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Use of new guidance to profile 'equivalent minutes' of aerobic physical activity for adults in England reveals gender, geographical, and socio-economic inequalities in meeting public health guidance: A cross-sectional study

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ABSTRACT

English physical activity guidance now recognises a double weighting of vigorous over moderate activity; 1 min of vigorous activity is the same as two 'equivalent' minutes of moderate activity. In addition, concerns of over-estimation of occupational PA led to newly applied measurement methods for this domain. Vigorous activity is associated with higher socio-economic position and occupational PA has the opposite association, so these changes may increase inequalities. We profiled adults' total and domain-specific 'equivalent minutes' of weekly PA in England 2012, and investigated inequalities in PA participation, accounting for the new weighting of vigorous PA, and new measurements of occupational PA.

Nationally representative cross-sectional survey data on the self-reported PA of 8158 adults was used to produce a profile of the domain and duration of weekly 'equivalent minutes' of PA. Vigorous PA was double-weighted compared to moderate PA, and the percentage contribution from each PA domain quantified, stratified by gender and activity status and split by socio-demographic variables.

Women, older adults, and adults without qualifications, from deprived areas, with worse employment conditions, or living in the North of England were significantly less likely to meet MVPA guidance. Type of activity was also socially patterned, particularly sport participation, which contributed a higher percentage of PA in adults of higher socioeconomic status. For active men, sporting activity was the most prevalent domain, and sports and walking for active women.

In England, there are important socio-demographic differences in how adults participate in PA, and in percentage meeting public health guidance.

1. Introduction

Physical activity (PA) has been described as 'the best buy in public health' because of its beneficial effects on cardiovascular disease prevention and cost-effectiveness of related interventions (Morris, 1994), and multiple other important facets of health are substantially improved by regular PA (Helmrich et al., 1991; Myers et al., 2004; Wolff et al., 1999). Systematic reviews have identified 150 min a week of moderate intensity activity, in bouts of at least 10 min, is associated with substantial health benefits (O'Donovan et al., 2010; Warburton et al., 2010; Shiroma and Lee, 2010). Importantly, vigorous activity accrued through sports and exercise is given greater weight than moderate activity, such that 75 min of vigorous activity is equal to 150 min of moderate activity; 2 min of 'equivalent physical activity' are gained for the price of one (O'Donovan et al., 2010; Warburton et al., 2010; Shiroma and Lee, 2010). Recent English Chief Medical Officer (CMO) guidance recommends adults participate in 150 min of moderate aerobic PA or 75 min of aerobic vigorous PA per week (Chief Medical Officers, 2011). Positive associations exist between vigorous PA and higher socio-economic status (defined by occupation or educational attainment) (Beenackers et al., 2012), whilst occupational PA contributes a larger proportion for lower status groups (Allender et al., 2008), making it potentially easier for higher status groups to accumulate more equivalent minutes of moderate and vigorous physical activity (MVPA) than other groups. In addition, new methods for measuring occupational PA have been employed after suggestions that it was previously inaccurately estimated (Scholes and Mindell, 2013). The effect of these changes on population-level PA, as well as on potential inequalities in PA, has not been quantified.

Representative population health surveys of health behaviours can be used to produce profiles of the amount and context (referred to as 'domains') of MVPA in which different groups participate. The Health

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Survey for England (HSE) is an annual, nationally-representative cross-sectional survey (Bridges et al., 2013). Using the HSE 2012, this study aimed to produce an updated profile of total and domain-specific population-MVPA, and to quantify inequalities in total and domain-specific MVPA between adults in England, taking into account the importance of vigorous activity for health.

2. Material and methods

2.1. Data source

Data were taken from the HSE 2012. All HSE survey samples include only those living in private households in England. The 2012 survey employed a multi-stage stratified probability sampling design. The sampling frame was the small user Postcode Address File (PAF) (Bridges et al., 2013). The survey was conducted throughout 2012, which avoids biasing responses due to seasonal differences (Bridges et al., 2013).

2.2. Questionnaire

The Physical Activity and Sedentary Behaviour Assessment Questionnaire (PASBAQ) was used within the HSE 2012 to ask respondents to recall daily physical activity over the past 4 weeks. The duration in minutes, frequency, and an estimate of intensity (moderate or vigorous) of episodes of PA is recorded for each PA domain of sports and exercise, walking, and housework and 'Do-it-Yourself' (DIY), but a different method was used for occupational activity (see below). When occurring in bouts of greater than 10 min duration, episodes of MVPA are summed, firstly for each domain and then for domains combined to derive a measure of total MVPA. This is then divided by 4 to provide an estimate of average weekly minutes of MVPA for each respondent. For occupational activity, the frequency (days per week) and duration with which respondents performed specific physical activities at work (stair- or ladder-climbing, and lifting, moving or carrying heavy loads) over the previous 4 weeks was recorded and divided by 4 to give a weekly average duration, which was then summed with MVPA estimates for other domains. The questionnaire has demonstrated moderate-weak convergent validity in comparison to accelerometry (Scholes et al., 2014), and strong test–retest reliability (The Health Survey for England Physical Activity Validation Study: Substantive Report, 2007) (see Section 4.2 of discussion for more detail).

The classification of activity intensity contributed by different domains is discussed in detail elsewhere (Scholes and Mindell, 2013), but PA accumulated by housework or DIY would only be counted as being of at most moderate intensity dependent upon classification of the particular domestic activity by the primary survey authors as being 'heavy' in nature (see the accompanying supplementary material for examples). Work-based occupational activities were assumed to be of moderate intensity for certain occupations only, as defined by the primary survey authors (see supplementary material for the list of occupations). Sports and exercise were classified as vigorous intensity using metabolic equivalent intensity (MET) levels for that activity, or if the subject 'felt warm, out of breath or sweaty' with the effort, otherwise, all sports and exercise were recorded as being of moderate intensity (see Supplementary material for MET classifications) (Scholes and Mindell, 2013). Walking was of moderate intensity if participants reported a brisk or fast pace, or if aged over 65 years, it made them 'breathe fast, feel warmer, or sweat' with the effort even if not at brisk or fast pace.

2.3. Socio-economic classification

Respondents' data were used to classify their socio-economic position (SEP) (defined as 'the socially derived economic factors that influence what positions individuals or groups hold within the multiple-stratified structure of a society'(Galobardes et al., 2007)) using the following: age and gender, index of multiple deprivation (IMD), highest attained educational qualification, and National Statistics Socio-economic Classification (NS-SEC). Ethnicity was not included as a marker of SEP as the sample sizes from the HSE 2012 were too small for robust associations to be made. Equivalised household income was not used due to the high number of respondents without this information recorded (n = 1620). The IMD is a household-level index derived by weighted scores in 7 domains according to the respondents' postcode: income deprivation; crime; employment deprivation; barriers in access to housing and services; health deprivation and disability; the local environment; education, skills and training (Bridges et al., 2013). NS-SEC nominally classifies the employment relations and conditions of respondents' occupations i.e. labour market factors and work situation factors of the respondent's occupation (The National Statistics Socio-economic Classification (NS-SEC rebased on the SOC2010), 2014). The collapsed format NS-SEC5, where respondents are classified into 5 response variables instead of 8, was used for this study. Full-time students, those who are long-term unemployed and those whose occupations are not adequately described are not included in this classification. Highest attained educational qualification is categorised ordinally from 'degree or equivalent' to 'no qualification', current full-time students being classified by their previous highest qualification (Bridges et al., 2013). Geographic region in which the respondents' address is located was recorded according to former Government Office region (Bridges et al., 2013) for analysis. Respondents who were not adequately classified by a SEP variable were excluded from that stratum of analysis.

2.4. Classification by activity level

Due to the skewed nature of population-level PA data, respondents were categorised by activity status for analysis: completely inactive (0 min MVPA per week), inactive (greater than 0 but less than 150 min MVPA per week), and active (greater than 150 min MVPA per week).

Table 1
Characteristics of the adult survey respondents to the Health Survey for England 2012.

Characteristic	All valid adult responses, n = 8158 (95% CI)	Adults excluded from any analysis by PA, n = 118 (95% CI	Adults excluded from stratification by unclassified education variable, n = 145 (95% CI)	Adults excluded from stratification by unclassified NS-SEC5 variable, n = 503 (95% CI)
Mean age (yrs)	47 (46–47)	48 (45–51)	67 (64–70)	28 (27–30)
% Female	51 (50–52)	51 (42–60)	81 (74–88)	54 (49–59)
% With degree level education	26 (24–27)	18 (11-25)	n/a	11 (8-15)
% Least deprived IMD quintile	21 (18-23)	21 (12–30)	27 (19–35)	13 (8-18)
% Professional/Managerial occupation	32 (31–34)	28 (20–36)	13 (7-18)	n/a
% Southern region[a]	42 (40–43)	38 (26–51)	33 (25–41)	47 (40–54)
% reporting >150 weekly min MVPA	61 (60–62)	n/a	40 (32–49)	55 (49–60)

IMD — Index of Multiple Deprivation; NS-SEC5 — National Statistics Socioeconomic Classification 5 tier; MVPA — moderate and vigorous physical activity.
[a] South includes London, South East, South Central and South West.

Table 2
Percentage of adults in England 2012 categorised as inactive, insufficiently active, or active, further stratified by gender and sub-stratified by socio-demographic indicator (n = 3621 men and 4537 women).

Men	% of population Inactive (0 min per week)	% of population Insufficiently active (1–149.99 min per week)	% of population Active (>150 min per week)	UWB	WB[b]	Women	% of population Inactive (0 min per week)	% of population Insufficiently active (1–149.99 min per week)	% of population Active (>150 min per week)	UWB	WB[b]
All men	15.0	17.7	67.2	3621	4013	All women	19.6	25.2	55.1	4537	4200
p for effect of gender[a]	n/a	n/a	**	n/a	n/a	*p* for effect of gender[a]	n/a	n/a	**	n/a	n/a
Age band (n = 3621)						Age band (n = 4537)					
16–24	6.1	10.4	83.4	372	596	16–24	14.3	28.9	56.7	461	593
25–34	8.7	15.2	76.1	478	684	25–34	12.1	26.4	61.5	684	695
35–44	8.9	19.6	71.4	583	711	35–44	11.0	23.2	65.8	756	720
45–54	13.9	16.2	69.9	607	708	45–54	15.8	22.7	61.5	804	709
55–64	22.7	22.4	54.5	615	589	55–64	21.6	23.6	54.8	675	603
65–74	22.8	18.9	58.3	587	421	65–74	21.4	26.5	52.0	630	458
75+	37.7	26.0	36.3	379	303	75+	55.7	26.9	17.5	527	421
p for effect of age	n/a	n/a	**			*p* for effect of age	n/a	n/a	**	n/a	n/a
Education level (3598)						Education level (4415)					
Degree+	8.2	15.4	76.4	933	1061	Degree+	9.3	22.4	68.3	1089	1059
Any other	11.5	17.7	70.8	1861	2169	Any other	16.0	26.2	57.8	2229	2117
No qual.	33.8	21.2	45.0	804	759	No qual.	37.8	26.4	35.9	1097	926
p effect of education	n/a	n/a	**	n/a	n/a	*p* for effect of education	n/a	n/a	**	n/a	n/a
Deprivation quintile (3621)						Deprivation quintile (4537)					
Q1 Least depr.	10.6	18.3	71.1	803	830	Q1 Least	12.9	23.4	63.7	986	882
Q2	11.0	16.3	72.8	768	843	Q2	17.7	24.3	58.0	952	876
Q3	13.8	18.9	67.3	728	816	Q3	19.7	26.5	53.8	916	870
Q4	16.0	17.6	66.4	686	771	Q4	21.6	27.2	51.2	879	827
Q5 Most depr.	24.7	17.5	57.8	636	753	Q5 Most	27.4	25.0	47.7	804	746
p for effect of QIMD	n/a	n/a	**	n/a	n/a	*p* for effect of QIMD	n/a	n/a	**	n/a	n/a
NS-SEC (3431)						NS-SEC (4224)					
I.	10.2	17.9	71.2	1349	1428	I.	12.1	22.2	65.7	1317	1215
II.	16.1	21.0	62.9	271	302	II.	17.1	27.5	55.5	953	861
III.	17.8	16.0	66.1	462	510	III.	14.3	21.6	64.2	290	266
IV.	15.4	15.4	69.2	371	406	IV.	22.8	30.8	46.5	185	165
V.	19.6	18.7	61.8	978	1071	V.	25.6	26.3	48.1	1479	1342
p for effect of NS-SEC5	n/a	n/a	**	n/a	n/a	*p* for effect of NS-SEC5	n/a	n/a	**	n/a	n/a
Region (3621)						Region (4537)					
North	16.9	18.1	65.0	2293	2371	North	20.2	26.4	53.4	2784	2430
South	12.3	17.2	70.6	1328	1642	South	18.8	23.7	57.5	1753	1770
p for effect of region	n/a	n/a	**	n/a	n/a	*p* for effect of region	n/a	n/a	*	n/a	n/a

ns p not significant.
Degree+ — adults with at least degree level educational attainment.
NS-SEC5 — National Socioeconomic Classification 5 level classification.
QIMD — Quintile of Index of Multiple Deprivation.
UWB — unweighted base; WB — weighted base.
[a] For SES variable Sex, logistic regression was of men compared to women, for all others it was within individual sex-strata.
[b] Sample weights are applied to account for non-response bias and unequal selection probabilities.
* Logistic regression for meeting MVPA guidelines in 'highest' vs. 'lowest' level of the sub-stratum variable $p < 0.05$.
** $p < 0.01$.

2.5. Statistical analyses

The weekly total minutes of MVPA, and the weekly minutes of domain-specific MVPA and their percentage contribution to the person's weekly total were calculated for all adults reporting any MVPA. Respondents were excluded if they were under 16 years of age, or not able to give information about their physical activity participation and had realistic activity duration, defined as >100 of activity per week. When counting MVPA minutes, 1 min of vigorous activity was equivalent to two of moderate PA, and this was incorporated into a respondent's weekly MVPA by multiplying any vigorous intensity PA minutes by 2 before summing their weekly minutes. Hence, when calculating percentage of MVPA time spent on domain-specific activities, those activities qualifying as vigorous PA will count for double those of moderate PA, to give a comparable 'equivalent MVPA time' as reflective of the relative importance of vigorous activity in reaching latest national PA recommendations. Weekly minutes and domain-specific proportions of MVPA were stratified by gender and activity level, and further split by: age in 10 year age-bands; SEP as defined by QIMD, NS-SEC and highest educational attainment re-coded into an ordinal categorical variable with three tiers (degree or equivalent, any other qualification, no qualification); and by region recoded into North or South (South including London, South Central, South East and South West). This geographical scale was used because these regions have relatively homogenous health, social and economic conditions that may influence MVPA (Hacking et al., 2011; Whitehead and Doran, 2011), and because positive correlations exist between meeting MVPA guidance and living in a Southern region of England (Townsend et al., 2012). Linear regression analyses were used to assess differences in the absolute and relative contributions of the domains stratified by sex and activity status and split by socio-demographic groups. Logistic regression was used to test for odds ratio of meeting MVPA guidance using the same stratification.

All statistical calculations were performed using Stata SE 11.2, StataCorp, Texas, USA. All analyses were conducted using the 'svyset' command to take into account the complex sampling design, which uses weights provided with the HSE dataset to correct for under-representation of adults in multiple-dwelling units, differential inclusion

Table 3
Mean weekly moderate and vigorous physical activity, and domain-specific moderate and vigorous physical activity for 'insufficiently active' men in England 2012 (unweighted n = 674), but note exclusions for educational attainment (unweighted n = 3) and NS-SEC5 (weighted n = 31).

Men	Mean min. MVPA	UWB	WB[b]	Mean weekly minutes of MVPA and % relative contribution to total									
				Sport[a]		Occupational		DIY		Housework		Walking	
				Min	%	Min	%	Min	%	Min	%	Min	%
All	65.6	674	721	17.5	24.7	1.4	2.2	8.5	10.7	22.3	38.9	15.9	23.6
Main effect of gender	*	n/a	n/a	ns	ns	ns	ns	**	††	**	††	**	††
Age band*													
16–24	69.2	40	62	23.6	28.5	1.3	1.1	3.0	3.1	19.6	34.3	21.7	32.8
25–34	72.6	75	104	30.6	43.7	3.6	5.1	1.6	3.7	16.4	20.9	20.4	26.6
35–44	63.4	113	140	22.1	35.3	0.6	1.6	7.0	7.7	20.9	38.0	12.8	17.4
45–54	67.6	99	114	13.7	19.0	2.3	4.2	9.9	10.5	26.9	44.9	14.9	21.4
55–64	67.9	135	132	12.6	15.7	0.8	1.2	15.9	19.6	27.5	46.9	11.1	16.6
65–74	63.4	113	79	9.3	15.0	1.1	1.4	9.6	12.2	22.6	42.1	20.8	29.3
75+	52.5	99	79	8.9	10.6	0	0	8.7	14.9	19.3	42.3	15.6	32.2
Main effect of age	*	n/a	n/a	**	††	ns	ns	**	††	ns	††	ns	ns
Education level													
Degree+	73.8	142	163	26.7	33.9	0.72	2.7	7.0	6.8	20.9	32.1	18.4	24.5
Any other	65.1	351	383	15.5	23.3	2.0	2.6	8.8	11.4	22.7	39.3	16.1	23.3
No qual.	58.5	178	161	12.2	18.3	0.60	0.8	9.2	13.1	23.3	44.6	13.1	23.1
Main effect of education	**	n/a	n/a	**	††	ns	ns	ns	†	ns	†	ns	ns
Deprivation quintile													
Least deprived	71.4	149	152	18.9	23.6	1.8	3.3	10.2	12.9	21.1	34.8	19.4	25.5
Q2	67.8	133	137	17.0	24.1	2.7	3.4	10.4	13.4	21.4	36.5	16.2	22.6
Q3	58.1	147	154	15.2	21.1	1.1	1.4	7.4	8.3	21.8	46.9	12.6	22.3
Q4	64.2	130	136	17.7	26.0	0.0	0.0	9.4	11.7	20.4	35.9	16.6	26.3
Most deprived	66.8	135	131	18.6	29.3	1.3	2.9	4.7	6.9	27.3	39.6	14.7	21.2
Main effect of QIMD	ns	n/a	n/a	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
NS-SEC													
I.	70.2	249	256	21.4	28.1	0.3	0.1	8.1	9.8	20.3	32.9	20.0	28.3
II.	59.7	58	63	14.9	20.5	0.0	0	6.2	7.4	25.6	50.6	13.0	21.5
III.	65.1	79	82	11.4	25.2	3.6	6.1	18.4	21.3	17.9	30.2	13.7	17.2
IV.	56.1	60	62	12.8	25.0	1.1	0.1	7.1	9.4	23.1	43.7	12.0	21.0
V.	64.1	197	200	13.1	17.6	2.8	3.8	7.8	11.2	26.5	46.3	13.9	21.1
Main effect of NS-SEC5	ns	n/a	n/a	**	††	*	ns	ns	ns	ns	††	ns	ns
Region													
North	65.3	430	428	18.1	25.4	1.8	3.0	7.9	11.0	22.8	39.4	14.6	21.2
South	65.9	244	282	16.5	23.4	0.8	1.1	9.3	10.1	21.5	38.0	17.9	27.3
Main effect of region	ns	n/a	n/a	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

South includes London, South East, South Central, and South West.
Degree+ — adults with at least degree level educational attainment.
QIMD — Quintile of Index of Multiple Deprivation.
NS-SEC5 — National Socioeconomic Classification 5 level classification.
UWB — unweighted base; WB — weighted base.
[a] 1 min of vigorous sporting activity is equivalent to 2 min of moderate activity in all other domains.
[b] Sample weights are applied to account for non-response and unequal selection probabilities.
* $p < 0.05$ for mean minutes trend over SES variable by linear regression (for Sex this is mean weekly minutes in men compared to women).
** $p < 0.01$.
† $p < 0.05$ for trend in relative contribution % of MVPA domain to total MVPA over SES variable by linear regression (for Sex this is the relative contribution % of that MVPA domain in men compared to women).
†† $p < 0.01$.

(at the household level) to expected age/sex ratios for the population of the household Government Office Region, and differential individual non-response (young adults and people from multiple dwelling units were under-represented) (Bridges et al., 2013; Aresu et al., 2008).

2.6. Ethical approval

The Health Survey for England 2012 primary research team obtained ethical approval from the Oxford A Research Ethics Committee (reference number 10/H604/56) (Bridges et al., 2013).

3. Results

HSE 2012 recorded a 64% household response rate with 10,333 respondents (Bridges et al., 2013). There were 8158 valid adult responses after exclusions (no record of activity n = 118, of which unrealistic activity estimations n = 14). For analyses by educational attainment or occupation, 145 and 503 adults were excluded, respectively, due to being unclassified by these variables. See Table 1 below for included and excluded survey respondent characteristics.

Of valid respondents, 61.1% (unweighted n = 4785) reported at least 150 min per week of MVPA, meeting PA guidelines (Table 1); 21.6% (unweighted n = 1826) reported between 1 and <150 min per week, and were insufficiently active; 17.4% (unweighted n = 1547) were inactive, reporting 0 min of weekly activity. The percentage meeting guidance was statistically significantly higher in men ($p < 0.01$), younger adults of either sex ($p < 0.01$), adults from the South of England ($p < 0.01$ for men, <0.05 for women), and increased with higher status over all other SEP variables (all $p < 0.01$, see Table 2). Our findings for percentage adults reporting greater than 150 min weekly MVPA were the same as those reported by the HSE 2012, and within 1 min per week for mean weekly domain MVPA estimates (other than occupational activity, for which weekly minutes are not given in the report to allow comparison) (Scholes and Mindell, 2013).

Total weekly activity was higher in insufficiently active men than women (65.6 vs 61.0 min, $p < 0.05$), fell with decreasing educational attainment in both genders (73.8 min to 58.5 min in men, 67.3 min to

Table 4
Mean weekly moderate and vigorous physical activity, and domain-specific moderate and vigorous physical activity for 'insufficiently active' women in England 2012 (unweighted n = 1152), but note exclusions for Educational attainment (unweighted n = 30) and NS-SEC5 (unweighted n = 82).

Women	Mean min. MVPA	UWB	WB[b]	Mean weekly minutes of MVPA and % relative contribution to total									
				Sport[a]		Occupational		DIY		Housework.		Walking	
				Min	%	Min	%	Min	%	Min	%	Min	%
All	61.0	1152	1060	17.8	25.4	0.9	1.3	1.7	2.6	30.4	54.2	10.1	16.4
Main effect of gender	*	n/a	n/a	ns	ns	ns	ns	**	††	**	††	**	††
Age band													
16–24	58.5	140	172	27.8	42.8	1.6	2.8	0.0	0.0	19.7	38.1	9.5	16.3
25–34	59.0	182	184	16.2	23.9	0.8	1.5	0.4	0.8	33.9	61.9	7.7	11.8
35–44	65.9	175	167	18.0	26.4	0.7	0.6	1.9	3.1	36.7	59.3	8.5	10.7
45–54	67.0	186	161	18.3	22.9	0.9	1.3	2.0	2.4	35.6	59.4	10.2	14.0
55–64	61.5	162	142	17.8	21.9	1.8	2.2	3.3	5.6	35.1	64.2	3.6	6.1
65–74	64.3	165	121	17.4	22.3	0.2	0.3	3.5	3.9	27.4	45.2	15.9	28.3
75+	48.1	142	113	4.8	11.1	0	0	2.0	3.4	21.8	49.3	19.6	36.2
Main effect of age	ns	n/a	n/a	**	††	ns	ns	**	††	ns	ns	**	††
Education level													
Degree+	67.3	259	238	24.3	32.4	0.2	0.6	2.3	3.5	29.4	48.5	11.1	14.9
Any other	60.6	576	554	18.1	26.4	1.4	1.9	1.3	1.9	30.9	55.1	8.8	14.7
No qual.	57.5	287	325	11.5	17.1	0.7	1.0	2.1	3.0	31.3	56.8	12.0	22.0
Main effect of education	**	n/a	n/a	**	††	ns	ns	ns	ns	ns	†	ns	ns
Deprivation quintile													
Least deprived	59.9	232	206	17.7	25.2	0.6	1.6	1.8	2.5	28.7	50.1	11.1	20.7
Q2	59.9	232	213	21.3	31.8	0.3	0.7	1.4	2.5	27.8	49.0	9.2	16.0
Q3	60.8	246	230	18.2	26.4	0.5	1.1	1.1	1.8	30.3	54.7	10.7	16.0
Q4	65.9	238	225	17.4	22.4	2.4	2.1	2.6	3.6	34.5	58.5	8.9	13.4
Most deprived	57.8	204	186	13.8	20.7	0.7	1.3	1.7	2.4	30.6	59.3	11.0	16.3
Main effect of QIMD	ns	n/a	n/a	ns	†	ns	ns	ns	ns	ns	††	ns	ns
NS-SEC													
I.	64.8	304	270	22.9	31.3	0.41	0.7	3.0	4.8	28.5	47.6	10.0	15.6
II.	61.7	261	237	17.3	25.8	0.0	0.0	1.7	1.7	30.6	55.1	12.1	17.4
III.	52.7	63	58	16.0	19.4	3.9	8.3	2.6	5.0	24.2	50.6	6.0	16.8
IV.	61.1	56	51	13.8	16.0	2.3	2.3	1.2	4.2	32.5	58.7	11.4	18.7
V.	60.6	386	353	15.4	22.2	1.4	1.8	1.1	1.2	34.5	60.3	8.2	14.4
Main effect of NS-SEC5	ns	n/a	n/a	*	††	*	ns	*	††	*	††	ns	ns
Region													
North	62.1	734	641	16.5	23.6	1.4	1.8	2.0	3.1	31.1	54.3	10.9	17.2
South	59.4	418	419	19.7	28.1	0.1	0.6	1.3	1.8	29.3	54.3	8.9	15.1
Main effect of region	ns	n/a	n/a	ns	ns	**	ns	ns	ns	ns	ns	ns	ns

South includes London, South East, South Central, and South West.
Degree+ — adults with at least degree level educational attainment.
QIMD — Quintile of Index of Multiple Deprivation.
NS-SEC5 — National Socioeconomic Classification 5 level classification.
UWB — unweighted base; WB — weighted base.
* $p < 0.05$ for mean minutes trend over SES variable by linear regression (for Sex this is mean weekly minutes in men compared to women).
** $p < 0.01$.
† $p < 0.05$ for trend in relative contribution % of MVPA domain to total MVPA over SES variable by linear regression (for Sex this is the relative contribution % of that MVPA domain in men compared to women).
†† $p < 0.01$.
[a] 1 min of vigorous sporting activity is equivalent to 2 min of moderate activity in all other domains.
[b] Sample weights are applied to account for non-response and unequal selection probabilities.

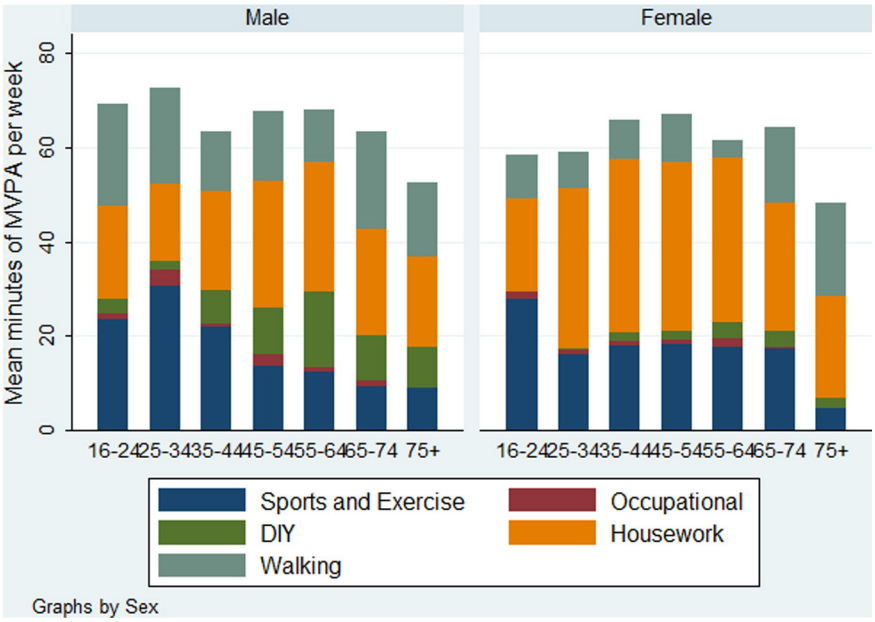

Fig. 1. Domain-specific mean weekly minutes of moderate and vigorous physical activity (MVPA) for insufficiently active adults in England 2012, by age band and sex (n = 1826).

57.5 min in women $p < 0.01$ for both), and, in men, fell with age (69.2 to 52.5 min $p < 0.05$) (see Tables 3 and 4, and Figs. 1 and 2). Housework contributed most MVPA in insufficiently active adults: nearly 40% of weekly activity in men and 54% in women. The relative contribution of housework increased with lower socioeconomic status in men (for educational attainment and occupation $p < 0.05$ and <0.01 respectively) and in women (for educational attainment, occupation $p < 0.01$, and IMD $p < 0.05$). Sport contributed 25% of weekly activity in both genders, with a significant decrease in absolute and relative terms with age ($p < 0.01$), and with decreasing socioeconomic status (educational attainment and occupation, all $p < 0.01$ except for absolute decrease with NS-SEC5 in women, $p < 0.05$). Walking accounted for 16–24% of activity, men having a significantly higher absolute and relative weekly figure ($p < 0.01$). Unlike sport, there was no change in walking activity with age or socioeconomic position in men, but walking significantly increased with age in women both relatively and absolutely (9.5 to 19.6 min, $p < 0.01$). There was no regional difference in any of the 3 major domains. Occupational activity accounted for very little weekly MVPA time in either gender, with no important variations by age or socioeconomic position. DIY also contributed relatively little activity, though it was significantly higher in men and increased with age in both genders (both $p < 0.01$); in older men it contributed up to 20% of weekly MVPA.

In 'active' adults, men had significantly higher weekly MVPA than women (903 vs. 730 min, $p < 0.01$, see Tables 5 and 6, and Figs. 3 and 4). Total activity decreased with age in men only (from 1097 to 648 min, $p < 0.01$), but increased with decreasing socioeconomic position (education, $p < 0.05$, and occupation, $p < 0.01$) in men, but not in

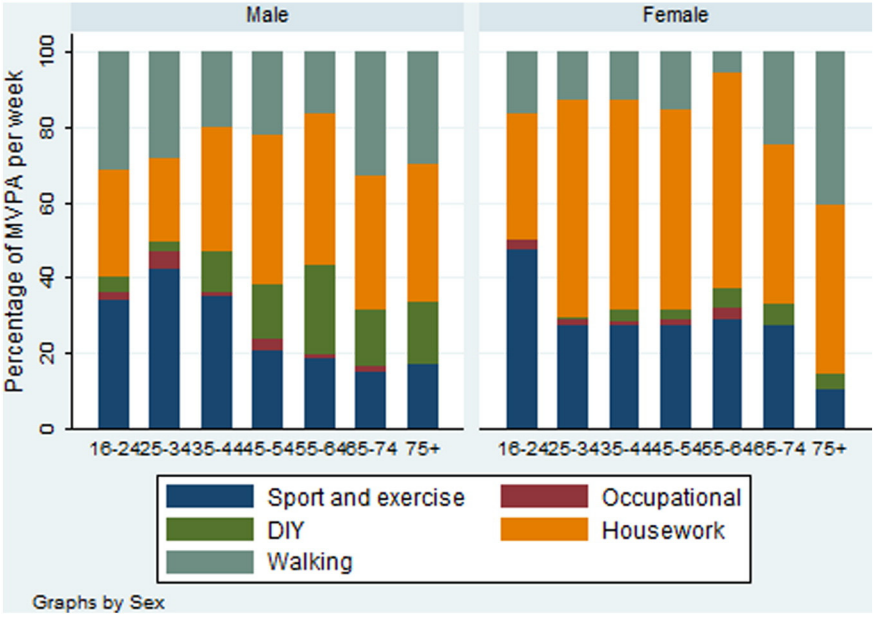

Fig. 2. Percentage contribution for domains to weekly moderate and vigorous physical activity (MVPA) for insufficiently active adults in England 2012, by age band and sex (n = 1826).

Table 5
Mean weekly moderate and vigorous physical activity, and domain-specific moderate and vigorous physical activity for 'active' men in England 2012 (n = 2325), but note exclusions for educational attainment (n = 11) and NS-SEC5 (n = 29).

Men	Mean min. MVPA	UWB	WB[b]	Mean weekly minutes of domain-specific MVPA and mean % relative contribution to total									
				Sport[a]		Occupational		DIY		Housework.		Walking	
				Min	%	Min	%	Min	%	Min	%	Min	%
All	903.3	2325	2670	322.1	38.6	214.4	14.6	79.3	9.5	75.0	11.6	212.3	25.7
Main effect of gender	**	n/a	n/a	**	††	**	††	**	††	**	††	ns	††
Age band													
16–24	1096.5	308	497	577.0	56.2	187.8	11.5	31.1	28.2	62.8	6.6	237.8	23.0
25–34	863.9	365	521	351.7	44.8	219.7	13.5	52.0	5.1	70.3	10.9	170.2	25.6
35–44	815.6	416	508	293.4	41.4	227.1	16.4	64.6	7.2	64.7	10.9	165.8	24.2
45–54	926.1	421	495	277.1	33.4	302.0	22.7	83.5	10.1	84.3	13.1	179.1	20.7
55–64	918.2	340	323	178.8	24.4	283.0	18.1	122.9	17.0	82.9	14.6	250.7	25.9
65–74	825.7	338	246	177.9	21.5	37.0	3.7	184.4	21.6	89.8	12.5	336.6	40.8
75+	648.0	137	110	109.2	19.3	51.7	3.3	113.7	19.5	102.2	23.9	271.2	34.0
Main effect of age	**	n/a	n/a	**	††	ns	ns	**	††	ns	††	**	††
Education level													
Degree+	791.1	707	811	345.0	44.8	88.8	6.5	71.6	9.2	68.0	11.5	217.8	28.0
Any other	954.7	1265	1536	331.0	37.3	271.8	18.4	81.0	9.4	75.5	10.9	195.4	24.0
No qual.	938.7	342	342	224.7	29.3	255.6	16.4	90.0	10.8	89.4	15.1	279.0	28.4
Main effect of education	*	n/a	n/a	**	††	**	††	ns	ns	ns	ns	ns	ns
Deprivation quintile													
Least deprived	875.0	587	590	326.5	38.8	164.6	11.3	95.3	12.5	68.2	11.1	220.4	26.2
Q2	860.2	532	613	340.4	41.4	182.7	13.4	85.2	10.7	58.8	10.5	193.1	24.1
Q3	941.1	467	550	324.0	39.5	261.9	16.8	78.8	9.4	64.6	9.9	211.9	24.4
Q4	936.3	425	512	270.9	32.7	293.2	19.6	63.5	7.4	85.7	13.1	223.1	27.1
Most deprived	915.4	344	435	348.4	40.0	174.0	12.0	68.7	6.3	107.7	14.3	216.5	27.4
Main effect of QIMD	ns	n/a	n/a	ns	ns	ns	ns	*	††	*	†	ns	ns
NS-SEC													
I.	713.1	942	1027	320.8	44.4	42.4	3.9	78.0	10.3	66.3	14.5	205.6	29.3
II.	775.1	163	190	341.3	43.9	56.5	3.5	75.2	11.0	74.5	12.2	227.8	30.0
III.	1068.0	291	337	236.5	24.6	465.0	33.6	120.7	13.0	64.2	11.6	181.7	18.6
IV.	971.8	241	281	282.4	34.0	307.1	22.8	76.8	9.0	83.4	10.2	222.0	23.5
V.	1083.8	559	662	286.1	30.0	425.3	25.6	81.0	8.5	87.3	10.6	204.1	22.7
Main effect of NS-SEC5	**	ns	ns	ns	††	**	††	ns	ns	*	ns	ns	††
Region													
North	899	1424	1541	312	37.7	245	16.8	83	9.8	73	12.0	186	23.6
South	909	901	1158	336	39.7	174	11.6	75	9.0	78	11.1	247	28.5
Main effect of region	ns	n/a	n/a	ns	ns	*	††	ns	ns	ns	ns	**	††

South includes London, South East, South Central, and South West.
Degree+ — adults with at least degree level educational attainment.
QIMD — Quintile of Index of Multiple Deprivation.
NS-SEC5 — National Socioeconomic Classification 5 level classification.
UWB — unweighted base; WB — weighted base.
* $p < 0.05$ for mean minutes trend over SES variable by linear regression (for Sex this is mean weekly minutes in men compared to women).
** $p < 0.01$.
† $p < 0.05$ for trend in relative contribution % of MVPA domain to total MVPA over SES variable by linear regression (for Sex this is the relative contribution % of that MVPA domain in men compared to women).
†† $p < 0.01$.
[a] 1 min of vigorous sporting activity is equivalent to 2 min of moderate activity in all other domains.
[b] Sample weights are applied to account for non-response and unequal selection probabilities.

women. Total activity was significantly higher in women in the South of England than the North (777 vs. 692 min, $p < 0.01$). Sport accounted for most activity in men (38.6%), but in women walking was of equal importance (both near 30%). Sporting activity decreased sharply with age (relatively and absolutely) in men (577 to 109 min) and women (301 to 41 min) (all $p < 0.01$), and also fell with decreasing socioeconomic position in women on all SEP measures in relative terms ($p < 0.01$ for NS-SEC5 and education, $p < 0.05$ for IMD), and all but IMD in absolute terms (both $p < 0.01$). The picture in men was more complex, with absolute and relative sporting activity falling with decreasing educational attainment (both $p < 0.01$), and decreasing in relative terms with decreased occupational SEP ($p < 0.01$), but with no association between IMD. There was no regional association with sport activity for either gender. Weekly walking MVPA increased in relative and absolute terms with age (all $p < 0.01$), and in southern compared to northern regions, for both genders (all $p < 0.01$), and in women from less deprived areas (both $p < 0.01$). Occupational activity was significantly higher in men (214 min) than women (102 min, $p < 0.01$), and increased in men in absolute and relative terms with decreasing occupational status and educational attainment (all $p < 0.01$), and in northern regions ($p < 0.05$ for absolute change, <0.01 for percentage). Occupational PA followed a similar pattern in women in terms of educational attainment ($p < 0.05$ for absolute change, <0.01 for percentage), but was also associated with decreasing IMD (both $p < 0.01$), whilst it only increased in relative terms with decreasing occupational status ($p < 0.01$). Housework formed a greater absolute and relative contribution to weekly MVPA in women (169 min) than men (75 min, $p < 0.01$)), in women of lower socioeconomic position by all SEP measures (all $p < 0.01$, except absolute terms for IMD, $p < 0.05$), and as a proportion of total activity in northern (30%) than southern women (25%, $p < 0.01$). In men, housework increased as a proportion of total activity in older men ($p < 0.01$) and in men in more deprived areas ($p < 0.05$). Men accrued more MVPA minutes through DIY than women (79 compared to 35 min, $p < 0.01$). DIY time and percentage rose with older age in men and women (all $p < 0.01$), and in men living in areas of lower deprivation ($p < 0.05$ for time, $p < 0.01$ for percentage).

Table 6
Mean weekly moderate and vigorous physical activity, and domain-specific moderate and vigorous physical activity for 'active' women in England 2012 (n = 2460), but note exclusions for Educational attainment (n = 47) and NS-SEC5 (n = 130).

Women	Mean min. MVPA	UWB	WB[b]	Mean weekly minutes of domain-specific MVPA and mean % relative contribution to total									
				Sport[a]		Occupational		DIY		Housework.		Walking	
				Min	%	Min	%	Min	%	Min	%	Min	%
All	729.5	2460	2317	203.4	29.9	102.0	7.2	34.8	4.7	169.0	28.0	220.2	30.0
Main effect of gender	**	n/a	n/a	**	††	**	††	**	††	**	††	ns	††
Age band													
16–24	701.4	256	337	301.3	44.4	87.2	5.9	10.7	1.5	110.6	17.9	191.5	30.3
25–34	711.2	423	427	242.0	35.7	105.2	6.7	12.2	1.7	175.2	30.2	176.7	25.8
35–44	795.4	501	474	230.3	31.5	125.0	8.7	30.9	3.5	179.3	28.8	229.8	27.5
45–54	753.6	487	436	168.5	25.5	149.6	11.3	48.5	7.2	190.6	30.2	196.4	25.9
55–64	721.9	372	331	162.7	23.8	99.2	7.4	54.3	8.2	171.8	30.6	234.0	30.0
65–74	694.6	329	238	113.1	19.0	13.1	1.0	66.1	7.8	173.4	26.9	328.9	45.3
75+	543.0	92	74	41.6	10.0	21.1	2.2	30.5	5.4	179.5	38.8	270.2	43.7
Main effect of age	ns	n/a	n/a	**	††	*	ns	**	††	*	††	**	††
Education level													
Degree+	727.0	726	723	274.4	39.0	71.1	4.8	30.3	4.2	128.1	20.6	223.2	31.4
Any other	734.7	1301	1224	193.8	28.5	120.5	8.6	29.1	4.5	175.5	30.0	215.8	28.4
No qual.	732.8	386	332	95.5	17.3	112.6	8.5	61.9	6.4	234.1	36.3	228.7	31.5
Main effect of education	ns	n/a	n/a	**	††	*	††	ns	ns	**	††	ns	ns
Deprivation quintile													
Least deprived	762.5	617	561	230.3	31.1	79.7	5.5	36.7	5.1	163.2	25.5	252.6	32.7
Q2	719.1	543	508	199.5	31.7	77.6	5.9	46.1	5.6	159.0	26.5	237.0	30.3
Q3	739.7	484	468	217.2	29.5	123.3	8.7	26.9	3.6	137.2	25.9	235.1	32.3
Q4	662.6	441	424	172.4	28.9	95.8	6.8	30.6	5.4	193.4	31.4	170.3	27.6
Most deprived	758.3	375	355	185.6	27.3	151.2	10.4	30.9	3.7	205.5	33.3	185.0	25.2
Main effect of QIMD	ns			*	ns	**	††	ns	ns	*	††	**	††
NS-SEC													
I.	762.8	843	799	251.3	36.6	111.4	6.9	37.2	5.0	141.9	23.3	221.0	29.4
II.	671.2	521	477	183.7	35.4	62.1	4.5	28.6	5.1	162.9	29.5	233.9	32.4
III.	894.4	183	171	223.3	28.5	189.7	11.9	46.6	5.6	185.5	24.3	249.3	29.4
IV.	656.6	84	77	122.9	28.8	55.9	6.6	48.9	7.0	241.0	40.6	188.0	25.6
V.	705.8	699	645	149.2	20.2	125.4	10.3	33.2	4.2	187.5	32.5	210.6	29.3
Main effect of NS-SEC5	ns			**	††	ns	††	ns	ns	**	††	ns	ns
Region													
North	692.0	1456	1298	191.6	29.8	103.8	7.6	31.9	4.3	177.2	30.4	187.6	27.7
South	777.1	1004	1018	218.5	30.1	99.6	6.7	38.4	5.2	158.6	25.0	261.9	32.9
Main effect of region	**	n/a	n/a	ns	ns	ns	ns	ns	ns	ns	††	**	††

South includes London, South East, South Central, and South West.
Degree+ — adults with at least degree level educational attainment.
NS-SEC5 — National Socioeconomic Classification 5 level classification.
UWB — unweighted base; WB — weighted base.
* $p < 0.05$ for mean minutes trend over SES variable by linear regression (for Sex this is mean weekly minutes in men compared to women).
** $p < 0.01$.
†† $p < 0.01$ for trend in relative contribution % of MVPA domain to total MVPA over SES variable by linear regression (for Sex this is the relative contribution % of that MVPA domain in men compared to women).
[a] 1 min of vigorous sporting activity is equivalent to 2 min of moderate activity in all other domains.
[b] Sample weights are applied to account for non-response and unequal selection probabilities.

4. Discussion

This paper presents the domain-specific, nationally-representative profile of MVPA for adults in England using the latest MVPA guidelines and more specific occupational PA measurement. Sport and exercise was the most prevalent activity in men meeting the guidance, and of similar prevalence to walking in active women. Domestic activity was the most prevalent activity in 'insufficiently active' adults of either gender.

Our population PA profile is the first using the updated guidance and occupational measurement methods to present the findings across a range of socioeconomic variables, revealing large inequalities in the percentage of adults meeting the guidance when stratifying by age, gender, region, and all measured aspects of socio-economic position. There were some consistent social differences in how PA is accrued across SEP measures, even amongst adults within the same activity status: higher social status was associated with a greater percentage of PA accrued through sporting activity than in 'routine' activities such as occupational PA or housework.

4.1. Our findings in relation to other studies

Total weekly MVPA was lower in men and women in our study, by around 100 min per week, particularly in the occupational domain, than a profile of PA in active adults (defined by participation in at least 30 minutes of moderate or vigorous activity on at least 5 days per week) in England using 2008 data (Belanger et al., 2011). Total MVPA in our study was also around 300 min per week lower for both genders in active adults than a recent study using 2012 data from Scottish Health Survey (SHS) (Strain et al., 2016), the difference mainly being due to large differences in occupational activity. Notably there was no difference in activity levels in insufficiently active adults between the Scottish study and ours; these adults reported very little occupational PA in either study. More specific measurements of the occupational PA domain by HSE 2012 likely resulted in lower estimation of occupational PA levels than previous HSE iterations (Scholes and Mindell, 2013), and in the SHS-based study, which uses less specific methods and likely inflates MVPA estimates (Strain et al., 2016), contributing to the apparent difference. Besides the difference in definition of 'active' adults, another key difference in findings

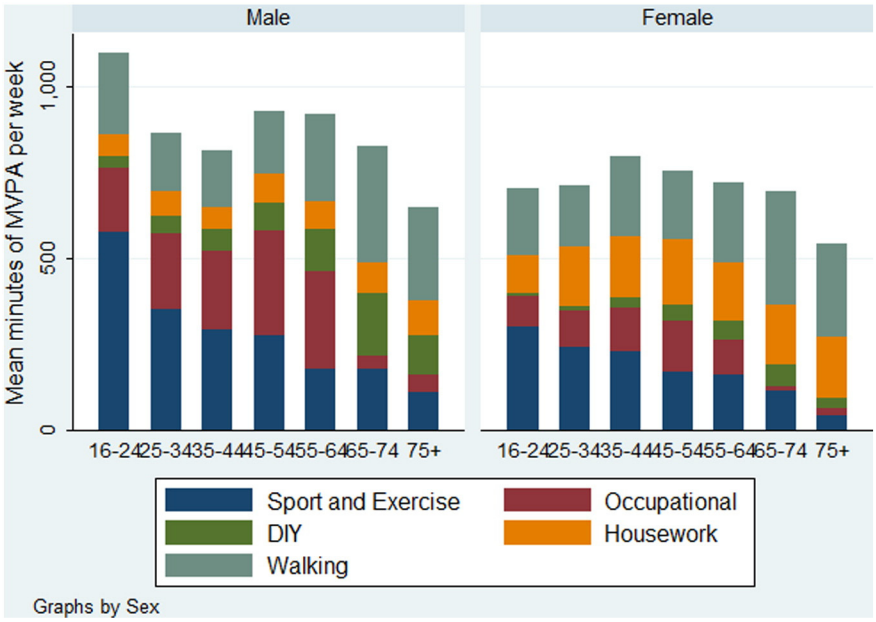

Fig. 3. Domain-specific mean weekly minutes of moderate and vigorous physical activity (MVPA) for active adults in England 2012, by age band and sex (n = 4785).

between the Belanger study and ours illustrates a further likely cause of this total PA disparity: when compared to our work, younger men in 2008 had lower MVPA than older men, and for all adults the percentage of sports and exercise minutes out of total MVPA in 2008 was lower. Similar patterns were noted on comparing Belanger's work with the recent Scottish findings (Strain et al., 2016). These differences are understandable given the 'double counting' of vigorous minutes in our study, but not the HSE 2008. Real changes in PA behaviour over time are possible but less likely to explain the differences in findings: when HSE 2008 and 2012 data were re-examined using the same methods of occupational activity and vigorous activity measurement, the percentage meeting MVPA guidance was almost identical, though re-calculated domain specific activity estimates are not available for comparison (Scholes and Mindell, 2013).

In terms of SEP and PA, previous studies have reported neutral associations, or even strong positive associations between lower socio-economic status (defined by occupation and education) and meeting PA guidelines (Allender et al., 2008; Macintyre and Mutrie, 2004). This might in part be due to our study taking into account updated guidance to 'double count' PA derived from vigorous, sporting activity, which is more common in high SEP groups. Previous studies also only examined the PA profiles of adults meeting PA guidelines and only without chronic limiting illness (Allender et al., 2008); omission of these factors would weaken the low SEP-low PA relationship seen in our findings, which is likely at least partly mediated by these variables (Popham and Mitchell, 2007). Compared with a study of Scottish adults that took these factors into account, our findings using the new guidelines are consistent: low SEP-status adults are less likely to be active, and to accrue PA through

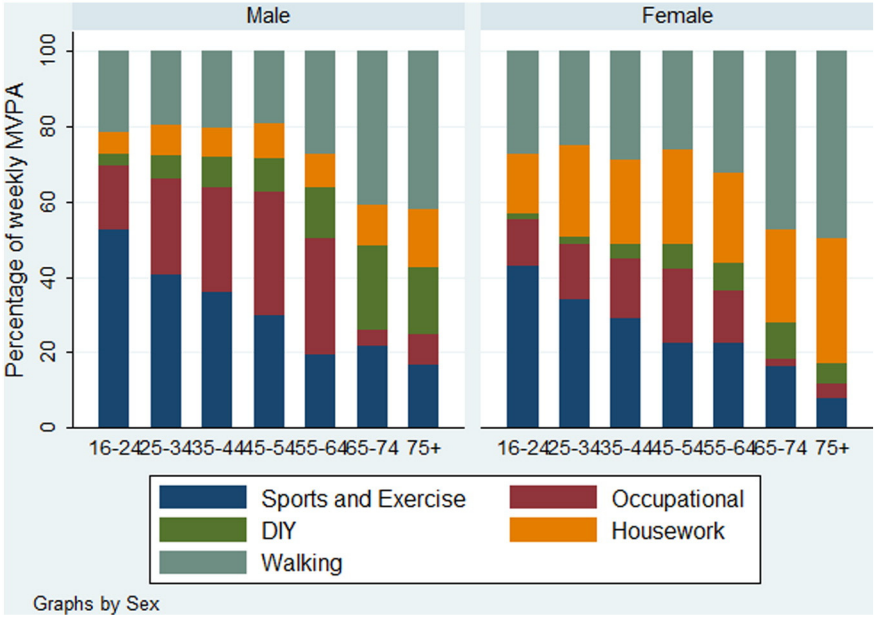

Fig. 4. Percentage contribution for domains to weekly MVPA for active adults in England 2012, by age band and sex (n = 4785).

sports or brisk walking, than 'routine' activity such as by occupation (Popham and Mitchell, 2007).

4.2. Study limitations and strengths

This research uses estimates of MVPA participation from a large and nationally representative survey. The version of the PA questionnaire used for HSE 2012 is likely more accurate at determining individual's MVPA levels than previously, especially for occupational MVPA (Scholes and Mindell, 2013). This research also recognises the current emphasis on the importance on vigorous activity, incorporating this into calculations to accurately compare 'equivalent minutes' of MVPA.

Self-reported PA is subject to recall and social desirability bias, inflating estimates. A small-scale study of 106 healthy adults demonstrated strong test–retest reliability for the PASBAQ (intraclass correlation coefficients were 0.76 for women and 0.89 for men) (The Health Survey for England Physical Activity Validation Study: Substantive Report, 2007). PASBAQ has been validated against accelerometry (an 'objective' measure of physical activity). Self-reported estimates of moderate and vigorous physical activity had a weak positive correlation (Spearman's rank correlation coefficient 0.39 for men and 0.36 for women) suggesting some mis-classification of self-report data in comparison to accelerometry (Scholes et al., 2014). This measurement was similar across age-group differences (Scholes et al., 2014).

Our study is cross-sectional in nature and purely descriptive; some of the associations between MVPA and socio-demographic variables could be accounted for by reverse causation, or increased or decreased by adjustment for other variables, though many of the relationships are strong. We were unable to profile activity by all important SEP indicators (particularly ethnicity and income), or the active-travel domain of MVPA. Some of our sample were excluded from analysis due to inadequate classification (education attainment and occupational status), and their omission could have inflated the differences in MVPA over these indicators.

4.3. Implications for policymakers and researchers

Our findings underline the importance of the wider social determinants of physical activity such as job status and area-level deprivation that are within the influence of policymakers, particularly when long-term trends in the economy and technology, such as increases in the number of manual jobs being replaced by non-manual service-sector employment (Holmes and Mayhew, 2012) may cause further decrease in routine access to PA. Attention must be given to the role of sports and exercise inequalities when commissioning interventions to increase population PA levels, so as not to inadvertently widen them. The importance of vigorous PA for health means that identifying measures that both allow for vigorous activity and are socially equitable is critical. Secondly, more accurate measures of occupational physical activity are required, as current measures may be overestimates and therefore masking greater inequalities in physical activity. Adjustment for multiple socioeconomic determinants and other potential confounders would help to understand the relative importance of SEP variables as possible determinants of activity, as well as answer questions about the relative role of environment versus personal characteristics. The regional differences in PA participation seen at the scale examined in our work may be driven by local environmental factors such as weather or facilities, or be due to concentration of factors such as lower educational attainment within regional populations, and further work should investigate these relationships.

5. Conclusions

CMO guidelines rightly emphasise the importance of vigorous activity for health; incorporating this into our calculations of 'equivalent MVPA' time, we have shown that large inequalities exist in meeting MVPA guidance in England, as well as significant social differences as to how PA is accrued. These may have previously been under-appreciated both due to the under-estimation of the impact of vigorous activity on health, and the over-estimation of MVPA accrued during occupational activity.

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Conflict of interest statement

The authors declare that there are no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.pmedr.2016.05.009.

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