Research

Low leisure-based sitting time and being physically active were associated with reduced odds of death and diabetes in people with chronic obstructive pulmonary disease: a cohort study

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ABSTRACT

Questions: In people with chronic obstructive pulmonary disease (COPD), are activity phenotypes (based on physical activity and recreational screen time) associated with mortality and cardiometabolic risk factors? **Design**: Cohort study. **Participants**: People with COPD aged $\geq$ 40 years and who were current or ex-smokers were identified from the 2003 Scottish Health Survey. **Outcome measures**: Data were collected regarding demographics, anthropometric measurements, medical history, physical activity, sedentary behaviour, health outcomes, and mortality. **Analysis**: Participants were categorised into one of the following activity phenotypes: 'couch potatoes' were those who were insufficiently active with high leisure-based sitting time and/or no domestic physical activity; 'light movers' were insufficiently active with some domestic physical activity; 'sedentary exercisers' were sufficiently active with high leisure-based sitting time; and 'busy bees' were sufficiently active with low leisure-based sitting time. 'Sufficiently active' was defined as adhering to physical activity (PA) recommendations of $\geq$ 7.5 metabolic equivalent (MET) hours/week. 'Low leisure-based sitting time' was defined as $\leq$ 200 minutes of recreational screen time/day. **Results**: The 584 participants had a mean age of 64 years (SD 12) and 52% were male. Over 5.5 years (SD 1.3) of follow-up, there were 81 all-cause deaths from 433 COPD participants with available data. Compared to the 'couch potatoes', there was a reduced risk of all-cause mortality in the 'busy bees' (Hazard Ratio 0.26, 95% CI 0.11 to 0.65) with a trend towards a reduction in mortality risk in the other phenotypes. The odds of diabetes were lower in the 'busy bees' compared to the 'couch potatoes' (OR 0.14, 95% CI 0.03 to 0.67). **Conclusions**: Adhering to physical activity guidelines and keeping leisure-based sitting time low had a mortality benefit and lowered the odds of diabetes in people with COPD. **[McKeough Z, Cheng SWM, Alison J, Jenkins C, Hamer M, Stamatakis E (2018) Low leisure-based sitting time and being physically active were associated with reduced odds of death and diabetes in people with chronic obstructive pulmonary disease: a cohort study. Journal of Physiotherapy 64: 114–120]**

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Introduction

In the general population and in the area of chronic disease, two distinct fields of research have developed to examine the impact of activity behaviours on health outcomes: physical activity (PA) research and sedentary behaviour (SB) research. Historically, PA research emerged first and examined behaviours described across a PA continuum based on intensity level from engagement in light, moderate, vigorous and very vigorous activity. This area of research has resulted in PA guidelines being developed. The aerobic component of these guidelines suggests that adults should have a minimum engagement of 150 minutes of moderate-intensity activity or 75 minutes of vigorous activity or an equivalent combination of both per week to prevent deterioration in

health.[1,2] By definition, physical inactivity now refers to not meeting the activity guidelines. This terminology around physical inactivity is distinct from the field of research on SB, which has been defined as engagement in activities at a low intensity of < 1.5 metabolic equivalents (METs) in a sitting or lying posture but not including sleep. This emerging field of research developed from the evidence that a large proportion of the healthy population engage in SB[3] and that it is an independent predictor of poor health outcomes.[4,5]

The extent of information in these two fields of research for chronic respiratory disease was recently reviewed[6] by examining clinical practice guidelines. While there are recommendations to guide clinicians about engagement in PA for people with chronic obstructive pulmonary disease (COPD) by following the general adult PA guidelines, there are no such recommendations for SB.[6]

Furthermore, several studies have indicated that people with COPD engage in low levels of PA[7–9] and that this is associated with increased mortality[10] and hospitalisation.[11] The consistent evidence of the effects of PA on COPD exacerbations and mortality has been rated as moderate, based on longitudinal designs.[10] Fewer studies have examined the associations between SB and health outcomes.[12,13] One study reported a higher mortality risk in people with COPD who engaged in > 8.5 hours/day of SB independent of disease severity.[12]

Recent evidence in the general population has examined the joint influences of PA and SB, given that people may be sufficiently physically active but still engage in large amounts of SB. A recent harmonised meta-analysis examined whether enough PA can offset the detrimental effects of too much sitting on mortality.[14] High levels of moderate intensity exercise of 60 to 75 minutes/day were shown to eliminate the increased risk of death from high levels of sitting in a general population of adults.[14] Another study divided adults into one of four activity phenotypes (ie, sufficiently active with low sedentary time; sufficiently active with high sedentary time; physically inactive with low sedentary time; and physically inactive with high sedentary time) to examine cardiometabolic markers of health.[15] That study reported that adults who were physically active had better cardiometabolic health than those who were physically inactive, irrespective of sedentary time. However, no studies have examined the joint influence of PA and SB on mortality or cardiometabolic risk in people with COPD. This information would go some way to examining whether PA and SB are causal factors on these health outcomes and, thus, may guide the development of interventions to encourage adequate activity behaviours and help to inform recommendations about engagement in SB.

The aim of this cohort study was to examine the possible aetiological associations of four activity phenotypes involving both PA and recreational screen time with mortality and cardiometabolic risk factors in people with COPD. Recreational screen time was used as a surrogate marker of leisure-based sitting time. It was hypothesised that people with COPD who were sufficiently active and had low recreational screen time would have a lower risk of mortality and reduced odds of cardiometabolic disease than the other phenotypes.

Therefore, the research question for this cohort study was:

In people with COPD, are activity phenotypes (involving physical activity and recreational screen time) associated with mortality and cardiometabolic risk factors?

Method

Design

A cohort study was conducted with the Scottish Health Survey 2003 providing data at both a national and regional level about the population living in private households in Scotland. The sample for this survey was selected using a multi-stage stratified random sampling procedure based on postcode regions. Further details on the sampling process have been reported elsewhere.[16]

Participants

Of eligible adults, 83% consented to take part in the survey. For this study, participants were included in the analysis if they: were aged $\geq$ 40 years; were current or ex-smokers; and met the Global Initiative for Chronic Obstructive Lung Disease (GOLD) spirometric criteria for severity of airflow limitation (forced expiratory volume in 1 second (FEV_1)/forced vital capacity (FVC) ratio of < 0.7).[17] Participants were followed up to time of death or, if there was no record of an event, until data were censored on December 31, 2009.

Measurements

Two household visits were conducted to collect survey data: an interviewer visit for information on socio-economic demographics, general health and quality of life, followed by a nurse visit to collect physiological measures. The measurements relevant to this study are described in more detail below.

Participant characteristics

Interviewers collected basic anthropometric information: height and weight; ethnic and educational background; information on general health; use of health services; and behaviours affecting health such as eating, drinking, smoking and PA.

Lung function

Spirometry was performed using a calibrated spirometer[a]. Participants performed at least one practice attempt, followed by five attempts or until they were deemed too tired to continue. The best of the five attempts was used as the final result. Further details of the spirometry protocol have been published elsewhere.[18]

Exposure variables: physical activity and sitting time

Two domains of PA performed in the 4 weeks before the interview were assessed: light-intensity (slow/average pace) and moderate-intensity (fairly brisk/fast pace) walking; and sport/exercise. For each of these variables, both frequency (number of days in the previous 4 weeks) and duration (of an average episode) of participation was reported. Participation in PA was then calculated in MET-hours/week by multiplying the volume of activity (frequency $\times$ duration) by the intensity of the activity in METs[19] to give a variable of MET-hours/week of leisure-time PA. This PA variable was converted into two categories based on adhering to the current PA recommendation of at least 7.5 MET-hours/week, which is equivalent to 75 minutes/week of vigorous PA or 150 minutes/week of moderate PA.[20] Participants were classified as 'insufficiently active' (< 7.5 MET-hours/week of PA) or 'sufficiently active' ($\geq$ 7.5 MET-hours/week of PA).[20] A third domain of domestic PA (eg, general tidying, spring cleaning, heavy manual work, gardening and 'do-it-yourself' activities) was also determined in the same way as the leisure-based PA to give a variable of MET-hours/week of domestic PA. This domestic PA variable was converted into two categories such that participants were classified as either 'no domestic PA' (equal to 0 MET-hours/week of domestic activity) or 'some domestic PA' (> 0 MET-hours/week of domestic activity). Both variables of leisure-time PA and domestic PA were used to define the activity phenotypes (see section on 'Categories of activity phenotypes'). More details on the PA interviews can be found in previous reports.[21]

Recreational screen time was used to determine the amount of leisure-based sitting behaviour. One question was used to elicit information about recreational screen time. The question was asked once in relation to screen time on weekdays and once in relation to screen time on weekends. The question was: 'Thinking of weekdays (or weekend days), how much time on an average day do you spend watching TV or another type of screen such as a computer, or video game? Please do not include any time spent in front of a screen while at school, college or work'. Participants were classified into two sedentary categories: 'low leisure-based sitting time' ($\leq$ 200 minutes of recreational screen time/day) and 'high leisure-based sitting time' (> 200 minutes of recreational screen time/day). A data-driven approach was used for this classification, where the median level of recreational screen time was determined as 200 minutes to provide the cut-off values for each category, given that there is no standard recommendation for what constitutes high or low levels of recreational screen time for the COPD population.

Box 1. The four activity phenotypes used in the study and their definitions.

'Couch potatoes'	• 'insufficiently active' with 'high leisure-based sitting time', or • 'insufficiently active' with 'low leisure-based sitting time' and 'no domestic physical activity'
'Light movers'	• 'insufficiently active' with 'low leisure-based sitting time' and 'some domestic physical activity'
'Sedentary exercisers'	• 'sufficiently active' with 'high leisure-based sitting time'
'Busy bees'	• 'sufficiently active' with 'low leisure-based sitting time'

Categories of activity phenotypes

The PA and sitting time exposures were combined in the following way to generate the four activity phenotypes, with labelling based on a previous study,[15] as shown in Box 1.

Outcomes: mortality and cardiometabolic variables

All-cause mortality was determined from the Scottish Health Survey 2003 data, which was linked to the Scottish Information Division Database with recorded deaths up to December 2009 for this study. Information on deaths was determined from the General Registrar Office for Scotland. Classification of the underlying cause of death was based on information collected on the death certificate as well as any additional information provided by the certifying doctor.

The cardiometabolic risk factors that were considered as outcomes included waist circumference, blood pressure, high-density lipoprotein (HDL) cholesterol and history of diabetes (based on self-report, doctor diagnosis or glycated haemoglobin). The physiological measures were determined from the nurse visit. For the analysis in this study, these measures were regarded as normal or abnormal based on the variable cut-offs as defined for metabolic syndrome.[22] Waist circumference was determined using a tape measure at the midpoint between the lower rib and the upper margin of the iliac crest. Two measures were taken and recorded to the nearest millimetre. If the two measures differed by more than 3 cm, a third measure was taken. Waist circumference measures were then averaged and defined as normal or high (ie, ≥ 102 cm if male or ≥ 88 cm if female).

Blood pressure was measured using an electronic sphygmomanometer[b]. Three readings were taken at 1-minute intervals, on the right arm, with the participant seated. The means of the second and third measures were used in calculations. Blood pressure was categorised as normal (ie, systolic < 130 mmHg and diastolic < 85 mmHg, and no self-reported hypertension) or high (ie, systolic ≥ 130 mmHg and diastolic ≥ 85 mmHg or self-reported hypertension).

HDL cholesterol was determined from the non-fasting blood samples taken during the nurse visit. A chemical analyser[c] was used to carry out the HDL cholesterol analysis using a direct method by the Biochemistry Department at the Royal Victoria Infirmary in Newcastle upon Tyne, UK. HDL cholesterol was categorised as normal (ie, ≥ 1.03 mmol/l if male or ≥ 1.29 mmol/l if female, and did not take lipid-lowering medication) or abnormal (ie, < 1.03 mmol/l if male or < 1.29 mmol/l if female, or took lipid-lowering medication).

Total glycated haemoglobin (HbA1c) was also determined from the non-fasting blood samples. One of two commercial analysers[d,e] was used to carry out the HbA1c analysis by the Haematology Department at the Royal Victoria Infirmary. Participants were categorised as having a history of diabetes based on self-report, doctor diagnosis or a HbA1c $\geq 6.5\%$.

Covariates

The following covariates were included in the analyses: age, gender, severity of COPD (mild, moderate, severe, or very severe according to the GOLD stages[17]), history of cardiovascular disease at baseline, history of cancer at baseline, self-reported longstanding illness, body mass index (BMI), smoking status (current smoker, ex-smoker, never smoked), age finished full-time education (≤ 14 years, 15 to 18 years, > 19 years), and alcohol consumption (does not drink, less than once a week, one to four times/week, five or more times/week).

Data analysis

Baseline characteristics across the four activity phenotypes were examined using chi-square tests for categorical variables and ANOVA for continuous variables. To determine all-cause mortality across the four activity phenotypes, Cox proportional hazards regression models were used to compute hazard ratios (HRs) with 95% confidence intervals (CIs) and survival duration was presented as mean and 95% CI. The proportional hazards assumption was examined using the cumulative hazard plot, and no apparent violations were noted. Covariates were added to the model in three stages. Model 1 used age and gender. Model 2 used the covariates from Model 1 plus severity of COPD, history of cardiovascular disease, history of cancer, self-reported longstanding illness, and body mass index. Model 3 used the covariates from Model 2 plus smoking status, age when finished full-time education, and alcohol consumption. To minimise the possibility of detecting spurious associations due to underlying/undiagnosed disease (reverse causality), a sensitivity analysis was also conducted excluding people who had a mortality event in the first 12 months. Lastly, binary logistic regression models, adjusted for relevant confounders (as per Models 1, 2 and 3 above), were used to compute ORs and 95% CI to examine the association between the four activity phenotypes and the cardiometabolic outcomes of waist circumference, BP, HDL cholesterol and diabetes history. All analyses were performed using SPSS software[f].

Results

A total of 8148 adults completed the Scottish Health Survey 2003 and were potentially eligible for this study. Of this group, 584 met the inclusion criteria (ie, COPD, aged > 40 years and current or ex-smokers). The variables with the highest number of missing data were HDL cholesterol (n = 205), blood pressure (n = 151), mortality (n = 68) and waist circumference (n = 18). Baseline characteristics of the included group (n = 584) and each of the four activity phenotypes can be found in Table 1. The greatest number of participants were categorised as 'couch potatoes' (n = 213, 36%). This group was older and had a significantly greater proportion of people who: had moderate-to-severe lung function; had a history of cardiovascular disease, diabetes or self-reported long-standing illness; and finished full-time education at a young age (≤ 14 years) (all $p < 0.05$).

Mortality data were available on 433 participants with COPD who had complete data on the covariates. A total of 81 all-cause deaths occurred during the 5.5 years (SD 1.3) of follow-up. Table 2 indicates the HRs and 95% CIs for all-cause mortality. Compared to the 'couch potatoes' there was a reduced risk of all-cause mortality in the 'busy bees' (fully adjusted HR 0.26, 95% CI 0.11 to 0.65) with a non-significant trend towards a reduction in all-cause mortality in the 'sedentary exercisers' and the 'light movers'. However, there was a statistically significant relationship in the reduction in mortality HR from 'couch potatoes' through 'light movers', then 'sedentary exercisers' and finally 'busy bees', with a p-value for linear trend of 0.005. The sensitivity analysis (ie, excluding people who had a mortality event in the first 12 months) showed similar results to the main analysis (data not shown).

Table 1
Baseline characteristics of 584 participants with chronic obstructive pulmonary disease recruited from the Scottish Health Survey 2003.

Characteristic	All participants	Activity phenotypes [a]				p
		'Couch potatoes'	'Light movers'	'Sedentary exercisers'	'Busy bees'	
Group size, n (%)	584	213 (36%)	138 (24%)	107 (18%)	126 (22%)	
Gender, % male	51.7	55.4	40.6	63.6	47.6	0.002
Age (yr), mean (SD)	64 (12)	68 (11)	61 (11)	63 (10)	60 (12)	< 0.001
Body mass index (kg/m²), mean (SD)	27 (5)	28 (5)	27 (5)	27 (4)	27 (4)	0.08
Caucasian, %	99.5	99.5	99.3	100	99.2	0.80
GOLD stage of COPD severity, % [b]						< 0.001
I: $FEV_1 \geq 80\%$ predicted	42.8	32.9	35.4	46.9	61.3	
II: $50\% \geq FEV_1 < 80\%$ predicted	31.6	31.7	36.9	36.5	21.8	
III: $30\% \geq FEV_1 < 50\%$ predicted	17.6	28.7	14.6	10.4	10.9	
IV: $FEV_1 < 30\%$ predicted	8.0	6.6	13.1	6.3	5.9	
History of cardiovascular disease, % [c]	19.3	34.7	10.9	13.1	7.9	< 0.001
History of cancer, %	8.2	8.9	4.3	9.3	10.3	0.28
History of diabetes, % [d]	9.4	16.4	5.8	8.4	2.4	< 0.001
Self-reported longstanding illness, %	60.4	76.1	60.1	53.3	40.5	< 0.001
Self-reported asthma, %	7.9	9.4	8.7	6.5	5.6	0.57
Abnormal waist circumference, % [e]	42.3	46.9	47.8	41.1	29.4	0.006
High blood pressure, % [f]	48.1	48.8	50.0	44.9	47.6	0.87
Abnormal HDL cholesterol, % [g]	24.8	34.3	21.7	19.6	16.7	0.001
Smoking status, %						0.01
current	46.6	46.0	58.0	41.1	39.7	
past	53.4	54.0	42.0	58.9	60.3	
Age at end of full-time education (yr), %						< 0.001
≤ 14	22.3	34.9	14.5	18.7	12.7	
15 to 18	65.9	55.7	76.8	68.2	69.0	
≥ 19	11.8	9.4	8.7	13.1	18.3	
Full-time work, %	74	76	71	76	72	0.7
Alcohol consumed (times/week), %						0.14
0	12.0	15.5	8.0	12.1	10.3	
< 1	27.9	29.6	33.3	20.6	25.4	
1 to 4	37.3	34.7	36.2	45.8	35.7	
≥ 5	22.8	20.2	22.5	21.5	28.6	

COPD = chronic obstructive pulmonary disease, FEV_1 = forced expiratory volume in 1 second; GOLD = global initiative for chronic obstructive lung disease, HDL = high density lipoprotein.
[a] Refer to Box 1 for the definition of each activity phenotype.
[b] COPD severity was classified according to spirometric grades using the GOLD summary.[17]
[c] A history of cardiovascular disease was defined as self-reported or doctor-diagnosed angina, heart attack or stroke.
[d] A history of diabetes was defined as self-reported diabetes or doctor-diagnosed diabetes or glycated haemoglobin (HbA1c) $\geq 6.5\%$.
[e] Abnormal waist circumference was defined as ≥ 102 cm for men and ≥ 88 cm for women.
[f] High blood pressure was defined as ≥ 130 mmHg systolic or ≥ 85 mmHg diastolic.
[g] Abnormal high-density lipoprotein (HDL) cholesterol was defined as < 1.03 mmol/l in men and < 1.29 mmol/l in women or specific treatment for lipid abnormality.

Table 2
Association between all-cause mortality and activity phenotype in participants with chronic obstructive pulmonary disease.

Activity phenotypes	Survival duration (months)	All-cause mortality (n = 433, 81 deaths)			
	Mean (95% CI)	cases/total	Model 1 HR (95% CI)	Model 2 HR (95% CI)	Model 3 HR (95% CI)
'Couch potatoes'	65.5 (61.9 to 69.0)	48/151	1.00	1.00	1.00
'Light movers'	72.9 (70.1 to 75.8)	16/107	0.65 (0.37 to 1.15)	0.74 (0.41 to 1.36)	0.77 (0.42 to 1.4)
'Sedentary exercisers'	72.0 (68.3 to 75.7)	11/73	0.56 (0.29 to 1.08)	0.57 (0.28 to 1.15)	0.57 (0.28 to 1.17)
'Busy bees'	76.2 (74.1 to 78.2)	6/102	0.22 (0.09 to 0.52)	0.24 (0.10 to 0.60)	0.26 (0.11 to 0.65)
P trend (linear)			0.002	0.003	0.005

Model 1 is adjusted for age and gender.
Model 2 is further adjusted for COPD severity, history of cardiovascular disease, history of cancer, history of diabetes, self-reported longstanding illness and body mass index.
Model 3 is further adjusted for smoking status, age when finished full-time education and alcohol consumption.
Cases/total refers to the number of deaths out of the number of participants in each category.
HR = hazard ratio.

Table 3 presents the results of the logistic regression models examining the associations between the cardiometabolic risk factors and the activity phenotypes. In the age-adjusted and gender-adjusted models, compared to the 'couch potatoes' referent group, the odds of a high waist circumference, abnormal HDL cholesterol and diabetes were lower in the 'busy bees'; the odds of abnormal HDL cholesterol and diabetes were lower in the 'sedentary exercisers'; and the odds of diabetes was lower in the 'light movers'. In the fully adjusted models, the odds of diabetes were lower in the 'busy bees' compared to the 'couch potatoes', although the overall number of cases in this analysis was small.

No other associations were found between the activity phenotypes and the cardiometabolic markers for the fully adjusted models.

Discussion

This is the first study in people with COPD to examine the association of activity phenotypes categorised for both PA and SBs with mortality and cardiometabolic risk factors. People with COPD who met current PA recommendations for healthy people by engaging in ≥ 7.5 MET-hours/week of PA and had low leisure-based

Table 3
Associations between high waist circumference, hypertension, abnormal high-density lipoprotein cholesterol and diabetes with activity phenotypes in participants with chronic obstructive pulmonary disease (n = 491).

Outcome	'Couch potatoes'		'Light movers'		'Sedentary exercisers'		'Busy bees'		p
	cases/total	OR (95% CI)	cases/total	OR (95% CI)	cases/total	OR (95% CI)	cases/total	OR (95% CI)	
Waist circumference [a]	80/167		56/123		35/86		32/115		
Model 1		1.00		0.90 (0.55 to 1.46)		0.79 (0.46 to 1.35)		0.43 (0.26 to 0.72)	0.01
Model 2		1.00		1.31 (0.62 to 2.78)		1.40 (0.65 to 3.04)		0.57 (0.25 to 1.31)	0.14
Model 3		1.00		1.33 (0.62 to 2.88)		1.48 (0.68 to 3.26)		0.60 (0.98 to 1.05)	0.16
Blood pressure [b]	82/167		64/123		39/86		55/115		
Model 1		1.00		1.48 (0.90 to 2.44)		1.02 (0.59 to 1.75)		1.28 (0.77 to 2.12)	0.40
Model 2		1.00		1.55 (0.91 to 2.63)		1.12 (0.63 to 1.99)		1.55 (0.89 to 2.70)	0.29
Model 3		1.00		1.46 (0.85 to 2.50)		1.05 (0.59 to 1.88)		1.39 (0.78 to 2.47)	0.46
HDL cholesterol [c]	57/167		28/123		17/86		20/115		
Model 1		1.00		0.61 (0.36 to 1.05)		0.49 (0.26 to 0.91)		0.43 (0.23 to 0.78)	0.02
Model 2		1.00		0.86 (0.47 to 1.58)		0.70 (0.35 to 1.39)		0.66 (0.33 to 1.29)	0.6
Model 3		1.00		0.86 (0.46 to 1.60)		0.77 (0.38 to 1.56)		0.70 (0.35 to 1.41)	0.77
Diabetes [d]	28/167		7/123		5/86		2/115		
Model 1		1.00		0.36 (0.15 to 0.88)		0.32 (0.12 to 0.87)		0.10 (0.02 to 0.44)	0.002
Model 2		1.00		0.38 (0.15 to 0.98)		0.43 (0.15 to 1.23)		0.14 (0.03 to 0.63)	0.02
Model 3		1.00		0.39 (0.15 to 1.03)		0.43 (0.15 to 1.24)		0.14 (0.03 to 0.67)	0.03

Model 1 is adjusted for age and gender.
Model 2 is further adjusted for COPD severity, history of cardiovascular disease, history of cancer, history of diabetes, self-reported longstanding illness and body mass index.
Model 3 is further adjusted for smoking status, age when finished full-time education and alcohol consumption.
Cases/total refers to the number of cases out of the number of participants in each category.
[a] Abnormal waist circumference was defined $\geq$ 102 cm for men and $\geq$ 88 cm for women.
[b] High blood pressure was defined as $\geq$ 130 mmHg systolic or $\geq$ 85 mmHg diastolic.
[c] Abnormal high-density lipoprotein (HDL) cholesterol was defined as < 1.03 mmol/l in men and < 1.29 mmol/l in women or specific treatment for lipid abnormality.
[d] A history of diabetes was defined as self-reported diabetes or doctor-diagnosed diabetes or glycated haemoglobin (HbA1c) $\geq$ 6.5%.

sitting time with recreational screen time $\leq$ 200 minutes per day ('busy bees') had a 74% (95% CI 35 to 89) reduction in all-cause mortality risk and an 86% (95% CI 33 to 97) reduction in the odds of diabetes after fully adjusting for covariates compared to those who were physically inactive and sedentary ('couch potatoes'). The statistically significant test for linear trend also suggested some mortality benefit from being physically active and from having low sedentary time, even though the comparisons of 'sedentary exercisers' and 'light movers' with the 'couch potatoes' were non-significant for mortality.

A recent review examined the studies reporting on the associations between PA and mortality in people with COPD.[10] Of the seven studies included in the review, five studies used subjective measures to categorise PA into high or low levels, with reduced risk of mortality (risk ratio ranging from 0.34 to 0.81) when performing higher levels of PA.[11,23–26] However, none of these studies categorised PA according to current activity recommendations by considering the volume and intensity of participation in activity using MET-hours/week as in the current study. When PA guidelines were met ('sedentary exercisers' and 'busy bees'), there was a reduction in the risk of mortality of between 43 and 74% compared to the 'couch potatoes'. Although this result cannot completely confirm that causation is present (ie, that not meeting PA guidelines causes death), it indicates that encouraging people with COPD to meet general PA guidelines may be important to maximise health outcomes.

Sedentary behaviour in people with COPD has mainly been examined through sitting time. One review, which included 10 studies measuring sitting time in people with COPD, indicated a median sitting time of 359 minutes/day.[27] Another study of 497 people with COPD specifically reported on time of TV

viewing/listening to music and reported this to be 300 minutes/day.[28] In the current study, the median self-reported recreational screen time was 200 minutes/day and was used as the cut-off to determine low or high 'leisure-based sitting time' as a marker of SB. People with COPD who had low 'leisure-based sitting time' with some domestic PA ('light movers') had some mortality benefit compared to 'couch potatoes' but the reduction in mortality risk was non-significant and smaller (23%) compared to that seen in people who were sufficiently active. The significant linear trend across all models (Table 2) indicated a pattern of smallest to largest risk reduction in all-cause mortality across the activity phenotypes from 'light movers' to 'sedentary exercisers' to 'busy bees'.

Few studies have examined the association between SB and mortality in COPD. One study examined the association between average daily TV viewing time and respiratory mortality in a Japanese population, and reported that men who watched TV for > 4 hours/day were more likely to die of COPD compared to those who watched TV for < 2 hours/day (HR 1.63, 95% CI 1.04 to 2.55).[13] Another study measured SB objectively and reported that mortality risk was 4.09 times higher in people with COPD who spent > 8.5 hours/day in SB of < 1.5 METs.[12] The results of the current study are consistent with these previous findings but suggest that a combination of meeting PA guidelines and minimising leisure-based sitting time is required for the greatest reduction in mortality risk rather than just focusing on interventions to minimise leisure-based sitting time. However, at minimum, if people with COPD are unable to meet PA recommendations, engagement in some domestic activity and limiting leisure-based sitting time (as per the 'light movers') may be important.

The cardiometabolic health profile was not as favourable for the participants in the 'couch potato' group. This group had a significantly higher proportion of participants with a history of cardiovascular disease and diabetes compared to the other activity phenotypes. For the age-adjusted and gender-adjusted models, when the 'light movers', 'sedentary exercisers' and 'busy bees' were compared to the 'couch potatoes', the odds of diabetes were lower by between 64 and 90%, and the odds of an abnormal HDL cholesterol were lower by between 39 and 57%. In the fully adjusted models, the odds for diabetes were lower in the 'busy bees' compared to the 'couch potatoes'. One other study of people with COPD examined the association of PA levels and sedentary time on metabolic outcomes.[29] This study showed that time spent in light and moderate activity was negatively associated with waist circumference and glucose level, while sedentary time was positively associated with these variables.[29] These authors suggested that interventions to reduce SB and promote PA would be important to minimise metabolic syndrome,[29] and this concurs with the findings from the current study and, furthermore, suggests that meeting PA guidelines should be the priority behaviour followed by a reduction in leisure-based sitting time through reduced recreational screen time.

A strength of this study was its clinical relevance in categorising participants according to PA recommendations while at the same time considering levels of SB. However, there were also a number of limitations. First, the activity phenotypes were created based on subjective interviews and self-report, rather than using an objective measure such as accelerometry. We acknowledge that there may have been some measurement error associated with the exposures, which would have resulted in attenuation of the associations. Furthermore, in this study, patterns of accumulation of physical activity and sedentary behaviour were not able to be addressed using these subjective measurement tools. Future studies could consider development of the activity phenotypes using categories of objectively measured activity, as has been used previously in English adults.[15] Secondly, the categorisation of SB was based on responses to questions on recreational screen time rather than specific questions on sitting or lying time. Recreational screen time does not capture all the leisure-based sitting time that participants may have been involved in through waking hours, and excludes other leisure-based sitting activities such as talking on the phone, reading and other sitting hobbies as well as excluding work-related screen time and sitting, which are increasing in workplaces. However, a previous study has shown that survey-assessed TV viewing time is the strongest correlate to monitor-assessed total sitting time across the week in non-workers.[30] Another study in people with COPD (the majority of whom were retired) indicated that watching TV is the predominant daily activity,[28] so as a representation of sitting time the questions on recreational screen time may be a reasonable broad surrogate measure of SB in this population. Again, an objective measure to determine sedentary categories could be considered in future studies. Another limitation was the relatively low number of participants in each subgroup, which may have compromised statistical power of some analyses and prevented the 'sedentary exercisers' and 'light movers' from being statistically different to the referent 'couch potatoes' despite the clear tendency for an association in some outcomes. This group was also not an inception cohort, as they were not people with COPD recruited at a specific defined point in the course of their disease. A final limitation was the age of the survey data, which spanned from 2003 to 2009. Any advances in COPD management in the last decade would not be reflected in the presented data.

This prospective cohort study indicated a mortality benefit and reduced odds of diabetes for people with COPD who meet PA guidelines and have low leisure-based sitting time compared to those who are physically inactive and have high leisure-based sitting time. These findings suggest that measurement of both PA levels and SB is important for health outcomes in people with COPD. Clinicians should encourage adherence to activity recommendations foremost for people with COPD, but that if this is not achievable, ways to minimise SBs should also be considered, such as through reduced recreational screen time.

What was already known on this topic: People with chronic obstructive pulmonary disease (COPD) engage in low levels of physical activity, which is associated with adverse health effects. Guidelines for people with COPD encourage them to meet the general physical activity guidelines for adults but advice about sedentary behaviour is lacking.
What this study adds: Among people with COPD, adhering to physical activity guidelines and keeping leisure-based sitting time low has a mortality benefit and lowers the odds of developing diabetes. Physiotherapists should encourage people with COPD to adhere to activity recommendations and also consider whether sedentary behaviour could be reduced.

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