			0.301		
	N = 66,153									
Walkers only	*Fully-adjusted*[a]									
	Constant	2.98	2.96	3.00	60.11	54.52	65.71	2.18	2.15	2.21
	Visit location (urban greenspaces = ref)									
	Countryside	−0.04***	−0.04	−0.03	0.95n.s	−0.29	2.19	0.01***	0.01	0.02
	Seaside resort	0.01*	0.00	0.02	10.66***	8.02	13.30	0.07***	0.05	0.08
	Other coast	−0.00n.s	−0.02	0.01	15.06***	11.30	18.81	0.10***	0.07	0.12
	R^2	0.354			0.104			0.125		
	N = 33,408									

LB Lower-bound; UB Upper-bound; *** $p < .001$; ** $p < .01$; * $p < .05$; n.s not significant.

[a] Adjusted for a) data on physical activity in the last week, b) individual-level data on gender, age, socio-economic status, work status, marital status, ethnicity and disability and; c) visit-level data on the presence of children, adults, and dogs on visits; day of the week; visit frequency in the last week; visit start point, season of visit and survey year.

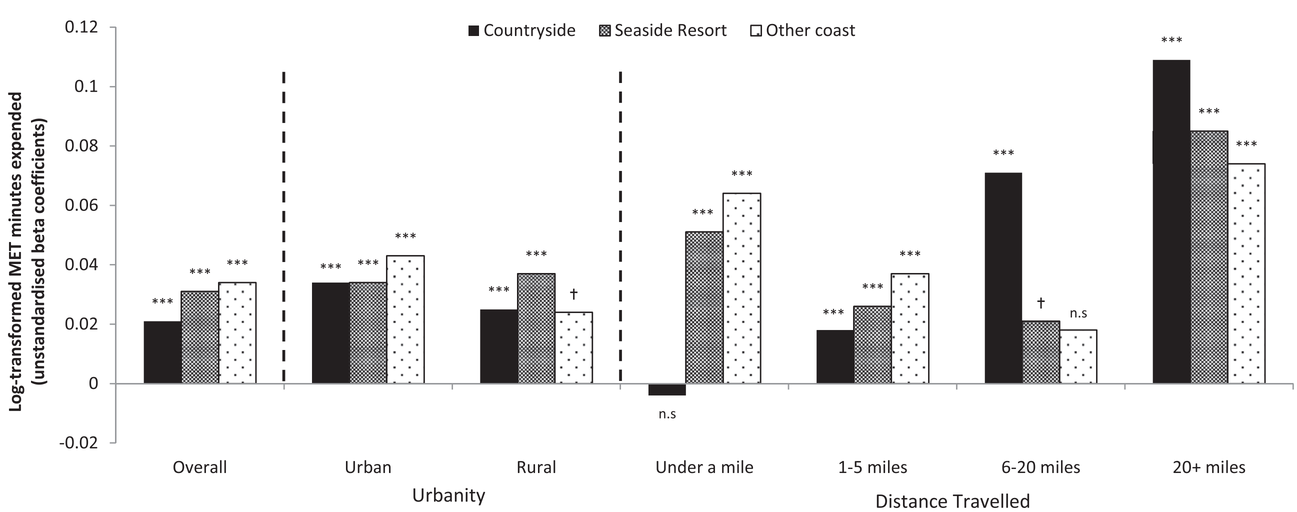

Fig. 1. Overall and stratified effects of visited environment on total MET minutes expended (model 1). Overall n = 71,603; urban n = 54,613; rural n = 15,392; under a mile n = 27,458; 1–5 miles n = 29,516; 6–20 miles n = 9733; 20+ miles n = 4896. Adjusted for a) data on physical activity in the last week, b) individual-level data on gender, age, socio-economic status, work status, marital status, ethnicity and disability and; c) visit-level data on the presence of children, adults, and dogs on visits; day of the week; visit frequency in the last week; visit start point, season of visit and survey year. ***comparison to the reference category (urban greenspaces) is significant at the $p < 0.001$ level. †comparison to the reference category (urban greenspaces) significant at the $p < 0.1$ level. n.s comparison to the reference category (urban greenspaces) is non-significant.

were still associated with more MET minutes than urban greenspaces, the order was different with seaside resorts averaging the most, followed by other coast, and then the countryside. The "walkers only" model displayed the same pattern as model 1, though differences between environments were greater. As associations did not change substantially as a function of the model used, and as we deem respondents to have actually reported the duration of time in the natural environment (rather than including travel time) the remainder of the analysis is conducted using model 1.

3.4.4. Sensitivity analysis

Model 1 regressions were repeated excluding dog-walking visits (32.3% of visits; see 2.4). Excluding these resulted in higher METs and longer durations in all environments but associations did not change systematically. The order in which environments were associated with MET minutes, however, did change. Countryside visits were now associated with the most ($b = 0.05$, 95% CI 0.04, 0.06), followed by other coastline ($b = 0.04$, 95% CI 0.02, 0.05) and seaside resorts ($b = 0.03$, 95% CI 0.02, 0.04), suggesting that more dog-walking visits took place in the countryside. However, as significance did not substantially change after exclusion, dog-walking visits were retained in all further analysis.

3.5. Are the relationships between environments and MET minutes moderated by urbanity?

For stratified regression results, consult Supplementary Tables H And I. Urban inhabitants expended most MET minutes in other coastline environments ($b = 0.04$, 95% CI 0.03, 0.06), followed by seaside resorts ($b = 0.03$, 95% CI 0.02, 0.05), and the countryside ($b = 0.03$, 95% CI 0.03, 0.04). Rural inhabitants expended the most MET minutes in seaside resorts ($b = 0.04$, 95% CI 0.02, 0.06), followed by the countryside ($b = 0.02$, 95% CI 0.01, 0.04), and other coastline ($b = 0.02$, 95% CI −0.00, 0.05) which in turn were only associated with marginally more than urban greenspaces. Concisely, whilst urban greenspaces were still associated with less energy expenditure than visits to other environments, urban inhabitants expended the most energy at other coastline environments and rural inhabitants at seaside resorts.

3.6. Are the relationships between environments and MET minutes moderated by travel distance?

Respondents who travelled under a mile to their destination expended more MET minutes in seaside resorts ($b = 0.05$, 95% CI 0.03, 0.07) and other coastline ($b = 0.06$, 95% CI 0.04, 0.09) but not in the countryside ($b = -0.00$, 95% CI −0.01, 0.01) compared to urban greenspaces. Respondents travelling 1–5 miles displayed the same pattern as the original regression whilst those who travelled 6–20 miles only expended significantly more MET minutes in the countryside ($b = 0.07$, 95% CI 0.06, 0.09) compared to urban greenspaces. Lastly, respondents travelling over 20 miles expended more MET minutes in all environments compared to urban greenspaces, but the order is the reverse of the original regression. In sum, respondents situated within a mile of the coastline expended more energy in these environments, and respondents travelling farther distances expended more energy in the countryside.

4. Discussion

This is the first study to illustrate how the English population expend energy in diverse natural environments through recreation, as well as how long and short-distance travellers, and urban and rural dwellers do so differently. Countryside and urban greenspace visits were associated with more intense activities than coastal visits. However, longer durations of coastal visits meant that these were associated with the most energy expenditure. Moreover, these relationships persisted using multiple model permutations which accounted for potentially different reportage of visit durations. Urban and rural inhabitants demonstrated higher energy expenditure in all environments compared to urban greenspaces, though the order and significance of these comparisons differed. Coasts were used for more MET minutes by locals than urban greenspaces and countryside were. However people travelling over 6 miles expended more energy in the countryside than in the other three environments.

4.1. Affordances of outdoor activity

Different natural environments promote different types of recreational visit, and can thus impact on the health benefit of such visits. Environments offer 'affordances' that elicit behaviour (Gibson, 1979) and whilst these exist in reality they better reflect relationships between environments and individuals (Heft, 2010). The findings suggest coasts are associated with visits incurring the most energy expenditure, and this appears to be driven by longer durations. Coasts could therefore be said to 'afford' longer bouts of lower-intensity PA resulting in higher overall energy expenditure. In Heft's (2010) view this could mean that there are less barriers to (or more opportunities for) longer visits when individuals visit the coast. This could be due to the variety of recreational opportunities in coastal environments (Wyles et al., 2014).

Nevertheless, individuals who visited countryside or urban greenspace environments were more inclined to do more intense activities. This may be because opportunities for more intense activity are better afforded by these areas. Running may be more suited to countryside and urban greenspaces where circular routes are more easily defined than they would be at the coast for example. The more intense activities possible in coastal locations (swimming and watersports) only attracted 0.7% of the sample (Table 1) perhaps because there are more barriers to these activities e.g. higher fitness or greater expertise. Again this supports the notion that whilst affordances are tangible (e.g. the sea affords swimming), they also reflect individual perceptions (e.g. more people perceive barriers towards watersports; less people perceive barriers to running in greenspaces).

Knowledge of which environments afford health-enhancing PA can aid tailored exercise promotion with consequent implications for public health. For example, people who enjoy running could be advised to visit green environments where this may be better facilitated. If an individual prefers lower intensity activity, a coastal visit could be encouraged, where, because longer visit durations are probable, they may be more likely to expend additional energy. Clearly, cognitive antecedents of environment and activity choice need to be better understood in order to facilitate such interventions. Nevertheless, distinguishing environmental affordances makes these recommendations at least feasible, where previous research dichotomising urban and natural spaces could not (Lee and Maheswaran, 2011).

4.2. Urban and rural distinctions

Rural inhabitants expended more energy on visits than urban residents, but the differences between environments were more modest. Previous research has demonstrated that proximity to accessible greenspaces may be most important for urban populations in terms of self-reported health (Maas et al., 2006; Mitchell and Popham, 2007). As such, rural inhabitants may display similar energy expenditure in different environments because proximity to them is less important. Indeed, in a previous study, rural inhabitants were more willing to travel further to recreational facilities (Solomon et al., 2013).

4.3. Travel distance

Coastal visits were associated with more energy expenditure than urban greenspace and countryside visits, but this relationship was most prominent in local visitors (people travelling less than a mile). This could explain why previous research has found English coastal residents to be more active (White et al., 2014) and report higher self-reported health (Wheeler et al., 2012). People travelling farthest tended to expend more energy in countryside environments. Again, this may be because coasts better afford long bouts of low-intensity activity (e.g. sunbathing) for long-distance travellers, whereas the countryside affords long bouts of at least moderate-intensity activity (e.g. hill-walking) for long-distance travellers. This finding may further reflect a distance decay effect, well recognised in tourism geography (McKercher, 2008), whereby the proportion of people who perceive a particular activity affordance associated with an environment declines with increasing travel distance to that environment.

4.4. The relative importance of the environment to energy expenditure

An estimation of the relative importance of the visited environment in predicting energy expenditure can be derived from comparing coefficients with those for other factors such as season, SES and gender. Taking Model 1 (Supplementary Table D) we can see that, compared to urban greenspaces, the coefficients for log-transformed MET minutes of countryside (0.02), seaside resorts (0.03) and other coast (0.03) appear relatively small (though these are all based on log-transformations). Nevertheless they are comparable to the effects of season (e.g. autumn vs. winter $= 0.03$), larger than SES (e.g. DE vs. AB $= 0.01$) and only a little smaller than gender (female vs. male $= -0.05$). In other words, the environment seems to play just as important a role in influencing energy expenditure as socio-demographic and seasonal variables.

4.5. Limitations and future research

The main strength of this research is that it utilised a large sample to highlight how visits to different natural environments can be more or less health-enhancing. Future GPS research could investigate how different environments afford different PA intensities. Furthermore, the health benefits of urban greenspace visits, which were visited most often by this sample (see 2.3.1), could be clarified by establishing estimates of how much energy is expended on urban or indoor leisure visits. Also, the shorter length of urban greenspace visits may not be a negative in terms of overall energy expenditure, as visitors may substitute other time with health-enhancing activity elsewhere such as in gyms. Additionally, our analysis is unable to account for any effects of 'moral self-licensing' (Merritt et al., 2010) where for instance, because an individual has engaged in a longer walk (something 'good'), they feel able to 'treat themselves' to a bigger piece of cake (something 'bad') resulting in overall energy intake which may be greater than that expended (e.g. Dolan and Galizzi, 2015). Further work is thus needed to focus on more extensive observations of specific visits to see whether certain types of visit are more likely to result in such 'moral self-licensing' than others, with implications for public health interventions.

This research is cross-sectional and thus subject to a number of limitations. For example, it implies that coastal locals use coasts in more health-enhancing ways than other environments. However, this research is unable to establish whether moving residence to coasts results in more active use of them, or whether more active people move there to seek PA opportunities. Although longitudinal designs for similar studies have been developed using panel data (e.g. White et al., 2013a,b), there is currently no comparable data on contact with natural environments so at present these limitations are difficult to address.

Furthermore, METs are a standardised unit of energy expenditure and subject to criticisms of generalizability. Energy expenditure involved in PA is dependent on factors such as body mass and terrain (Ainsworth et al., 2000). For example, walking on softer substratum like sand substantially affects energetic costs (Lejeune et al., 1998). Also, two activities in the study involve energy intake (eating or drinking out; picnicking) which cannot be accounted for. Despite this, measuring energy expenditure objectively with accelerometry may not be feasible on a similar scale (Trost et al., 2005). Additionally, despite establishing the robustness of our results using different model permutations, it is not possible to determine precisely how long an individual was in an environment doing a particular activity; this is a priority for future research.

Lastly, despite the potential for health-enhancing PA opportunities in more expansive environments, access to these areas is impractical for all of the population and therefore research is needed to isolate features of environments that promote behaviour such as longer visit durations. Knowledge of these could in turn inform urban park and trail design, for instance, to encourage urban areas to be used for longer bouts of activity. These need not be physical features as previous research has shown auditory water stimuli in urban areas is appreciated (Völker and Kistemann, 2013) and can positively influence visitation (Yang and Kang, 2005).

4.6. Conclusion

When undertaking recreational visits to natural environments, people visiting more expansive types such as coasts and countryside often expend more energy. Although statistically the effects reported in this study are small, at a population level the differences could be substantial. Furthermore, isolating how different environments afford different activities could allow future PA promotion to be tailored more closely to the interests and dispositions of target groups, especially those who undertake relatively little PA at present. Designers should consider what volumes and intensities of physical activity they wish to elicit when designing new recreational spaces or routes so the correct environmental qualities for eliciting such behaviour are selected. Knowing the behavioural affordances of a more diverse range of natural environments provides a useful starting point.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.socscimed.2015.06.038.

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