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How do physical activity and sedentary behaviours in workers impact on their health? A 12-month prospective study

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Abstract:	OBJECTIVES: Explore the impact of incremental increases in physical activity and incremental decreases in sedentary behaviours on health outcomes in employees of five organisations. Investigate the association between physical activity and sedentary behaviours. METHODS: Self-reported physical activity and sedentary behaviours were recorded at four time points (baseline, 3, 6, 12 months). BMI, % body fat, waist circumference, blood pressure and resting heart rate were collected in health checks (baseline, 12 months). Well-being and health were collected via questionnaire. Participants were classified into five physical activity groups (n=308) and three sedentary groups (n=358). MANCOVAs explored the impact of activity and sedentary group on health. Spearman's correlation analysis investigated associations between behaviours. RESULTS: Low activity and high sedentariness were evident. More activity was associated with improved BMI, % body fat, resting heart rate, waist circumference and well-being. Sedentary behaviour was not associated with health. A weak positive association between physical activity and sedentary behaviours emerged. CONCLUSIONS: The low activity levels are of particular concern as linked to health outcomes. The weak association between behaviours suggests worksite interventions should target both behaviours.

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ABSTRACT

Objectives: Explore the impact of *incremental* increases in physical activity and *incremental* decreases in sedentary behaviours on health outcomes in employees of five organisations. Investigate the association between physical activity and sedentary behaviours.

Methods: Self-reported physical activity and sedentary behaviours were recorded at four time points (baseline, 3, 6, 12 months). BMI, % body fat, waist circumference, blood pressure and resting heart rate were collected in health checks (baseline, 12 months). Well-being and health were collected via questionnaire. Participants were classified into five physical activity groups (n=308) and three sedentary groups (n=358). MANCOVAs explored the impact of activity and sedentary group on health. Spearman's correlation analysis investigated associations between behaviours.

Results: Low activity and high sedentariness were evident. More activity was associated with improved BMI, % body fat, resting heart rate, waist circumference and well-being. Sedentary behaviour was not associated with health. A weak positive association between physical activity and sedentary behaviours emerged.

Conclusions: The low activity levels are of particular concern as linked to health outcomes. The weak association between behaviours suggests worksite interventions should target both behaviours.

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BACKGROUND

Physical activity is important in the primary and secondary prevention of chronic diseases, in particular coronary heart disease, stroke, hypertension, breast cancer, colon cancer, type 2 diabetes mellitus and osteoporosis (Warburton et al. 2007). Globally, 5.3 million premature deaths are caused by physical inactivity each year (Lee et al. 2012). Indeed, the risk of dying prematurely is estimated to be 66% lower for the most physically active compared to the least active (Warburton et al. 2007). Yet physical activity levels remain low. In England, 60% of men and 70% of women do less than the recommended amount for health benefit (Craig et al. 2008) and these figures are consistent with other westernised countries (Cavill et al. 2006; Department of Health 2011; Department of Health and Ageing 2011). In 2010 the British Association of Sport and Exercise Sciences produced a consensus statement on the levels of recommended activity for health benefit (ABC of Physical Activity for Health; O'Donovan et al. 2010). Whilst broadly the same as previous national (Department of Health 2004) and international recommendations (Surgeon General 1996) this statement provides further guidance on the combination of moderate and vigorous activity levels required for adults (Figure 1).

Figure 1

It is now acknowledged that sedentary behaviour is not merely the absence of physical activity but rather are 'activities that do not increase energy expenditure substantially above the resting level' and include sleeping, sitting, lying down and watching TV (Pate et al. 2008, p174). Individuals can therefore be both highly active and highly sedentary (British Heart Foundation 2012). There is increasing evidence that sedentary behaviour is a risk factor for poor health, independent of physical activity (Katzmarkzyk 2010; Thorp et al. 2011); specifically, moderate evidence exists for a relationship between sedentary behaviour and risk for type 2 diabetes; and strong evidence for all-cause and cardiovascular disease mortality (Proper et al. 2011). We also know that adults currently spend considerable time in sedentary behaviours in their leisure, travel and occupational time (Bauman et al. 2011); for example, in Europe, 64% reported sitting for more than 4 hours a day (Hallal et al. 2012). Currently there are no specific recommendations for the duration of sedentary time above which health may be at risk. It is simply recommended that adults minimise the amount of time being sedentary for extended periods of time (British Heart Foundation 2012).

Studies are increasingly assessing physical activity behaviours across different volumes and intensities with a view to confirming the 'dose-response relationship' with health outcomes (O'Donovan et al. 2010). They are also exploring *both* activity and sedentary levels (Biddle 2007). However, many studies are cross-sectional and also do not account for age, sex, ethnicity and socioeconomic status (SES) variations (Bryan and Katzmartzy 2011; O'Donovan et al. 2010). Studies need to be prospective and assess total energy expenditure from physical activity and sedentary behaviours across all domains rather than focusing only on work or leisure time (Bryan and Katzmartzy 2011). In this paper we address these limitations. We present prospective data collected from employees of five organisations in the UK over a 12 month period. Most adults spend half their waking hours at work, and many are in occupations which require low levels of activity and prolonged bouts of sitting (van Uffelen et al. 2010) making the workplace an excellent setting for understanding these health behaviours to inform interventions. We explore the impact of *incremental* increases in physical activity and *incremental* decreases in sedentary behaviours on objective and self-reported health outcomes. We also investigate the association between activity and sedentary behaviours.

METHODS

Ethics approval

Ethics approval was granted by the University of Leeds, Institute of Psychological Sciences and Sheffield East NHS Local Research Ethics Committees in October 2007.

Participants

Participants were employees of five UK organisations who took part in the 'AME for Activity' study (McEachan et al. 2011). We present data from 467 participants who completed a postal questionnaires at four time points: baseline (T1), 3 months (T2), 6 months (T3) and 12 months (T4) and attended a health check at T1 and T4.

Data collection and measures

Postal questionnaire

Participant demographics were recorded at T1: gender, age, marital status, ethnicity, socio-economic status using the self-coded UK National Statistics Socio-Economic Measure (SES; NS-SEC) and employer organisation.

Self-reported physical activity and sedentary behaviour were measured at all four time points using the short form of the International Physical Activity Questionnaire (IPAQ; Craig et al. 2003) which has demonstrated validity and reliability and performs similarly to the longer version of the questionnaire (Hagstromer et al. 2006). The IPAQ short

form exhibits moderate correlations with objectively assessed physical activity via pedometer or accelerometer data (Craig et al. 2003) performing similarly to other questionnaire physical activity indices (De Cocker et al. 2009).

The IPAQ short form assesses the duration (minutes) and frequency (days) an individual engages in three types of activity (walking, moderate and vigorous) over the previous seven days. Each type of activity is then weighted by its energy requirements defined in METs (a multiple of resting metabolic rate, walking = 3.3, moderate = 4, vigorous = 8). This results in a MET-minute score per week for the three types of activity.

Using the MET-minute scores per week we classified participants at each time point according to the ABC of Physical Activity for Health consensus statement (Figure 1). Participants were classified as **B**eginner if their MET-minutes per week were less than 600, as **A**ll healthy adults if their MET-minutes per week were between 600 and 1199; and as **C**onditioned if their MET-minutes per week were more than 1200. Where MET-minutes per week data were missing (T1 9%, T2 13%, T3 18%, T4 7%) participants were classified as **B**eginner. Little's MCAR test confirmed that these data (and the missing sitting data presented below) were missing completely at random ($\chi 2$ (8) = 13.22; p=0.11).

In order to explore the impact of *incremental* increases in physical activity behaviour on health outcomes (as per the ABC classification), we created five independent *12-month physical activity* groups:

1. **B**eginner at all 4 time points
2. Either **B**eginner or **A**ll healthy adults across the 4 time points
3. **A**ll healthy adults at all 4 time points
4. Either **A**ll healthy adults or **C**onditioned across the 4 time points
5. **C**onditioned at all 4 time points

Group size was unequal across the five 12-month physical activity groups however we retained all five groups in the analyses as per the ABC classification. We excluded participants who had reported *non incremental*, mixed levels of activity over the 12 months (i.e. moved between **A**ll healthy adults, **B**eginner and **C**onditioned levels, n=159).

The IPAQ short form also assesses the duration (hours, minutes) an individual spends sitting on a week day during the previous seven days. Since there are currently no specific recommendations for the duration of sedentary time above which health may be at risk, we categorised participants at each time point using a classification of sitting time from a large survey of sedentary behaviour in workplace employees (Brown et al. 2003): Sitting more than 444 minutes (7.4

hours) a day, sitting 282 to 444 minutes a day or sitting 281 minutes (4.7 hours) or less a day. Where data were missing (T1 10%, T2 17%, T3 21%, T4 10%) participants were classified as Sitting more than 444 minutes a day.

To explore the impact of *incremental* decreases in 12 months sitting behaviour on health outcomes, we first created five independent *12-month sedentary* groups:

1. Sitting more than 444 minutes a day at all 4 time points
2. Either sitting more than 444 minutes or sitting 282 to 444 minutes a day across the 4 time points
3. Sitting 282 to 444 minutes a day at all 4 time points
4. Either sitting more than 282 to 444 minutes or sitting 281 minutes or less a day across the 4 time points
5. Sitting 281 minutes or less a day at all 4 time points

We excluded participants who had reported *non incremental*, mixed levels of sitting over the 12 months (i.e. moved between levels of sitting, n=109). We subsequently merged groups 3 to 5 as they were small (n=9, n=34 and n=21 respectively) creating three *12-month sedentary groups*: High (group 1 above), Moderate (group 2 above) and Low (groups 3 to 5 above).

Self-reported mental well being and health:

At all four time points participants completed the GP-CORE (Evans et al. 2005). This 14-item scale records subjective well-being (e.g. I have felt OK about myself), problems/symptoms (e.g. I have felt anxious or nervous) and functioning (e.g. I have felt able to cope when things go wrong) over the past week. It is designed for use in non-clinical settings and has shown acceptable reliability and validity within a student sample (Evans et al. 2005). Items were scored 1 (‘not at all’) to 5 (‘all the time’) and divided by 14 to yield a mean item score between 1 and 5.

Self-reported health was measured at all four time points using the standardised visual analogue scale from the EQ-5D, where 0 = worst imaginable health and 100 = best imaginable health (The EuroQol Group 1990).

The T1 and T4 data for both measures were used in the analyses for this paper as these were time points where objective health data were collected.

Health check

Objective health data were collected in a health check at baseline (T1) and at (T4) which took place in the participants’ worksite and was conducted by a trained health technician following a detailed protocol. The following data were recorded: body mass index (BMI) and per cent body fat (using OMRON BF306 body fat monitor), waist circumference

(mean of three tape measurements), diastolic and systolic blood pressure (lowest of two measurements using OMRON M7 blood pressure monitor), and resting heart rate (RHR, using OMRON M7).

Data analysis

Descriptive statistics were used to summarise participants' demographic characteristics across the independent 12-month physical activity and sedentary groups. Chi-squared analyses explored the associations between these characteristics and the 12-month physical activity and sedentary groups. One way ANOVAs compared mean age across the 12-month physical activity and sedentary groups.

Means and standard deviations were calculated for the objective and self-reported health outcomes across the five 12-month physical activity and three 12-month sedentary groups. Two MANCOVAs explored the impact of 12 months physical activity and sedentary behaviour on objective and self-reported health outcomes. Demographic characteristics, employer organisation; and baseline health measures were entered as covariates. Where significant between-subjects effects were identified pairwise comparisons investigated where these differences occurred. To correct for multiple testing, a Bonferroni correction was carried out.

Spearman's correlation analysis explored the association between participants' physical activity (A, B or C) and sitting (> 444 minutes a day, 282 to 444 minutes a day, 281 minutes or less a day) classifications at each time point. All 467 participants were included in these analyses.

RESULTS

Participants

The majority of participants were White British (89%), married (71%), and in intermediate and managerial/professional roles (91%). Just over half were female (59%) and just under half worked for the council organisation (44%). The mean age was 40 years. Demographic characteristics for participants by the 12-month physical activity and sedentary groups are presented in Tables 1 and 2 respectively.

Approximately one third of participants were categorised as Beginner (30%), one third as **B**eginner or **A**ll Healthy Adult (31%) and just 7% as **Al**l Healthy Adult; 16% were **A**ll Healthy Adult or **C**onditioned and 15% as **C**onditioned. No demographic characteristics were statistically significantly associated with 12-month physical activity group.

Table 1

Over one third of participants were categorised as High sitting (37%), nearly half as Moderate sitting (45%) and 18% as Low sitting over the 12 months. SES ($\chi 2$ (2, N=358) = 7.46; p=0.02) and employer organisation ($\chi 2$ (8, N=358) = 28.85; p<0.001) were significantly associated with 12-month sedentary group. Participants classified as lower SES were more likely to be in *both* the Low sitting group and the High sitting group and less likely to be in the Moderate sitting group; the reverse pattern was evident for high SES participants. Employees of the bus company and the government organisation were more likely to be in the High sitting group, council employees were less likely to be in this group.

Table 2

What is the impact of physical activity behaviour over 12 months on health?

The objective and self-reported health outcomes across five 12-month physical activity groups (n=308) are presented in Table 3. MANCOVA revealed statistically significant multivariate effects for 12-month physical activity group (F(32, 788)=1.22, p=0.02). Between subjects effects for 12-month physical activity group are presented in Table 3. These were statistically significant for BMI, per cent body fat, waist circumference, resting heart rate and mental well-being. In general, as activity levels moved from **B**eginner to **C**onditioned all five health outcomes improved i.e. more activity was associated with lower BMI, lower per cent body fat, smaller waist circumference, lower resting heart rate and better mental well-being.

Table 3

Pairwise comparisons revealed that the two lowest 12-month physical activity groups (**B**eginner; **B**eginner or **A**ll healthy adult) had statistically significantly higher BMI and per cent body fat than the **A**ll healthy adult (p<0.05), **A**ll healthy adult or **C**onditioned (p<0.05) and **C**onditioned (p<0.01) groups. These two lowest 12-month physical activity groups also had statistically significantly larger waist circumference than the **C**onditioned group (both p<0.05). In terms of resting heart rate the **B**eginner group had a statistically significantly higher mean score than all the other 12-month activity groups (p values range from <0.001 to <0.05). Mean resting heart rate for the **B**eginner or **A**ll healthy adult group was also significantly higher than the **C**onditioned group (p<0.05). Finally, the **B**eginner group had statistically significant poorer mental wellbeing than the two highest 12-month physical activity groups. The **B**eginner or **A**ll healthy adult group had statistically significant poorer mental wellbeing than the **A**ll healthy adult or **C**onditioned group (all Mean, SD and p values are presented in Table 3).

Health outcomes did not vary as a function of marital status, ethnicity, SES or employer organisation. A near statistically significant multivariate effect emerged for age ($F(8, 194)=1.99$, $p=0.05$. Between subjects effects for age are presented in Table 3. There were no statistically significant interactions between 12-month physical activity group and any of the demographic characteristics. Statistically significant multivariate effects emerged for all the objective and self-reported T1 health outcome covariates which were significant in the predicted direction, for example those with the highest BMI at baseline also had the highest BMI at 12 months.

What is the impact of sedentary behaviour over 12 months on health?

The objective and self-reported health outcomes across three 12-month sedentary groups (n=358) are presented in Table 4. There was no effect for 12-month sedentary group. In other words, as sitting levels decreased from high to low there was no improvement in objective or self-reported health outcomes.

Table 4

Two significant interactions with 12-month sedentary group did emerge: sedentary group by gender ($F(16, 534)=2.06$, $p=0.009$) and sedentary group by SES ($F(16, 534)=1.80$, $p=0.03$). The significant between subjects effect for sedentary group by gender was for self-reported health (see Figure 2). For sedentary group by SES, significant between subjects effects emerged for self-reported health and mental well-being (see Figures 3 and 4). However for all three effects, there were no statistically significant differences in any pairs of mean scores.

Figures 2 to 4

MANCOVA revealed a statistically significant multivariate effect for gender ($F(8, 266)=2.88$, $p=0.004$) which had not emerged in the physical activity group analysis presumably because of the different sample sizes in the two analyses (a difference of n=50). Females ($M=31.57$, $SE=0.46$) had statistically significantly higher per cent body fat than males ($M = 26.61$, $SE=0.51$; ($F(1, 273)=10.67$, $p=0.01$) and lower systolic blood pressure (Females $M = 115.45$, $SE=1.63$; Males $M = 121.17$, $SE=1.78$; $F(1, 273)=3.76$, $p=0.05$). Finally, as reported above there were statistically significant multivariate effects for all the T1 objective and self-reported health outcome covariates in the predicted direction.

Are physical activity and sedentary behaviours associated?

Spearman correlation analysis revealed weak positive correlations between activity and sitting behaviours at all four time points (T1: r_s=0.21; p<0.001; T2: r_s = 0.22; p<0.001; T3: r_s = 0.23; p<0.001; T4: r_s =0.17; p=0.001). In summary, high activity was weakly associated with high sitting at each time point.

DISCUSSION

The aim of this study was to explore how *incremental* increases in physical activity as per the recent ABC classification (O'Donovan et al. 2010; Figure 1) and *incremental* decreases in sitting (High to Moderate to Low) over a 12-month period impact on health outcomes in employees of five organisations. We also investigated the association between physical activity and sedentary behaviours. The participating employer organisations represent large UK employers (Health and Social Care Information Centre 2012; Office for National Statistics 2011) and our findings provide important insight into the activity and sedentary behaviours of employees as well as their health which has implications for the design of effective interventions across different types of workplaces.

Two study limitations are acknowledged. We used a self-report measure of physical activity and sedentary behaviour which is open to potential bias and measurement issues (Heesch et al. 2011). That said this method is pragmatic and reliably associated with health outcomes (Heesch et al. 2011). Second, there were missing IPAQ data. However these were confirmed to be missing completely at random. To address this we imputed the lowest activity (**B**eginner) and highest sedentary (sitting more than 444 minutes a day) classifications at each time point. As such we are confident that we have not over-estimated the positive effect of physical activity or low sitting on health outcomes. Indeed we may have diluted their impact.

How physically active and sedentary are these employees?

Less than half (38%) of employees met the levels of physical activity recommended for health benefit at all four time points. These activity levels, whilst captured over 12 months, are consistent with cross-sectional national adult surveys (Cavill et al. 2006; Craig et al. 2008; Department of Health and Ageing 2011) and with the UK Well@Work study (Bull et al. 2008). Differences in activity levels across the organisations were not statistically significant. Our measure of activity included all types of physical activity, within and outside work, meaning any differences in workplace physical activity would be hard to pick up if employees compensated for high or low activity levels outside of work.

The lack of a specific recommendation for the duration of sedentary time above which health may be at risk means that studies which categorise sitting timeuse different cut off points as well as measure different domains of sedentary behaviour e.g. TV viewing, occupational sitting; making comparison across studies difficult (Bauman et al. 2011). Over

a third (37%) of employees reported sitting for more than 7.4 hours on weekdays and a further 45% sat for more than 4.7 hours a day at each time point. This is noticeably less than the 82% of men and 55% of women reported by Brown et al. (2003) in their study of Australian workers (whose classification of sitting behaviour we used) but is in line with levels of *total sitting* reported in Dutch workers (Jans et al. 2007). Consistent with previous workplace studies (Bull et al. 2008, Jans et al. 2007) we found statistically significant associations between levels of sedentary behaviour, employer organisation and SES (using a measure based on occupation). Because of our use of a single index of sedentary behaviour, we cannot be sure that these differences are due to the nature of the work of employees, although it would seem likely. For example, council employees, found to be less sedentary, included a broad range of occupations (including teachers, social workers, refuse collectors) compared to the highly sedentary bus drivers and government organisation office workers. This explanation assumes that employees are not compensating for high or low sedentary levels outside of work (Jans et al. 2007), which is in contrast to our interpretation of the physical activity patterns reported above. In westernised countries many people have occupations that require long periods of sitting (van Uffelen et al. 2010); if our interpretation of these findings is correct it suggests that those who cannot reduce their work sitting time need to be prompted to reduce sitting in their travel and leisure time.

What is the impact of physical activity behaviour over 12 months on health?

As 12-month physical activity levels increased, four (of six) objective and one (of two) self-reported health outcomes improved. More activity was associated with lower BMI, per cent body fat and RHR, smaller waist circumference and better mental well-being. This was observed after controlling for demographic characteristics, orgnasiation and baseline health outcomes. Specifically, the two highest activity groups (**A**ll healthy adult or **C**onditioned, **C**onditioned) had statistically significantly better scores on these health outcomes compared to the two lowest activity groups (**B**eginner, **B**eginner or **A**ll healthy adult). Across all five groups systolic and diastolic blood pressure was within the normal range (NICE, 2011) and self-reported health was marginally below UK adult population norms (Kind et al. 1999).

Health data by 12-month physical activity group and gender are presented in Appendix 1. In terms of *clinical* significance, mean BMI and waist circumference scores for men in the two lowest activity groups placed them into the 'overweight' and 'high waist circumference' categories (NICE, 2006) resulting in a classification of 'increased health risk'. Mean body fat percentage for these two groups defined them as 'obese' (Gallagher et al. 2000). High RHR is a risk factor for both cardiovascular and all-cause mortality (Palatini and Julius 2004). Men in the two highest activity groups had 'good' resting heart rate (RHR) levels compared to 'average/below average' for the two lowest activity groups (YMCA 1989). Mean RHR scores placed women in the 'average' category, with the exception of the **C**onditioned group who would be classified as 'good/excellent'. The differences across activity groups for mental well-

being did not equate to a clinically significant benefit. Mean scores were marginally higher (reflecting poorer mental well-being) than norms for a non-clinical student population (Evans et al. 2005).

Of interest, is whether adults consistently meeting the **A**ll healthy adult level of physical activity over 12 months confer greater health benefit than those not meeting it. Only 22 participants fell into this group so it is difficult to draw meaningful conclusions. A benefit was evident for men in terms of BMI and per cent body fat. Those achieving these levels would no longer be classified as having an 'increased health risk' (NICE 2006). To our knowledge there are no other prospective studies in workplace or general population samples that present adults' activity levels using the ABC classification. Physical activity and fitness surveys (Cavill et al. 2006; Department of Health 2011) and workplace studies (e.g. Bull et al. 2008) often compare **B**eginner with **A**ll Healthy Adult only. Given the body of evidence demonstrating additional health benefits of higher frequency and intensity of activity (O'Donovan et al. 2010; Lee et al. 2012; Warburton et al. 2007) evident also in our data; classifying adults across the full ABC spectrum would seem sensible.

We found no effect for 12-month sedentary behaviour. As sitting levels decreased from high to low there was no statistically significant or clinically meaningful improvement in health. Evidence for an association of sedentary behaviours with three of the health outcomes we explored (BMI, waist circumference, mental health) whilst considered 'plausible' (British Heart Foundation 2012, p3) remains mixed (Teyenne et al. 2010; Thorp et al. 2011; van Uffelen et al. 2010). Indeed, the precise dose-response relationships between sedentary behaviours and different health outcomes remain unknown (Katzmarzyk 2010). Furthermore, it may be that some health outcomes require high energy expenditure (i.e. increased physical activity) for improvement rather than reduced sedentariness.

Are physical activity and sedentary behaviours associated?

Finally, sitting and physical activity behaviours at each time point were weakly associated. This further confirms that physical activity and sedentary behaviours can be independent and co-exist, rather than one displacing the other (Biddle 2007). The implication is that in designing worksite interventions one cannot assume that strategies to increase physical activity will also reduce sedentary behaviours or vice versa. Yet public health guidance for worksites (e.g. NICE 2008) commonly focus exclusively on increasing physical activity rather than *also* targeting reducing sitting. Worksite interventions that have been evaluated have also tended to target physical activity alone or if both behaviours, sedentary behaviour is a secondary outcome (Chau et al 2010). More research is needed to understand the impact of workplace layout and policy on *both* increasing physical activity and breaking up sedentary behaviours across different types of employer organisations.

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Appendix 1: Objective and self-reported health of participants by 12- month physical activity group and gender

	All				Beginner				Beginner or All healthy adult				All healthy adult				All healthy adult or Conditioned				Conditioned			
	Males		Females		Males		Females		Males		Females		Males		Females		Males		Females		Males		Females	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Body mass index	25.59	3.17	24.40	4.44	26.12	3.72	24.61	4.69	25.73	3.31	24.80	4.87	26.11	2.96	23.93	3.15	25.29	2.81	23.46	4.29	24.88	2.76	23.97	3.09
% body fat	24.84	5.63	34.58	6.84	27.00	6.10	35.33	6.74	25.70	5.56	24.80	4.87	24.35	4.67	32.80	5.05	24.33	5.13	32.94	6.99	21.98	5.03	33.15	7.00
Waist circumference	92.62	9.70	82.64	11.78	96.76	12.69	84.06	12.56	93.50	8.69	83.18	11.37	91.97	8.20	80.79	9.20	90.77	7.13	81.60	12.62	88.85	8.45	79.07	10.70
Systolic BP	125.92	12.28	113.37	13.71	124.34	9.53	114.17	16.05	126.94	16.80	114.03	12.70	125.10	7.71	111.92	7.98	126.88	11.67	113.32	15.11	125.69	10.21	109.86	9.42
Diastolic BP	79.54	9.00	76.16	9.86	79.48	8.16	77.38	9.97	81.86	10.44	76.56	10.12	81.20	6.60	74.08	8.27	78.72	9.04	76.28	10.96	76.62	8.13	72.33	7.74
Resting heart rate	65.63	10.98	70.17	9.77	72.93	10.73	73.20	10.38	68.09	9.14	70.15	8.71	58.20	10.35	69.75	12.48	63.20	8.70	68.00	7.26	59.38	10.26	63.86	8.70
Mental well-being[a]	3.78	0.63	3.80	0.62	3.56	0.64	3.71	0.75	3.77	0.58	3.80	0.52	3.60	0.69	3.89	0.47	4.01	0.59	3.84	0.51	3.88	0.65	3.97	0.64
Self-reported health[b]	74.12	16.50	73.66	17.34	67.97	19.21	71.02	19.46	72.34	14.54	71.89	17.79	74.20	20.71	73.50	15.71	81.84	7.77	78.36	13.17	75.92	18.05	81.38	11.35

N = 308 (125 male, 183 female): n = 93 Beginner (29 male, 64 female), n = 96 Beginner/All healthy adult (35 male, 61 female); n = 22 All healthy adult (10 male, 12 female), n = 50 All healthy adult/Conditioned (25 male, 25 female); n = 47 Conditioned (26 male, 21 female).

[a]Scores range from 1 (worst mental wellbeing) to 5 (best mental wellbeing); [b]Scores range from 0 (worst imaginable health) to 100 (best imaginable health).

Figure 1: Key recommendations in the ABC of Physical Activity for Health

- **A**ll healthy adults should take part in at least 150 min of moderate-intensity aerobic activity each week, or at least 75 min of vigorous-intensity aerobic activity each week, or equivalent combinations of moderate- and vigorous-intensity aerobic activities.
- **B**eginners should steadily work towards meeting the physical activity levels recommended for all healthy adults.
- **C**onditioned individuals who have met the physical activity levels recommended for all healthy adults for at least 6 months may obtain additional health benefits by engaging in 300 min or more of moderate-intensity aerobic activity each week, or 150 min or more of vigorous-intensity aerobic activity each week, or equivalent combinations of moderate- and vigorous-intensity aerobic activities.
- All adults should minimise the amount of time spent being sedentary (sitting) for extended periods.

Adapted from O'Donovan et al. (2010)

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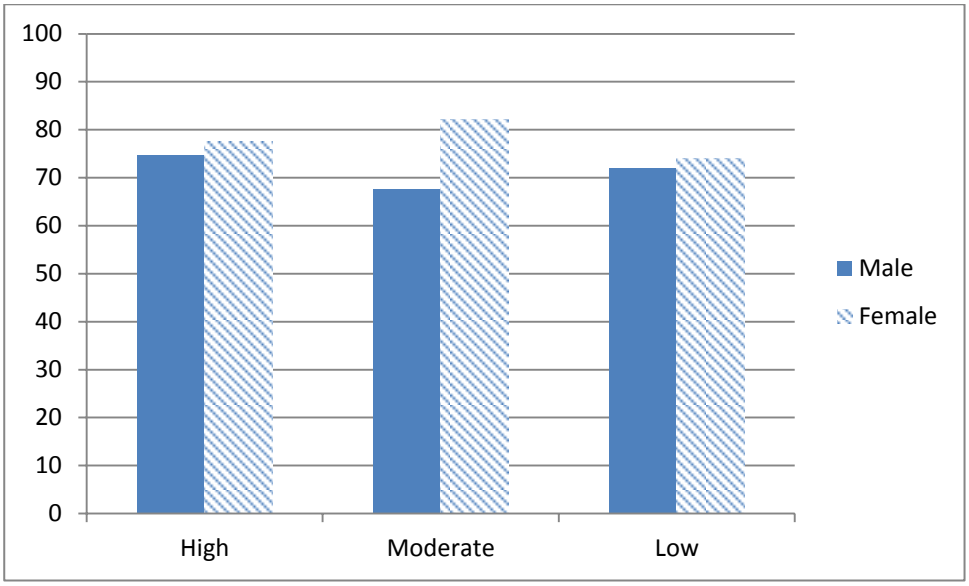
Figure 2: Mean Self-reported Health State[a] by 12-month sedentary group x gender



[a]Scores range from 0 (worst imaginable health) and 100 (best imaginable health)

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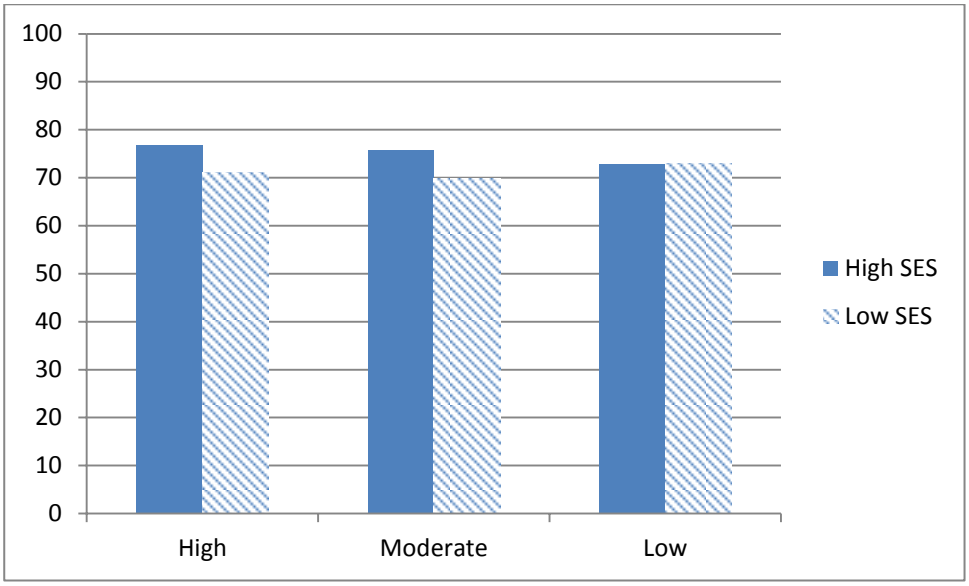
Figure 3: Mean Self-reported Health State[a] by 12-month sedentary group x SES



[a]Scores range from 0 (worst imaginable health) and 100 (best imaginable health).

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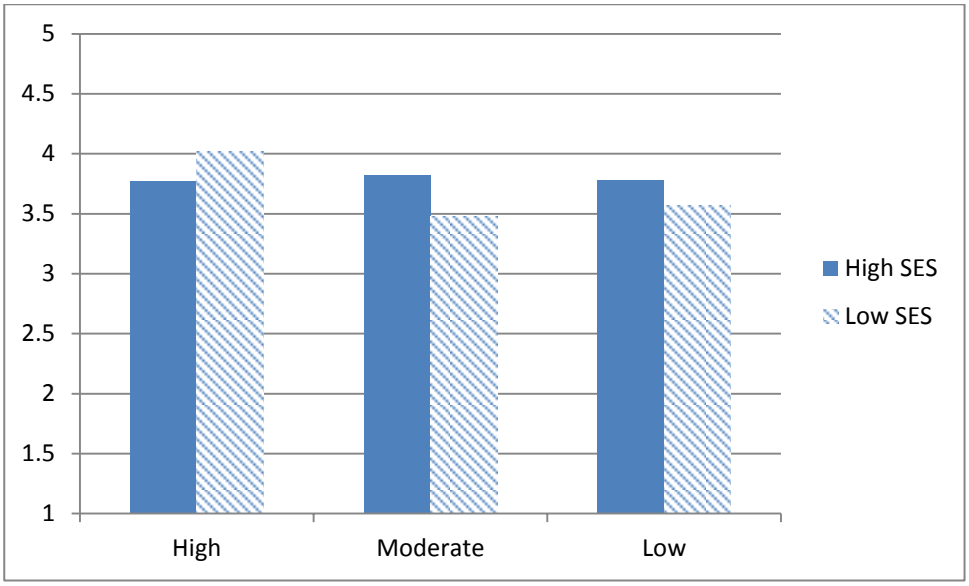
Figure 4: Mean Self-reported Mental Well-being[a] by 12-month sedentary group x SES



[a]Scores range from 1 (good mental well-being) to 5 (poor mental well-being)

table
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Table 1: Demographic characteristics of participants across 12-month physical activity groups

		All		Beginner		Beginner or All healthy adult		All healthy adult		All healthy adult or Conditioned		Conditioned	
		n	%	n	%	n	%	n	%	n	%	n	%
	All[a]	308	100	93	30	96	31	22	7	50	16	47	15
Gender	Male	125	41	29	31	35	36	10	45	25	50	26	55
	Female	183	59	64	69	61	64	12	55	25	50	21	45
Marital Status[b]	Married	219	71	58	62	71	74	17	77	39	78	34	72
	Single	89	29	35	38	25	26	5	23	11	22	13	28
Ethnicity	White British	274	89	85	91	85	89	19	86	46	92	39	83
	Other	34	11	8	9	11	11	3	14	4	8	8	17
NSSEC[c]	Higher SES	280	91	80	86	90	94	20	91	48	96	42	89
	Lower SES	28	9	13	14	6	6	2	9	2	4	5	11
Employer Organisation	Council	136	44	33	35	41	43	10	45	28	56	24	51
	Hospital	58	19	24	26	18	19	3	14	6	12	7	15
	Bus company	23	8	13	14	6	6	0	0	2	4	2	4
	Government	70	23	17	18	25	26	7	32	11	22	10	21
	University	21	7	6	6	6	6	2	9	3	6	4	9
	Age (years; M, SD)	40.47, 9.77		40.73, 9.70		40.06, 9.13		38.77, 9.56		39.76, 10.02		42.34, 11.01	

N=308. [a]Percentages across for 'All' are calculated across physical activity groups. Percentages for demographics and employer organisation characteristics are calculated within physical activity groups. All percentages are presented to the nearest full number and may not total 100.
[b]Married/Civil partnership/living together; Single/in relationship. [c]Higher SES=Intermediate, Managerial/Professional; Lower SES=Lower Supervisory, Semi-routine/Routine.

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Table 2: Demographic characteristics of participants across the 12-month sedentary groups

		High sitting		Moderate sitting		Low sitting	
		n	%	n	%	n	%
	All[a]	134	37	160	45	64	18
Gender	Male	59	44	66	41	26	41
	Female	75	56	94	59	38	59
Marital Status[b]	Married	96	72	119	75	52	81
	Single	38	28	41	25	12	19
Ethnicity	White British	122	91	137	86	58	91
	Other	12	9	23	14	6	9
NSSEC[c]	Higher SES	115	86	150	94	53	83
	Lower SES	19	14	50	6	11	17
Employer Organisation	Council	42	31	80	50	35	55
	Hospital	22	16	28	18	12	19
	Bus company	20	16	7	4	1	2
	Government	40	30	29	18	10	16
	University	10	7	16	10	6	9
	Age (years; M, SD)	40.95, 10.71		40.80, 10.19		42.13, 9,.27	

N=358. [a]Percentages across for 'All' are calculated across sedentary groups. Percentages for demographics and employer organisation characteristics are calculated within sedentary groups. All percentages are presented to the nearest full number and may not total 100.
[b]Married/Civil partnership/living together; Single/in relationship. [c]Higher SES=Intermediate, Managerial/Professional; Lower SES=Lower Supervisory, Semi-routine/Routine.

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Table 3: Objective and self-reported health (mean, SD) of participants across 12-month physical activity groups

	All		Beginner		Beginner or All healthy adult		All healthy adult		All healthy adult or Conditioned		Conditioned		Between-subjects effects	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	12-month physical activity group	Age
Body mass index	24.88	4.01	25.08[1,2,3]	4.45	25.14[4,5,6]	4.37	24.93[1,4]	3.19	24.38[2,5]	3.70	24.47[3,6]	2.92	**F(4)=2.44, p=0.04**	**F(1)=4.31, p=0.04**
% body fat	30.63	7.97	32.73[7,8,9]	7.58	31.81[10,11,12]	8.02	29.00[7,10]	6.42	28.63[8,11]	7.47	26.97[9,12]	8.16	**F(4)=2.48, p=0.04**	**F(1)=4.04, p=0.04**
Waist circumference	86.48	10.62	88.02[13]	13.86	86.94[14]	11.56	85.87	10.27	86.18	11.15	84.48[13, 14]	10.62	**F(4)=5.32, p<0.001**	F(1)=2.23, p=0.14
Systolic BP	118.46	14.51	117.34	15.05	118.74	15.55	117.91	10.20	120.10	15.01	118.62	12.59	F(4)=1.18, p=0.32	**F(1)=4.20, p=0.04**
Diastolic BP	77.53	9.65	78.03	9.45	78.49	10.50	77.32	8.23	77.50	10.02	74.70	8.16	F(4)=1.25, p=0.29	**F(1)=5.95, p=0.02**
Resting heart rate	68.33	10.50	73.12[15,16,17,18]	10.43	69.40[15,19]	8.88	64.50[16]	12.73	65.60[17]	8.29	61.38[18,19]	9.56	**F(4)=2.94, p=0.02**	F(1)=0.25, p=0.62
Mental well-being[a]	3.79	0.62	3.66[20.21]	0.72	3.79[22]	0.54	3.76	0.58	3.93[20]	0.55	3.92[21,22]	0.64	**F(4)=3.37, p=0.01**	F(1)=0.13, p=0.72
Self-reported health[b]	73.85	16.98	70.07	19.33	72.05	16.60	73.82	17.70	80.10	10.84	78.36	15.51	F(4)=0.78, p=0.54	F(1)=2.46, p=0.12

N = 308: n = 93 Beginner, n = 96 Beginner/All healthy adult; n = 22 All healthy adult, n = 50 All healthy adult/Conditioned; n = 47 Conditioned.
Statistically significant pairwise comparisons:
Pairwise comparisons: 1,2,4,5,7,8,10,11,13,14,15,19,21,22 all $p<0.05$; 3,6,9,12,16,17 all $p < 0.01$; 18,20 $p<0.001$.
[a]Scores range from 1 (worst mental wellbeing) to 5 (best mental wellbeing); [b]Scores range from 0 (worst imaginable health) to 100 (best imaginable health).

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Table 4: Objective and self-reported health (mean, SD) of participants across 12-month sedentary groups

	All		High sitting		Moderate sitting		Low sitting		Between-subjects effects		
	M	SD	M	SD	M	SD	M	SD	Gender	12-month Sedentary Group by gender	12-month Sedentary Group by SES
Body mass index	24.96	4.08	25.10	4.50	24.87	3.72	24.87	4.08	F(1)=0.40, p=0.53	F(2)=1.49, p=0.23	F(2)=0.92, p=0.40
% body fat	30.74	7.76	30.67	8.21	30.64	7.54	29.67	7.37	**F(1)=4.60, p=0.03**	F(2)=2.05, p=0.13	F(2)=0.43, p=0.65
Waist circumference	87.11	12.54	87.88	13.66	86.96	11.50	85.86	12.64	F(1)=2.50, p=0.12	F(2)=0.40, p=0.67	F(2)=0.96, p=0.39
Systolic BP	119.32	15.14	119.91	15.68	119.65	14.76	117.28	15.00	**F(1)=4.08, p=0.04**	F(2)=1.97, p=0.14	F(2)=0.58, p=0.56
Diastolic BP	77.78	9.94	78.01	9.40	78.04	10.10	76.63	10.67	F(1)=1.61, p=0.21	F(2)=1.31, p=0.27	F(2)=0.80, p=0.45
Resting heart rate	67.98	9.94	66.99	10.01	67.71	10.09	66.56	9.29	F(1)=2.65, p=0.11	F(2)=1.25, p=0.29	F(2)=0.10, p=0.91
Mental well-being[a]	3.82	0.59	3.84	0.59	3.76	0.58	3.94	0.60	F(1)=0.35, p=0.55	F(2)=0.85, p=0.43	**F(2)=3.19, p=0.04**
Self-reported health[b]	75.34	15.09	74.22	16.34	75.21	14.16	78.03	14.48	F(1)=2.15, p=0.14	**F(2)=7.04, p=0.001**	**F(2)=5.92, p=0.003**

N = 358: n = 134 High sitting, n = 160 Moderate sitting; n = 64 Low sitting.
[a]Scores range from 1 (best mental wellbeing) to 5 (worst mental wellbeing); [b]Scores range from 0 (worst imaginable health) to 100 (best imaginable health).

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