Preventive Medicine 91 (2016) 383–388

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Recreational physical activity in natural environments and implications for health: A population based cross-sectional study in England

M.P. White [a,*], L.R. Elliott [a], T. Taylor [a], B.W. Wheeler [a], A. Spencer [b], A. Bone [c], M.H. Depledge [a], L.E. Fleming [a]

[a] European Centre for Environment & Human Health, University of Exeter Medical School, Knowledge, Spa, Royal Cornwall Hospital Treliske, Cornwall, TR1 3HD, United Kingdom
[b] Health Economics Group, University of Exeter Medical School, South Cloisters, St Luke's Campus, Exeter EX1 2LU, United Kingdom
[c] Public Health England, Environmental Change Department, 133–135 Waterloo Road, London SE1 8UG, United Kingdom

ARTICLE INFO

Article history:
Received 13 May 2016
Received in revised form 25 July 2016
Accepted 15 August 2016
Available online 9 September 2016

Keywords:
Physical activity
Natural environments
Quality adjusted life years
England

ABSTRACT

Background. Building on evidence that natural environments (e.g. parks, woodlands, beaches) are key locations for physical activity, we estimated the total annual amount of adult recreational physical activity in England's natural environments, and assessed implications for population health.

Methods. A cross-sectional analysis of six waves (2009/10–2014/5) of the nationally representative, Monitor of Engagement with the Natural Environment survey ($n = 280{,}790$). The survey uses a weekly quota sample, and population weights, to estimate nature visit frequency across England, and provides details on a single, randomly selected visit ($n = 112{,}422$), including: a) duration; b) activity; and c) environment type.

Results. Approximately 8.23 million (95% CIs: 7.93, 8.54) adults (19.5% of the population) made at least one 'active visit' (i.e. ≥30 min, ≥3 METs) to natural environments in the previous week, resulting in 1.23 billion (1.14, 1.32) 'active visits' annually. An estimated 3.20 million (3.05, 3.35) of these also reported meeting recommended physical activity guidelines (i.e. ≥5 × 30 min a week) fully, or in part, through such visits. Active visits by this group were associated with an estimated 109,164 (101,736, 116,592) Quality Adjusted Life Years (QALYs) annually. Assuming the social value of a QALY to be £20,000, the annual value of these visits was approximately £2.18 billion (£2.03, £2.33). Results for walking were replicated using WHO's Health Economic Assessment Tool.

Conclusions. Natural environments provide the context for a large proportion of England's recreational physical activity and highlight the need to protect and manage such environments for health purposes.

1. Introduction

Regular physical activity is associated with a decreased risk of obesity, coronary heart disease, diabetes, some cancers, mental ill health, and mortality (National Institute for Health Care Excellence, 2008; World Health Organization, 2009). Nevertheless, in England only 34% of adults report meeting the minimum recommended weekly levels of activity (i.e. 5 × 30 min) (Bélanger et al., 2011), and inactivity is estimated to cost the healthcare system more than £1 billion annually (Scarborough et al., 2011). Consequently, there is great interest in understanding the barriers to, and enablers of, physical activity, including the role of environmental factors (Ding et al., 2012; National Institute for Health Care Excellence, 2012; Ogilvie et al., 2007). Although explicitly linked to health promotion for centuries (Thompson, 2011), the potential of 'natural environments', such as parks, woodlands and beaches, to support and encourage regular outdoor physical activity has only been investigated systematically, relatively recently (Hunter et al., 2015). Crucially, natural environments offer opportunities for informal or incidental physical activity among those who, for lack of time, money or confidence, are reluctant to participate in organised sports or gym-related activities (Schutzer and Graves, 2004; Withall et al., 2011).

To date, however, most studies have examined the relationship between a person's self-reported physical activity level *in general* and their proximity to natural environments *in general* without exploring how much activity occurs in outdoor natural settings (Hunter et al., 2015). Although several studies have monitored physical activity in adults and children using accelerometers and GPS trackers, these studies tend to involve few individuals making it hard to generalise to an entire population (Evenson et al., 2013; Wheeler et al., 2010). We know of no previous attempt to estimate either the total amount of physical activity that takes place in an entire country's varied natural environments, or the potential benefits to population health of such activities. The aim of the current research was to address these gaps.

Specifically, we estimated annual adult levels of physical activity occurring in natural environments across England, using data from the

* Corresponding author.
E-mail addresses: mathew.white@exeter.ac.uk (M.P. White), l.r.elliott@exeter.ac.uk (L.R. Elliott), t.j.taylor@exeter.ac.uk (T. Taylor), b.w.wheeler@exeter.ac.uk (B.W. Wheeler), a.e.spencer@exeter.ac.uk (A. Spencer), angie.bone@phe.gov.uk (A. Bone), m.depledge@exeter.ac.uk (M.H. Depledge), l.e.fleming@exeter.ac.uk (L.E. Fleming).

http://dx.doi.org/10.1016/j.ypmed.2016.08.023
0091-7435/

Monitor of Engagement with the Natural Environment (MENE) Survey (Natural England, 2015a). The MENE is a nationally representative survey investigating visits to natural environments for recreational purposes, and survey weights allow population estimates of visit type and frequency. As physical activity needs to be both regular and sustained to benefit health (Haskell et al., 2007), our assessment of the health implications of nature visits focused on those individuals who met recommended physical activity guidelines either fully, or partly, in natural environments. The potential health effects associated with this cumulative level of activity were considered in terms of Quality Adjusted Life Years (QALYs) (Beale et al., 2012), and a monetary estimate of the social value of these QALYs made. (National Institute of Health and Care Excellence, 2013) Finally, a robustness check of this estimate (focused on walking) was conducted using the World Health Organisation's, Health Economic Assessment Tool (HEAT).

2. Methods

2.1. Study design and sample

Data were from Waves 1–6 (years 2009/10–2014/5) of the MENE survey. The MENE is a repeat cross-sectional survey of over 40,000 adults annually (total $n = 280{,}790$). It is commissioned by Natural England and is part of a face-to-face nationally representative omnibus survey conducted throughout the year to reduce seasonal biases. Data are collected via in-home interviews using Computer Assisted Personal Interviewing (CAPI) (Natural England, 2015a). Respondents are asked about occasions in the last week when they spent leisure time "out of doors", defined as, "*open spaces in and around towns and cities, including parks, canals and nature areas; the coast and beaches; and the countryside including farmland, woodland, hills and rivers. This could be anything from a few minutes to all day. It may include time spent close to your home or workplace, further afield or while on holiday in England. However, this does not include routine shopping trips or time spent in your own garden*" (p.35) (Natural England, 2015a). Approximately 40% of respondents report at least one visit in the last week. General information is collected about all visits, and detailed data are collected for a single visit ($n = 112{,}422$), randomly selected (via CAPI) from those taken in the last week.

Based on participant demographic profiles and frequency of visits, Natural England developed two weighting variables relevant here: a) 'weekweight', and b) 'weekVweight'. The use of these weights was necessary to make extrapolations from the current sample of individuals and visits per year, to the entire adult population. Details of the derivation and testing of these weights are provided elsewhere, [Appendix *A*1 and ref Natural England, 2015b]. Current analyses estimating population totals and demographic sub-groups making active visits to natural environments in the last week were weighted using 'weekweight'. Analysis of the total annual number of visits, as well as activities undertaken and environment types visited, used the 'weekVweight'. Our institutional ethics board did not require a formal ethics application for the current analysis of this secondary, publically available, anonymised data.

2.2. Data and variables

The main visit variables of interest were: a) duration; b) activity; and c) environment type. For estimating health-related implications, we were also interested in physical activity in general.

Visit duration was estimated by asking, *"How long did this visit last altogether –that is from the time you left to when you returned?"*. Estimates for time spent in the natural environment were derived after subtracting estimated travel time; the latter based on: a) distance travelled; and b) mode of transport (Appendix A2, and ref (Elliott et al., 2015)). To avoid suggesting over precise duration estimates, duration was dichotomised as being either <30 or ≥30 min, a meaningful threshold in terms of meeting the recommended physical activity guidelines.

Although respondents could select multiple activities from a list of 19, our main analyses only included visits involving a single activity as it was impossible to estimate duration for each activity on multi-activity visits. Based on the Compendium of Physical Activities (Ainsworth et al., 2011), Metabolic Equivalence of Task (MET), rates for each MENE activity have been developed (Appendix A3, (Elliott et al., 2015)). One MET is equivalent to a standard resting metabolic rate of 3.5 ml of oxygen consumption per kg of body weight, per minute engaged in an activity. METs are thus a ratio of the metabolic rate associated with an activity compared to this resting rate. Our main analyses focused on those activities categorised as either 'moderate' (i.e. 3–5.9 METs) or 'vigorous' (i.e. ≥6 METs) in intensity, i.e. those most linked to health (Ainsworth et al., 2011; US Department of Health, 2008).

Regarding environment type, respondents could select from one or more categories: 'a park in a town or city' (*town park*), 'a children's playground' (*play area*), 'a playing field or other recreation area' (*play area*), 'another open space in a town or city' (*open space*), 'an allotment or community garden (*allotment*)', 'a country park' (*country park*), a 'woodland or forest' (*woods*), 'farmland' (*farmland*), 'a river lake or canal' (*waterway*), 'a mountain, hill or moorland' (*uplands*), 'a village', 'a path, cycleway or bridleway' (*path*), 'open space in the countryside' (*open country*), 'a beach' (*beach*), 'other coastline' (*coast*); and 'Other'. Visits involving multiple environments were classified as 'Mixed' (Appendix A4). As the chosen visit was randomly selected from all visits in the last week, we assumed it was representative in terms of duration, activity and environment.

The following socio-demographic factors were considered in terms of who constituted 'active visitors': gender, age, socioeconomic status (Social Grades AB (Highest), C1, C2 and DE (Lowest); Appendix A5), urbanity of residence (Appendix A6), region of residence (9 Government Office Regions), and dog ownership.

Frequency of recreational and active travel-related physical activity was measured using the item: *'In the past week, on how many days have you done a total of 30 minutes or more of physical activity, which was enough to raise your breathing rate? This may include sport, exercise, and brisk walking or cycling for recreation or to get to and from places, but should not include housework or physical activity that may be part of your job'*. For current purposes, respondents were dichotomised as either 'sufficiently active individuals' (i.e. ≥5 days) or 'insufficiently active individuals' (i.e. <5 days). Although health gains may still be made with $<5 \times 30$ min a week, (Wen et al., 2011) we adopted the more conservative threshold.

2.3. Estimating potential health gains

Building on an estimation of the benefits to health associated with a scheme to promote walking in natural environments, (Natural England, 2009) the current study estimated the potential value to health associated with a wider range of physical activities undertaken during recreational visits to natural environments across England, using a much larger and more representative sample, and calculated the Quality Adjusted Life Years (QALYs) associated with these visits. QALYs are a metric used to compare the health benefits associated with different health-related interventions, where one QALY is equivalent to one year lived in full health. In the current analysis, we used QALY estimates derived by (Beale et al. (2012); Beale et al., 2007) which aimed to estimate the potential health benefits of "*environmental interventions to promote physical activity*" (20, p.26). Based on analysis of Health Survey for England data, (Beale et al. (2007)) estimated that 30 min a week of moderate-intense physical activity, if undertaken 52 weeks a year, would be associated with 0.010677 QALYs per individual, per year. Beale et al. (2007) also assumed that the relationship between physical activity and QALYs is both cumulative and linear (e.g. 2×30 min $\times 52$ weeks $=$ 0.021354 QALY, Appendix A7).

As well as enabling comparisons of health gains across a range of interventions, the QALY is also used to evaluate the relative cost effectiveness of interventions by the National Institute for Health and Care Excellence (NICE). At the time of writing, the implicit social value of a QALY in England, based on the NICE cost-effectiveness threshold, was £20,000. Specifically, NICE states that: "generally we consider that interventions costing the NHS less than £20,000 per QALY gained are cost-effective", (National Institute of Health and Care Excellence, 2013) implying that enhancing health by a single QALY is saving up to £20,000 in health care costs (for further discussion of the NICE threshold see (Claxton et al., 2015; Barnsley et al., 2013)). Of note, the earlier Natural England study used the higher QALY value of £30,000 to estimate a monetary value of the health gains from the Walking to Health Initiative (Natural England, 2009).

To test the robustness of our monetary estimates of potential health gains using QALYs, we conducted a similar analysis using WHO's HEAT tool (http://www.heatwalkingcycling.org/). This approach estimates the number of lives saved through sufficient physical activity (via walking and cycling only), and makes monetary estimates using the 'value of a statistical life', which at the time of writing was £3,229,114, per person. As the HEAT tool only estimates the value of two activities, we selected the most frequent activity (i.e. walking) to compare across both valuation approaches. The HEAT analysis requires: a) the number of walkers, b) the average per capita amount of time spent walking, and c) the regularity of walking, and does not require that individuals meet the 5 × ≥ 30 min threshold. However, in order to keep the two estimates as comparable as possible we only included walkers who did report 5 × ≥ 30 min overall, even if not all of this was in natural environments (Appendix A8).

3. Results

Pooling data across the six waves, and using annual population weights (Table 1), the estimated number of people who made 'active visits' (i.e. ≥30 min and ≥3METs) to natural environments in any given week was 8.23 million (95% CIs: 7.93, 8.54 million) individuals, or 19.5% of the adult population of England. The vast majority, 7.72 million (7.44, 7.99), made visits associated with moderate levels of activity (3–6 METs). Only 0.52 million (0.47, 0.56) engaged in vigorous activities (≥6 METs). Across the year, the total number of visits was approximately 2.83 billion (2.66, 2.99), of which 51.5% (1.23 billion) were categorised as 'active' (of note many individuals made more than one visit per week which is why these figures are not simply visitor numbers multiplied by 52 weeks).

Further details on the demographic profiles of all visitors to nature and the subset who engaged in active visits are presented in Supplementary Table A. Gender, age, urban-rural, and region profiles of active vs. non-active visitors were all relatively close to the overall population distribution. Reflecting potential income-related inequalities in the use of natural environments, individuals in the highest socio-economic groups (24.4% of the population) accounted for 30.9% of all visits and 30.1% of active visits; while those in the lowest socio-economic groups (26.2% of the population) accounted for 19.3% of all visits, and 19.9% of active visits. Thus although less likely to visit in general, individuals in the lowest socio-economic groups were just as likely as those in the highest socio-economic groups to be active on any given visit.

Table 2 presents a summary of activities engaged in during visits. The most frequent moderate-intensity activity visits (3–6 METs) ≥30 min were walking, either with a dog, or without a dog. Running and road cycling were the most popular vigorous-intensity activities (≥6METs). Table 3 presents data on where these active visits took place, broken down into moderate- and vigorous- intensity. Nearly a quarter of visits associated with moderate activities, and an eighth of vigorous activities, took place in urban parks. Popular rural locations for moderate physical activity included: woodlands, open countryside, and country parks; and for vigorous physical activity included: open countryside, pathways, and farmland. Aquatic (or 'blue space') settings including inland waterways, beaches and coasts were also popular, accounting for 12.6% of moderate-intensity visits, and 9.6% of vigorous-intensity visits.

In order to explore the potential health implications from active visits to nature we identified those individuals who met physical activity guidelines fully, or in part, via nature visits. This group (Table 4) consisted of individuals who said they met guidelines and made from 1 (n = 939,833) through to ≥5 (n = 1,007,333) active visits to nature last week; alongside those who said they did not meet guidelines but nonetheless made ≥5 active nature visits in the last week (n = 376,833). In total this added up to approximately 3.20 million (3.05, 3.35) individuals, or approximately 7.6% of the population. Of note, we also identified 4.32 million (4.24, 4.39) individuals (10.2%) who also met guidelines but reported *no visits* to nature in the last week.

Using (Beale et al.'s (2007)) calculations, we assigned a QALY value to each individual commensurate with their respective level of activity in nature (i.e. 0.010677 per weekly visit), allowing us to isolate the contribution to health from activity in nature alone. Multiplying the number of individuals who made 1–5 visits by the relevant QALY values, and summing the results, provided an overall population estimate of 109,164 (95% CIs: 101,736, 116,592) QALYs per year. Assuming the social value of a QALY to be £20,000, the estimated welfare gain was in the order of £2.18 billion (95% CIs: £2.03, 2.33) per year.

To explore the robustness of this estimate, we estimated the number of 'active individuals' whose 'active visits' to nature consisted of walking using both the QALY and HEAT tool approach. Using the QALY approach, 'walkers' accounted for an estimated 79,673 QALYs annually and a potential health gain worth £1.59 billion (Supplementary Table B). Using the HEAT approach, walkers constituted, on average, 2.12 million individuals annually, the average number of walking visits (≥30 min) was 3.7 per person, and 93% said they walked in nature at least weekly. To simplify the estimate, we made the assumption that all walkers visited weekly but made just 3 × 30 min visits. Based on this approach, the

Table 1
Weekly and annual visits to natural environments in England (annual averages, 2009/10–2014/15).

		Visitors to nature last week		Visits to nature per year	
		N/%	(Std Error)	N/%	(Std error)
No visits		24,520,834	(257,657)	–	–
	%	58.2	(0.6)	–	–
Selected visit <30 min					
Low intensity		108,000	(13,672)	12,679,333	(1,503,775)
	%	0.3	(0.0)	0.5	(0.1)
Moderate intensity		3,958,833	(61,678)	978,235,167	(8,326,602)
	%	9.4	(0.2)	40.1	(1.4)
Vigorous intensity		478,000	(22,661)	74,750,000	(4,115,821)
	%	1.1	(0.5)	3.1	(0.1)
≥30 min					
Low intensity		937,000	(64,687)	92,283,833	(8,326,602)
	%	2.2	(0.1)	3.9	(0.3)
Moderate intensity		***7,717,833***	***(140,247)***	***1,164,152,000***	***(40,479,926)***
	%	***18.3***	***(0.3)***	***48.7***	***(0.5)***
Vigorous intensity		***516,667***	***(20,390)***	***65,191,667***	***(4,243,887)***
	%	***1.2***	***(0.1)***	***2.7***	***(0.1)***
Indeterminate					
Other activity		673,334	(41,913)	97,038,500	(7,916,617)
	%	1.6	(0.1)	3.4	(0.3)
Multiple activities		3,258,667	(149,743)	345,169,500	(21,500,627)
	%	7.7	(0.3)	12.2	(0.5)
	Total	42,169,168	(249,673)	2,829,500,000	(85,770,489)
Total "Active" Visitors/visits		***8,234,500***	***(156,781)***	***1,229,343,667***	***(43,978,103)***
	%	***19.5***	***(0.30)***	***51.5***	***(0.56)***

*Bold/Italic = defined as 'Active visits' in the present analysis.

Table 2
What did people do on visits to natural environments in England (2009/10–2014/15)?

	MET rate	<30 min		≥30 min	
		N/%	(Std error)	N/%	(Std error)
Low intensity activities (<3 METs)					
Appreciate scenery from car	1.30	1,617,333	(232,470)	6,631,500	(708,871)
		0.1	(0.0)	0.5	(0.1)
Eat or drinking out	1.75	5,873,667	(629,635)	57,294,167	(8, 827,069)
		0.6	(0.1)	4.3	(0.5)
Picnicking	1.75	1,433,333	(380,262)	8,571,833	(624,199)
		0.1	(0.0)	0.7	(0.0)
Beach, sunbathing or paddling	1.90	1,791,834	(360,832)	11,715,000	(485,161)
		0.2	(0.0)	0.9	(0.1)
Wildlife watching	2.50	1,960,167	(312,877)	8,068,667	(728,681)
		0.2	(0.0)	0.6	(0.1)
Sub-total		*12,679,333*	*(1,503,775)*	*92,283,833*	*(8,326,602)*
		1.1	(0.2)	7.0	(0.3)
Moderate intensity activities (3–5.99 METs)					
Walking with a dog	3.00	722,121,167	(16,100,161)	582,460,167	(20,496,807)
		67.8	(0.7)	44.1	(0.5)
Walking without a dog	3.50	224,349,000	(7,089,819)	341,859,667	(14,518,012)
		21.1	(0.6)	25.9	(0.2)
Visiting an attraction	3.50	362,500	(124,813)	10,745,000	(552,215)
		0.0	(0.0)	0.8	(0.0)
Fishing	3.50	2,962,000	(452,173)	34,408,833	(2,303,608)
		0.3	(0.0)	2.6	(0.2)
Playing with children	3.58	16,110,000	(864,752)	94,787,000	(6,026,950)
		1.5	(0.1)	7.1	(0.3)
Allotment/gardening	4.00	538,833	(197,208)	2,028,000	(206,751)
		0.1	(0.0)	0.2	(0.0)
Off road driving/motorcycling	4.00	5,721,500	(901,735)	8,360,500	(1,112,174)
		0.5	(0.1)	0.6	(0.1)
Informal games and sport (e.g. frisbee/golf)	4.43	2,750,833	(520,927)	60,780,167	(2,739,892)
		0.3	(0.0)	4.6	(0.3)
Horse riding	5.50	2,608,834	(634,641)	20,641,167	(1,306,467)
		0.3	(0.1)	1.6	(0.1)
Watersports	5.78	705,500	(140,380)	8,076,167	(751,669)
		0.1	(0.0)	0.6	(0.1)
Sub-total		978,235,167	(8,326,602)	***1,164,152,000***	***(40,479,926)***
		91.9	(1.4)	***88.1***	***(0.3)***
Vigorous intensity activities (≥6 METs)					
Swimming outdoors	6.00	1,055,000	(267,882)	3,680,000	(453,558)
		0.1	(0.0)	0.3	(0.0)
Fieldsports (i.e. hunting)	6.00	150,833	(77,969)	3,457,167	(319,643)
		0.0	(0.0)	0.3	(0.0)
Running	7.00	44,801,000	(2,869,166)	24,259,166	(1,888,832)
		4.2	(0.2)	1.8	(0.1)
Road cycling	7.50	23,968,833	(1,515,022)	21,227,334	(1,427,428)
		2.3	(0.1)	1.6	(0.1)
Off road cycling/mountain biking	8.50	4,771,834	(419,123)	12,565,667	(857,293)
		0.5	(0.0)	1.0	(0.0)
Sub-total		74,750,000	(4,115,821)	***65,191,667***	***(4,243,887)***
		7.0	(0.1)	***5.0***	***(0.1)***

Bold/italic = defined as 'Active visits' in the present analysis.

tool estimated that this amount of walking in natural environments was "likely to lead to a reduction in the risk of mortality of 6%" and that "the number of deaths per year prevented by this level of walking is: 542,". The tool concluded that the "annual benefit of this level of walking, per year, is: £1,750,922,000".

4. Discussion

The present study is, we believe, the first to estimate the total annual amount of physical activity associated with recreational visits to natural environments by adults for an entire country. Using 6 years of population-weighted survey data, our findings suggest that over 8 million adults in England regularly undertake meaningful physical activity in natural environments each week, and that for over 3 million of these individuals, this activity contributes to them achieving recommended guidelines for weekly physical activity. The implications for health among this subset, in terms of QALYs, was considerable, and potential financial implications, even from just walking (the most frequent activity), were large and consistent across both the QALY and HEAT tool approaches. Given that regular walking both reduces the risk of various health conditions (Hamer and Chida, 2008), and is feasible for many individuals (Ogilvie et al., 2004), further promotion of, and support for, walking in nature could be an important public health intervention. (Natural England, 2009).

Although natural environments were used for recreational physical activity by all sectors of society, a socio-economic gradient was observed. Nonetheless, the data also highlight that once in nature, individuals from all socioeconomic groups are equally likely to engage in physical activity which suggests that if they can be encouraged to visit more often or that access to local natural environments can be improved, all sectors of society could benefit (Mitchell and Popham, 2008). Given that growing urbanisation places a premium on previously undeveloped green and blue spaces in and around urban centres, a greater appreciation of the health benefits that might be lost during

Table 3
In which type of natural environments did 'active visits' in England take place (2009/10–2014/15)?

	Moderate intensity visits 3–5.99 METs (Annual M)		*Vigorous intensity visits ≥6 METs (Annual M)*	
	N/%	(Std error)	N/%	(Std error)
Town parks	272,409,5007	(12,2970,703)	13,644,500	(1,333,222)
	23.4	(0.4)	20.7	(0.9)
Play areas	88,372,167	(2,181,257)	2,550,833	(277,520)
	3.7	(0.1)	3.9	(0.2)
Open space towns	59,812,833	(3,707,415)	3,257,000	(558,036)
	5.1	(0.1)	5.1	(0.8)
Allotments	4,600,333	(349,158)	0	(0)
	0.4	(0.0)	0	(0)
Country parks	75,291,500	(3,745,706)	4,355,000	(366,573)
	6.5	(0.2)	6.7	(0.3)
Woodlands	102,087,833	(3,369,598)	4,626,500	(463,317)
	8.8	(0.2)	7.0	(0.4)
Inland waters	66,643,333	(3,369,597)	3,540,167	(325,030)
	5.7	(0.1)	5.5	(0.5)
Open countryside	83,000,333	(4,477,708)	3,715,000	(170,544)
	7.2	(0.6)	5.8	(0.3)
Farmland	46,245,000	(1,585,392)	1,794,833	(205,460)
	4.0	(0.1)	2.9	(0.4)
Uplands	17,043,667	(1,566,540)	1,715,333	(360,272)
	1.5	(0.1)	2.6	(0.5)
Pathways	52,354,333	(2,053,455)	9,583,833	(504,654)
	4.5	(0.1)	14.9	(0.7)
Beaches	51,364,167	(2495,8343)	1,681,833	(259,204)
	4.4	(0.2)	2.5	(0.3)
Other coast	27,983,167	(1,174,162)	1,057,333	(208,246)
	2.4	(0.1)	1.6	(0.2)
Other	28,309,333	(2,137,877)	2,553,167	(363,243)
	2.5	(0.2)	4.0	(0.5)
Multi-environment	188,627,167	(15,037,827)	11,109,333	(971,702)
	16.1	(0.8)	17.1	(1.1)
Total	***1,164,152,000***	***(40,479,926)***	***65,191,667***	***(4,243,887)***
	100*		100*	

Bold/italic = defined as 'Active visits' in the present analysis.
* Column totals may not sum to 100% due to rounding.

further development, especially in areas of relative deprivation, may help planning authorities make more informed decisions (Zhou and Wang, 2011).

We recognise that our estimates were based on comparing current baseline levels of physical activity in natural environments with a counterfactual of no physical activity occurring in these environments. They are not estimates based on a change in physical activity levels resulting from an intervention, nor do they examine the substitutability of physical activity across natural and urban/indoor locations. We therefore remain cautious, seeing our approach more as a tool for promoting discussion of how the potential health and wellbeing benefits of natural environments could be estimated. For instance, this approach might help in estimating the effects on the nation's health from large-scale environmental interventions that promote physical activity (e.g. the development of an English national coastal path, https://www.gov.uk/government/collections/england-coast-path-improving-public-access-to-the-coast), or widespread restrictions on access to natural environments resulting from events such as the 2001 UK Foot and Mouth outbreak, which as well as affecting the mental health of those directly involved, significantly restricted access for millions of visitors (Mort et al., 2005).

A number of further limitations need to be considered. The use of self-reported data assumes that respondents were: a) accurately reporting the duration of activities; b) engaging in the level of intensity associated with these activities, as set out by (Ainsworth et al. (2011)) for the entire visit duration; and c) accurately reporting the frequency of physical activity ≥30 min a week. Although we made several attempts to mitigate the effects of any violations of these assumptions in the current work (see Appendix A9) we remain cautious about over-interpreting the precise estimates made. Further research using more objective measures of naturalistic physical activity in different natural environments is needed to help assess the robustness of our assumptions and to provide more accurate assessments in future work.

Further, the conversion from physical activity in nature to QALYs is based on (Beale et al. (2007)) where there are number of uncertainties over how best to model the benefit of accrued exercise over time, or how to account for accidents and injuries, which would need to be explored in future work. Future research may also want to include physical activity undertaken in nature for occupational purposes (e.g. farming), by children, or in (private) gardens. Children were present on approximately 17% of all MENE visits by adults, and children make many visits without adult supervision (Page et al., 2009). Although private gardens did not count as natural environments in the MENE survey, gardening is one of the most popular outdoor physical activities, (Office for National Statistics, 2011) is associated with moderately-intensive activity, and encourages contact with the natural world. Moreover, physical activity in nature may be even better for people than physical activity in general (Thompson Coon et al., 2011), and even visits involving low levels of physical activity (e.g. picnics), may be associated with benefits to health via stress reduction (White et al., 2013), neither of which was investigated here.

We also recognise that as little as 90 min of moderate-vigorous physical activity a week can be beneficial for health (Wen et al., 2011). Thus although we selected a relatively conservative approach to identifying those who qualified as 'physically active' in our sample, future work might consider a lower threshold resulting in more individuals being included in future estimates. Future work, might also investigate the potential health benefits of particular types of natural environment or particular activities in natural settings at the population level (Willis et al., 2015; Papathanasopoulou et al., 2016). Finally, we were also unable to estimate the costs of sustainably managing environments and maintaining access, or the opportunity costs of alternative land use practices. Future work is needed to develop a full cost-benefit analysis that would take these, and other, factors into account (Natural England, 2012).

Table 4
Implications for health and welfare from 'active visits' to natural environments by 'active individuals' in England (2009/10–2014/15).

		Number of individuals		QALY value	QALYs (per year)		Annual welfare gain in £s (1 QALY = £20,000)	
Self-reported exercise a week	Active visits last week	N	(Std error)	Per person	N*	(Std error)	N*	(Std error)
≥5 × 30 min	*1*	939,833	(11,490)	0.010677	10,034	(123)	200,617,033	(2,431,401)
	2	450,500	(18,019)	0.021354	9619	(385)	192,399,540	(7,695,937)
	3	251,000	(9288)	0.032303	8108	(300)	162,161,060	(6,000,595)
	4	175,833	(8308)	0.042707	7509	(355)	150,186,283	(7,096,447)
	5	1,007,333	(44,625)	0.053384	53,775	(2382)	1,075,509,653	(47,645,863)
<5 × 30 min	*5*	376,833	(25,424)	0.053384	20,116	(1357)	402,337,413	(27,145,704)
TOTAL		3,201,332	(75,762)		109,164	(3790)	2,183,210,983	(75,788,102)

* Column totals are slightly different from the sum of the individual rows due to rounding.

5. Conclusions

A considerable amount of moderate-vigorous intensity recreational physical activity, predominantly walking, takes place in natural environments in England. Such activity is undertaken by all sectors of the population and may be more appealing, and thus more sustainable, than other forms of physical activity (e.g. gyms), for many individuals. Healthcare practitioners could use this evidence to support patients, especially those reluctant to engage in formal exercise programmes, recognise that even regular walks in the park can have meaningful benefits for their health. By beginning to understand the value to health from various natural settings, we may also better justify efforts to protect these settings from development or disrepair, and thus continue to offer the public health benefits envisaged by Victorian era park designers.

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ypmed.2016.08.023.

Conflict of interest statement

All authors declare no conflict of interest.

Acknowledgments

We would like to thank three reviewers of an earlier version of this manuscript for their insightful comments and suggestions on ways to improve the current paper. This work was supported by the National Institute for Health Research Health Protection Research Unit (NIHR HPRU) in Environmental Change and Health at the London School of Hygiene and Tropical Medicine in partnership with Public Health England (PHE), and in collaboration with the University of Exeter, University College London, and the Met Office. The funders had no role in the study design, analysis, interpretation of data, or decision to submit the article for publication. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR, the Department of Health, or Public Health England.

References

Ainsworth, B.E., Haskell, W.L., Herrmann, S.D., et al., 2011. 2011 compendium of physical activities: a second update of codes and MET values. Med. Sci. Sports Exerc. 43, 1575–1581.

Barnsley, P., Towse, A., Karlsberg Schaffer, S., Sussex, J., December 2013. Occasional paper - critique of CHE research paper 81: methods for the estimation of the NICE cost effectiveness threshold. (Downloaded on 8th March 2016 from) https://www.ohe.org/publications/critique-che-research-paper-81-methods-estimation-nice-cost-effectiveness-threshold#sthash.flHbT4ZM.dpuf.

Beale, S., Bending, M., Trueman, P., 2007. An Economic Analysis of Environmental Interventions That Promote Physical Activity. University of York: York Health Economics Consortium.

Beale, S.J., Bending, M.W., Trueman, P., Naidoo, B., 2012 Dec 1. Should we invest in environmental interventions to encourage physical activity in England? An economic appraisal. Eur. J. Pub. Health 22 (6), 869–873.

Bélanger, M., Townsend, N., Foster, C., 2011. Age-related differences in physical activity profiles of English adults. Prev. Med. 52, 247–249.

Claxton, K., Martin, S., Soares, M., Rice, N., Spackman, E., Hinde, S., Devlin, N., Smith, P.C., Sculpher, M., 2015. Methods for the Estimation of the National Institute for Health and Care Excellence Cost-Effectiveness Threshold. Feb 2015, Health Technology Assessment 19 p. 14.

Ding, D., Sallis, J.F., Conway, T.L., et al., 2012. Interactive effects of built environment and psychosocial attributes on physical activity: a test of ecological models. Ann. Behav. Med. 44, 365–374.

Elliott, L.R., White, M.P., Taylor, A.H., et al., 2015. Energy expenditure on recreational visits to different natural environments. *Soc. Sci. Med.* 139, 53–60.

Evenson, K.R., Wen, F., Hillier, A., et al., 2013. Assessing the contribution of parks to physical activity using GPS and accelerometry. Med. Sci. Sports Exerc. 45, 1981–1987.

Hamer, M., Chida, Y., 2008. Walking and primary prevention: a meta-analysis of prospective cohort studies. Br. J. Sports Med. 42, 238–243.

Haskell, W.L., Lee, I.M., Pate, R.R., et al., 2007. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Circulation 116, 1081–1093.

Hunter, R.F., Christian, H., Veitch, J., et al., 2015. The impact of interventions to promote physical activity in urban green space: a systematic review and recommendations for future research. Soc. Sci. Med. 124, 246–256.

Mitchell, R., Popham, F., 2008. Effect of exposure to natural environment on health inequalities: an observational population study. Lancet 372, 1655–1660.

Mort, M., Convery, I., Baxter, J., et al., 2005. Psychosocial effects of the 2001 UK foot and mouth disease epidemic in a rural population: qualitative diary based study. BMJ 331, 1234–1237.

National Institute for Health Care Excellence, 2008. Physical Activity and the Environment. NICE Public Health Guidance 8 (London).

National Institute for Health Care Excellence, 2012. Walking and cycling: local measures to promote walking and cycling as forms of travel. NICE Public Health Guidance 41.

National Institute of Health & Care Excellence, 2013. Judging whether public health interventions offer value for money (NICE advice LGB, 10). (Downloaded on 2th Feb 20–16 from:) https://www.nice.org.uk/advice/lgb10/chapter/judging-the-cost-effectiveness-of-public-health-activities.

Natural England, 2009. An estimate of the economic and health value and cost-effectiveness of the expanded WHI scheme (TIN055). (Accessed June 30th, 2015 from:) http://publications.naturalengland.org.uk/publication/35009.

Natural England, 2012. Costing the walking for health programme (NERC099). (Accessed June 30th, 2015 from:) http://publications.naturalengland.org.uk/publication/2188355.

Natural England, 2015a. Monitor of engagement with the natural environment. Technical Report 2013–14. London: Natural England (Accessed June 30th, 2015 from: http://publications.naturalengland.org.uk).

Natural England, 2015b. Weighting and analysing MENE data – a guide for SPSS and Excel users Accessed June 30th (from:) http://publications.naturalengland.org.uk/file/4633484557549568.

Office for National Statistics. Lifestyles and social participation (social trends 41). 2011. (Accessed 24th Feb 2016 from:) file:///C:/Users/Matbina/Downloads/st41lifestyle_tcm77–219087.pdf

Ogilvie, D., Egan, M., Hamilton, V., et al., 2004. Promoting walking and cycling as an alternative to using cars: systematic review. BMJ 329, 763–766.

Ogilvie, D., Foster, C.E., Rothnie, H., et al., 2007. Interventions to promote walking: systematic review. BMJ 334, 1204–1207.

Page, A.S., Cooper, A.R., Griew, P., et al., 2009. Independent mobility in relation to weekday and weekend physical activity in children aged 10–11 years: the PEACH project. Int. J. Behav. Nutr. Phys. Act. 6, 1–9.

Papathanasopoulou, E., White, M.P., Hattam, C., et al., 2016. Valuing the health benefits of physical activities in the marine environment and their importance for marine spatial planning. Mar. Policy 63, 144–152.

Scarborough, P., Bhatnagar, P., Wickramasinghe, K.K., et al., 2011. The economic burden of ill health due to diet, physical inactivity, smoking, alcohol and obesity in the UK: an update to 2006–07 NHS costs. J. Public Health (Oxf.) 33, 527–535.

Schutzer, K.A., Graves, B.S., 2004. Barriers and motivations to exercise in older adults. Prev. Med. 39, 1056–1061.

Thompson, C.W., 2011. Linking landscape and health: the recurring theme. Landsc. Urban Plan. 99, 187–195.

Thompson Coon, J., Boddy, K., Stein, K., Whear, R., Barton, J., Depledge, M.H., 2011. Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. Environ. Sci. Technol. 45, 1761–1772.

US Department for Health and Human Services, 2008. 2008 Physical Activity Guidelines for Americans. US Department of Health and Human Services, Washington DC.

Wen, C.P., Wai, J.P., Tsai, M.K., et al., 2011. Minimum amount of physical activity for reduced mortality and extended life expectancy: a prospective cohort study. Lancet 378, 1244–1253.

Wheeler, B.W., Cooper, A.R., Page, A.S., et al., 2010. Greenspace and children's physical activity: a GPS/GIS analysis of the PEACH project. Prev. Med. 51, 148–152.

White, M.P., Pahl, S., Ashbullby, K., Herbert, S., Depledge, M.H., 2013. Feelings of restoration from recent nature visits. J. Environ. Psychol. 35, 40–51.

Willis, K., Crabtree, B., Osman, L.M., et al., 20 July 2015. Green space and health benefits: a QALY and CEA of a mental health programme. J. Environ. Econ. Policy http://dx.doi.org/10.1080/21606544.2015.1058195 (Published Online First:).

Withall, J., Jago, R., Fox, K.R., 2011. Why some do but most don't. Barriers and enablers to engaging low-income groups in physical activity programmes: a mixed methods study. BMC Public Health 11, 1–13.

World Health Organization, 2009. Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks. World Health Organization, Geneva, Switzerland.

Zhou, X., Wang, Y.C., 2011. Spatial–temporal dynamics of urban green space in response to rapid urbanization and greening policies. Landsc. Urban Plan. 100, 268–277.