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## **Bidirectional association between physical activity and symptoms of anxiety and depression: The Whitehall II study**

**Running title:** physical activity and common mental disorders

Marine Azevedo Da Silva, MSc<sup>1,2</sup>

Archana Singh-Manoux, PhD<sup>1,2,3,4</sup>

Eric J Brunner, PhD<sup>4</sup>

Sara Kaffashian, MSc<sup>1,2</sup>

Martin J Shipley, MSc<sup>4</sup>

Mika Kivimäki, PhD<sup>4,5</sup>

Hermann Nabi\*, PhD<sup>1,2</sup>

1. INSERM, U1018, Centre for Research in Epidemiology and Population Health, Epidemiology of occupational and social determinants of health, F-94807, Villejuif, France
2. Université de Versailles St Quentin, UMRS 1018, F-94807, Villejuif, France
3. Centre de Gérontologie, Hôpital Ste Péline, AP-HP, Paris, France
4. Department of Epidemiology and Public Health, University College London, London, UK
5. Finnish Institute of Occupational Health and University of Helsinki, Finland

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\*Corresponding author & address

INSERM, U687

Hôpital Paul Brousse/Bâtiment 15/16 avenue Paul Vaillant Couturier

94807 VILLEJUIF CEDEX, France

Tel: + 33 1 77 74 74 21

Fax: + 33 (0)1 77 74 74 03

Email: Hermann.Nabi@insERM.fr

## **ABSTRACT**

Although it has been hypothesized that the association of physical activity with depressive and anxiety symptoms is bidirectional, few studies have examined this issue in a prospective setting. We studied this bidirectional association using data on physical activity and symptoms of anxiety and depression at 3 points in time over 8 years. A total of 9309 participants of the British Whitehall II prospective cohort study provided data on physical activity, anxiety and depression symptoms and 10 covariates at baseline in 1985. We analysed the associations of physical activity with anxiety and/or depression symptoms using multinomial logistic regression (with anxiety and depression symptoms as dependent variables) and binary logistic regression (with physical activity as the dependent variable). There was a cross-sectional inverse association between physical activity and anxiety and/or depressive symptoms at baseline (ORs between 0.63 to 0.72). In cumulative analyses, regular physical activity across all three data waves, but not irregular physical activity, was associated with reduced likelihood of depressive symptoms at follow-up (OR= 0.71, 95% CI 0.54, 0.99). In a converse analysis, participants with anxiety and depression symptoms at baseline had higher odds of not meeting the recommended levels of physical activity at follow-up (OR= 1.79, 95% CI 1.17, 2.74). This was also the case in individuals with anxiety and/or depression symptoms at both baseline and follow-up (OR=1.70, 95% CI 1.10, 2.63). The association between physical activity and symptoms of anxiety and/or depression appears to be bidirectional.

**Keywords:** Common mental disorders, physical activity, bidirectional association, longitudinal studies.

**Abbreviations:** **BMI**, body mass index; **CI**, confidence interval; **GHQ**, General Health Questionnaire; **OR**, Odds Ratios

## **INTRODUCTION**

The beneficial effects of physical activity on somatic health outcomes have been recognized for a long time (1-4). In addition, a positive influence of physical activity on mental health has been reported (5-9).

Systematic reviews of observational and interventional studies (10-12) have assessed the relationship between physical activity and depression. Although there is some heterogeneity in the results, these reviews generally conclude that physical activity is associated with a reduced likelihood of experiencing depression or depressive symptoms. A dose-response association between physical activity and depressive symptoms has been shown in several studies (13, 14). A number of investigations have also examined the association between physical activity and anxiety symptoms (8, 15-17). A recent meta-analysis of 40 studies concluded that regular physical activity is associated with a reduction in anxiety symptoms (18).

Taken together, these results suggest an inverse association between physical activity and symptoms of depression and anxiety. However, many of these studies have important methodological and conceptual shortcomings. First, most of these studies were cross-sectional, making it difficult to determine the temporal sequence between physical activity, depression and anxiety symptoms (19). Second, the prospective studies that examined the effect of physical activity, generally assessed at one point in time, on subsequent depressive or anxiety symptoms several years later; made the assumption that physical activity levels remain constant over time (14, 20). Third, potential confounders, such as comorbidity, stressful life events (21), satisfaction with work (22, 23) are rarely taken into account in these studies.

Finally, and perhaps more importantly, very few studies have examined the hypothesis (24) that the relationship between physical activity, depressive and anxiety symptoms may be bidirectional - that is, symptoms of depression and anxiety may also affect the likelihood of undertaking physical activity. Longitudinal studies with repeated measures on both physical activity and depression/anxiety symptoms are required to address the two causal directions.

In this study, we examined the bidirectional association between physical activity at recommended levels and depression and/or anxiety symptoms, all measured three times over 8 years, using cross-sectional, prospective and cumulative exposure analyses.

## **METHODS**

### **Participants**

The Whitehall II study, established in 1985, is a longitudinal study based on 10 308 civil servants (6895 men and 3413 women)(25). All civil servants aged 35-55 years in 20 London based departments were invited to participate by letter, and 73% agreed. Baseline examination (phase 1) took place between 1985 and 1988 and involved a clinical examination and a self-administered questionnaire. The University College London Medical School Committee on the Ethics of Human Research approved the protocol and informed consent was gained from all participants.

### **Measures**

**Physical activity:** Physical activity was assessed using a standard self-administered questionnaire at phases 1, 2 (1989-1990), and 3 (1991-1993). Participants were asked two questions on the average number of hours per week spent in “moderately energetic” (eg, dancing, cycling, leisurely swimming) and “vigorous” (eg, running, hard swimming, playing squash) physical activity. They were then categorized into two groups based on whether they met the current recommendations on physical activity (ie, at least 30 minutes a day of at least moderate intensity on at least five days of the week)(26). Thus, participants reporting **2.5 hours** or more of at least moderately energetic physical activity per week were considered to have a sufficient level of physical activity and assigned the value 0. Those with levels of physical activity under the recommended levels were assigned the value 1 for the analysis.

**Depression and anxiety symptoms:** Depression and anxiety symptoms were also assessed at phases 1, 2, and 3 using the 30-item General Health Questionnaire (GHQ)(27, 28). A

depressive symptom score (29) was derived from the 30-item General Health Questionnaire using the following four items: 'been thinking of yourself as a worthless person', 'felt that life is entirely hopeless', 'felt that life isn't worth living', and 'found at times you couldn't do anything because your nerves were too bad' (Cronbach's  $\alpha=0.88$ ). Responses to these items were on a four-point Likert scale, range 0–3. A sum score was calculated and, as previously, a total score of 4 or more was used to define the presence of depressive symptoms (29).

An anxiety symptom score ('lost much sleep over worry', 'felt constantly under strain', 'been getting scared or panicky for no good reason', 'found everything getting on top of you', 'been feeling nervous and strung up all the time'; Cronbach's  $\alpha=0.86$ ) was derived using five items of GHQ. Participants were asked to rate these items on a four-point scale (range 0–3) and scores in the top decile (8 or more points of the total of 15 points) were used to define anxiety cases (30). The prevalence of anxiety cases of the Whitehall II study has been found to be close to that of anxiety disorders in the general UK population (31).

We created a four-category variable based on the cross-classification of depression (yes vs. no) and anxiety symptoms (yes vs. no) at the three waves of data collection. At each wave, this variable was assigned a value of 0 for participants without symptoms of depression and anxiety, 1 for those with anxiety but not depression symptoms, 2 for those with depression but not anxiety symptoms, and 3 for those with both anxiety and depression symptoms.

**Covariates:** We used 10 baseline (phase 1) covariates as potentially confounding variables. Sociodemographic characteristics included sex, age, ethnicity (white vs. other), marital status (married/cohabitant vs. other), and occupational position. In the Whitehall II study, occupational position reflects education, income and job responsibilities; it was categorised as high (administrators), middle (executives, professionals and technical staff) and low (clerical and office support staff). Two psychosocial variables were included: stressful life events (0, 1 and  $\geq 2$  events) and satisfaction with work (low, intermediate and high). Health-related behaviours included were alcohol intake (high ( $>14$  units/week for women and  $>21$

units/week for men) vs. other; **where a unit is 8 g of alcohol**), and smoking status (never, ex, and current smokers). Self-reported respiratory disease (yes vs. no) was included as health-related covariate.

### **Statistical analysis**

Differences in baseline characteristics of participants as a function of physical activity and anxiety and/or depression symptoms were assessed using a chi-square test. To explore associations between physical activity and anxiety and/or depression symptoms, described below, we undertook two logistic regressions, one multinomial (with anxiety and depression symptoms as dependent variable) and one binary (with physical activity as dependent variable). **Model 1** shows crude odds ratios (ORs). In **model 2**, ORs were adjusted for sociodemographic characteristics (age, sex, ethnicity, marital status and occupational position), psychosocial variables (stressful life events and satisfaction with work), health-related behaviours (smoking, alcohol intake) and self-reported respiratory disease.

#### Physical activity as a predictor of anxiety and/or depression symptoms

Cross-sectional, prospective and **cumulative exposure** analyses based on multinomial logistic regression were conducted. The cross-sectional analysis aimed to assess the association between physical activity and anxiety/depression symptoms at baseline (phase 1). The prospective analysis, undertaken among participants with no anxiety and depression symptoms at phase 1, examined the association between physical activity at phase 1 and incident anxiety and/depression symptoms at phases 2 or 3. The **cumulative exposure** analysis examined the association between cumulative measures of physical activity, calculated by summing the values at the three data points, and anxiety/depression symptoms at the last follow-up (phase 3). The physical activity score ranged from 0 to 3 and was recoded into 3 categories: regular if physical activity level corresponded to the recommended levels at least at two phases (score 0 to 1), irregular if physical activity level corresponded to the recommended levels at one phase only

(score 2), and none if the physical activity level did not correspond to the recommended levels at any phase (score 3).

#### Anxiety/depression symptoms as predictor of physical activity

Prospective and **cumulative exposure** analyses based on binary logistic regression were conducted. The prospective analysis examined the association between anxiety/depression symptoms at baseline (phase 1) and subsequent practice of physical activity at phases 2 or 3 among participants with physical activity level under the recommended levels at phase 1. The **cumulative exposure** analysis examined the association between the cumulative score of anxiety/depression symptoms from phases 1 to 3 and physical activity at the last follow-up (phase 3). For this analysis, a cumulative anxiety score ranging from 0 to 3 was obtained by summing values at each phase. The value 0 corresponded to participants without anxiety symptoms at any phase and values 1, 2, and 3 represented participants with anxiety symptoms at one, two and three phases, respectively.

A similar score was also calculated for depressive symptoms. Then, a new score was created by summing the cumulative scores of anxiety and depression scores. This score ranged from 0 to 6 and was re-categorized as follows: 0 for participants without anxiety and depression symptoms at any phase, 1-3 for participants who experienced anxiety and/or depression symptoms less frequently between phases, 4-6 for participants who experienced anxiety and/or depression symptoms more frequently; the score of 6 corresponding to participants who experienced both anxiety and depression symptoms at all three phases.

## **RESULTS**

Among the 10308 participants of the Whitehall II cohort study, 9309 had complete data on all variables at baseline and were included in the cross-sectional analysis. Among these participants, 13.4% reported practising physical activity at the recommended levels and 19.9% experienced anxiety and/or depression symptoms. Tables 1 and 2 present the baseline



characteristics of the participants as a function of physical activity and anxiety/depression symptoms.

### **Cross-sectional association between physical activity, anxiety and/or depression symptoms**

Table 3 presents the odds ratios (OR) estimating the association of physical activity, anxiety and/or depression symptoms at baseline. Model 1 shows that participants who reported practicing physical activity at recommended levels were less likely to have anxiety symptoms (OR = 0.71, 95% CI, 0.54-0.91), depressive symptoms (OR=0.63, 95% CI, 0.48-0.81) and both (OR=0.72, 95% CI, 0.54- 0.97). After adjustment for sociodemographic characteristics, psychosocial factors, health-related behaviours, and self-reported respiratory disease these inverse associations remained fairly unchanged.

### **Physical activity as a predictor of anxiety and/or depression symptoms**

**Figure 2** presents ORs for the associations between physical activity and incident anxiety and/or depressive symptoms at either phase 2 or 3 among participants without anxiety and/or depression symptoms at phase 1. In the model unadjusted for covariates (model 1), physical activity at phase 1 was not associated with the incidence of anxiety and/or depressive symptoms over the follow-up. A similar pattern was observed in the fully adjusted model.

**Figure 3** shows the associations between the physical activity score (cumulative score from phase 1 to 3) and anxiety and/or depression symptoms at phase 3. In model 1, participants who reported practicing physical activity at recommended levels regularly had reduced odds of depressive symptoms (OR=0.72, 95% CI, 0.52-0.99) compared to those who did not practice physical activity at recommended levels at any of the three phases. These associations were unchanged after adjustment for all potentially confounding variables.

### **Anxiety and /or depression symptoms as predictor of physical activity practice**

Figure 4 shows ORs for the association between anxiety and/or depression symptoms at phase 1 and physical activity levels at phases 2 and 3 among participants who reported physical activity below recommended levels at phase 1. Participants with elevated anxiety and depression symptoms at phase 1 were more likely not to engage in physical activity at the recommended levels over the follow-up (OR = 1.79, 95% CI, 1.17-2.74) compared to those without such symptoms.

To examine this association further, we repeated the analysis in a subgroup of participants who undertook physical activity at the recommended levels at phase 1. The results suggested that baseline depressive symptoms were associated with higher probability of not meeting the recommended levels of physical activity at follow-up (adjusted OR= 1.52,  $p>0.05$ ), even though this association did not reach statistical significance at the 5% level, perhaps because it was based on small numbers (N=901).

Finally, figure 5 presents the associations between the cumulative score (phases 1 to 3) of anxiety and/or depression symptoms and physical activity at phase 3. In model 1, participants who experienced anxiety and/or depression symptoms less frequently (cumulative score of 1 to 3) were more likely to be physically inactive at phase 3 (OR=1.44, 95% CI, 1.21-1.70) compared to those without such symptoms (cumulative score of 0). The OR was even higher in participants who experienced anxiety and/or depression symptoms more frequently (cumulative score of 4 to 6) (OR=1.82, 95% CI, 1.19-2.79). When all covariates were included in the model 2, ORs remained statistically significant but were slightly reduced.

## DISCUSSION

### Key findings

We examined the bidirectional association of physical activity with anxiety and/or depressive symptoms in a large cohort of men and women. Results of cross-sectional analyses showed that physical activity at recommended levels was associated with a reduced probability of anxiety and depressive symptoms. **In cumulative exposure analysis**, we found that regular physical activity during the follow-up was associated with a reduced likelihood of depressive symptoms. **In the converse analysis**, exposure to anxiety and depressive symptoms, once or more times, was associated with an increased probability of not meeting the recommended levels of physical activity over the follow-up.

### Results in the context of previous studies

Our cross-sectional results are consistent with previous studies showing an inverse association of physical activity with anxiety and depressive symptoms (7, 8, 13-16, 18). The prospective findings of our study showing no significant associations between physical activity at baseline with incident anxiety and/depression symptoms are also consistent with those from previous studies. For example, a study conducted in a community-based sample of older men and women in southern California found that exercise did not protect against future depressed mood in those not clinically depressed at baseline (32). In the same vein, a study conducted among physicians found that the incidence of depression 15 years later was similar among those who were physically active and those who were physically inactive at baseline (33). In contrast, some other studies have found physical activity to be associated with the reduced incidence of depression (6, 9, 14). However, in these studies physical activity was generally assessed at one point in time with the assumption that it remains unchanged over time.

Compared to previous prospective studies, the present study is novel in its use of repeated measures of physical activity, anxiety and/or depressive symptoms. The use of repeated measures in our study allowed us to examine the association between regular physical activity practice at recommended levels and anxiety and/or depressive symptoms. Indeed, it appears that it is only regular practice of physical activity which is associated with reduced risk of depression symptoms.

In contrast to the results of the cross-sectional and prospective analyses, the use of repeated measures provides further insight into the nature of the physical activity-depressive and/or anxiety symptoms link. Based on the results of our cross-sectional and prospective analyses only, we would have had mixed conclusions about this association; not being able to conclude whether the associations we observed cross-sectionally were due to a higher prevalence of physical inactivity in depressed or anxious participants. Cumulative exposure analysis was vital to determine whether the lack of associations in prospective analysis is likely to be true or an artefact owing to the fact that physical activity was assessed only at one point in time at baseline”.

.Furthermore, our study adds to the literature in this domain by considering simultaneously anxiety and depression symptoms and their co-occurrence. Epidemiological studies have documented the co-occurrence of anxiety disorders and depression symptoms (34), but the relationship between physical activity and co-occurring anxiety and depression symptoms has not been examined previously.

Finally, our study design also allowed us to show that the association is likely to be bidirectional: physical activity decreases the risk for anxiety and/or depression symptoms, but these symptoms are also likely to be associated with poor levels of physical activity. A further strength was the opportunity to take into account a wide range of potential confounders in the analysis.

## **What are the mechanisms behind the observed associations?**

Several hypotheses have been posited to explain the protective association of physical activity on mental health outcomes. The distraction hypothesis (35) suggests that the diversion of individuals from negative stimuli may lead to an improvement in mood during and subsequent to the practice of physical activity. The self-efficacy/mastery hypothesis (36) suggests that physical activity could be seen as a challenging activity, the ability of individuals to be physically active on a regular basis may lead to improvements in their mood and self-confidence. Finally, the social interaction hypothesis (37) views social relationships resulting from physical activity practice and associated social support among individuals involved in physical activity to play a role in the effects of physical activity on mental health.

Physiological mechanisms have also been proposed to explain this inverse relationship. The monoamines hypothesis (37, 38) based on animal models suggests that physical activity increases the synaptic transmission of monoamines, which are assumed to have antidepressant effects. Another hypothesis (37) highlights the role of endorphins, released upon physical activity, on the central nervous system to create feeling of calm and improved mood after physical activity (39).

We were not able to test these mechanistic hypotheses, but our findings raise other possibilities, particularly in relation to the observed reciprocal association between physical activity, depressive and anxiety symptoms. Poor health may prevent or reduce the ability to undertake physical activity (40, 41) and it may also be associated with the development of symptoms of anxiety and depression (42), which in turn may decrease the possibility of physical activity. A further possibility lies in the fact that symptoms of anxiety and depression are associated with increased risk of gaining weight (43), which then could reduce the likelihood of undertaking physical activity at recommended levels (44). Finally, it is possible that individuals with anxiety and depression are more socially isolated than those free of these symptoms, and therefore less motivated to engage in physical activity (45). In the same vein, individuals with

anxiety and depressive symptoms may be less likely to engage in physical activity simply because of lower energy levels or apathy (8). In sum, the precise mechanisms underlying the current observations remain to be examined.

## **Limitations**

In interpreting the present results, it is important to note some limitations. First, this cohort of civil servants did not include blue collar workers, unemployed or individuals with precarious jobs and younger adults; thus it is not representative of the general population of working age, which may limit the generalisability of our findings. **In addition, our data were collected between 1985 and 1993 when the participants were 39 to 64 years of age. This may also limit the applicability of the present findings to today's society or other age groups such younger and older adults**

Second, we assessed anxiety and depressive symptoms rather than clinical anxiety and depression, even though it has been suggested that significant anxiety and depressive symptomatology are a risk factor for clinical anxiety and depression (46). **Thus, we cannot completely exclude misclassification bias as a source of error that explains the current observed associations.** Third, self-reported physical activity is problematic; a declaration bias for instance cannot be ruled out. This implies that the relationship between physical activity and symptoms of anxiety and depression may have been underestimated. Objective measures of physical activity and an assessment of mental health based on psychiatric interview are required for more accurate estimates. **Fourth, although we were able to control for a wide range of potentially confounding variables, we cannot exclude the possibility of residual confounding from unmeasured variables, such as personality traits, social isolation or genetic factors.** Finally, experimental studies with longer follow-up would be needed to assess the real impact of physical activity on symptoms of anxiety and depression, because the few existing studies have limited follow-up(10).

## Implications

Despite these potential limitations, the results of this study suggest that the association between physical activity and symptoms of anxiety and/or depression is likely to be bidirectional. The practice of physical activity on a regular basis reduces the risk of developing symptoms of anxiety and/or depression, but having symptoms of anxiety and/or depression increases the probability of not meeting the recommended levels of physical activity. These findings suggest that health promotion strategies should consider including physical activity not only to improve physical health but because it has the potential to improve mental health as well. Physical activity can also be considered an important part of treatment to alleviate depression and anxiety symptoms, in particular when the symptoms are moderate rather than severe

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**CONFLICT OF INTEREST:** none to declare



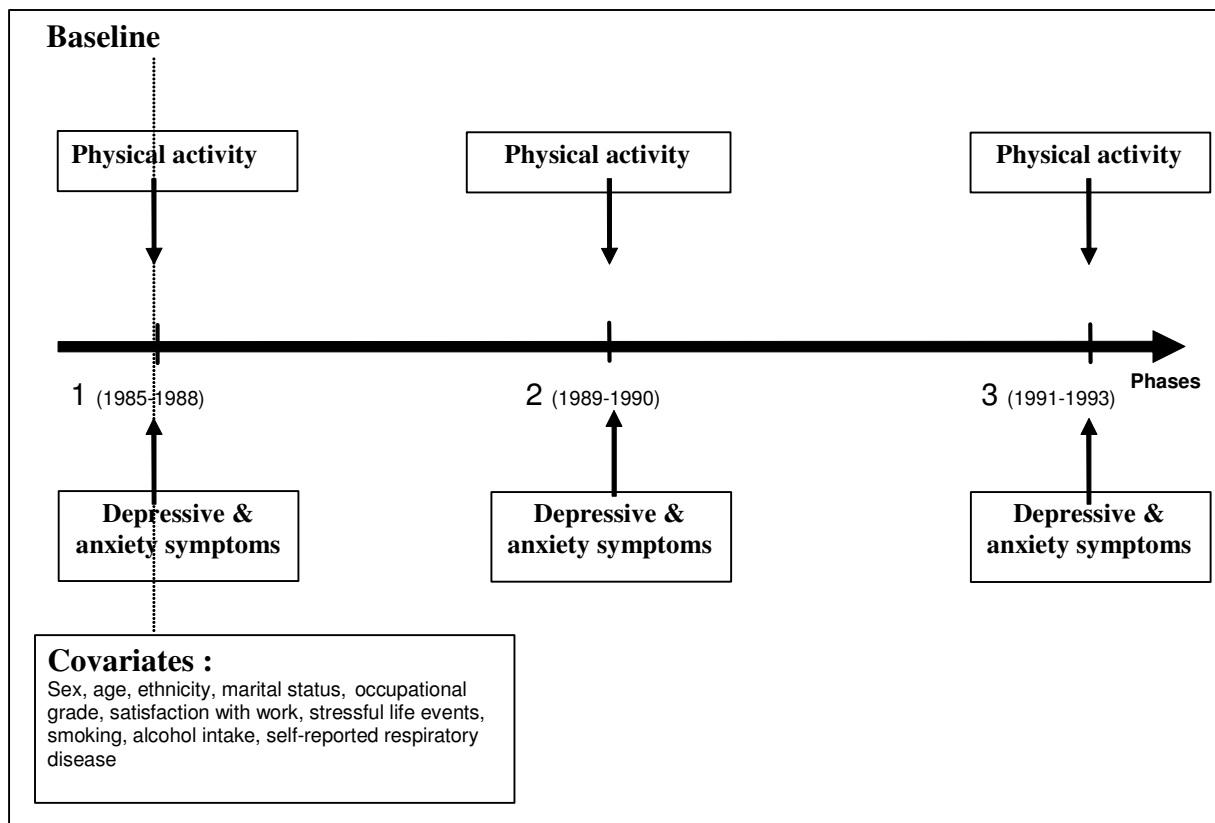
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**Fig. 1** Study design



**Table 1:** Characteristics of participants in phase 1 (1985–1988) of the Whitehall II Study by physical activity level.

Variables	N total (9309)	Physical activity at recommended levels		
		Yes N (%)	No N (%)	<i>P</i> value
<b>Sex</b>				<0.001***
Men	6374 (68.5)	1056 (83.9)	5318 (66.1)	
Women	2935 (31.5)	202 (16.1)	2733 (33.9)	
<b>Age groups (years)</b>				<0.001***
≤39	2582 (27.7)	386 (30.7)	2196 (27.3)	
40-44	2436 (26.2)	375 (29.8)	2061 (25.6)	
45-49	1892 (20.3)	240 (19.1)	1652 (20.5)	
≥50	2399 (25.8)	257 (20.4)	2142 (26.6)	
<b>Ethnicity</b>				<0.001***
White	8487 (91.2)	1180 (93.8)	7307 (90.8)	
Other	822 (8.8)	78 (6.2)	744 (9.2)	
<b>Marital Status</b>				<0.001***
Married/cohabiting	6943 (74.6)	1018 (80.9)	5925 (73.6)	
Other	2366 (25.4)	240 (19.1)	2126 (26.4)	
<b>Occupational grade</b>				<0.001***
High	2828 (30.4)	427 (33.9)	2401 (29.8)	
Middle	4573 (49.1)	682 (54.3)	3891 (48.4)	
Low	1908 (20.5)	149 (11.8)	1759 (21.8)	
<b>Satisfaction with work</b>				0.33
Low	3299 (35.4)	473 (37.6)	2826 (35.1)	
Intermediate	2363 (25.4)	293 (23.3)	2070 (25.7)	
High	3647 (39.2)	492 (39.1)	3155 (39.2)	
<b>Stressful life events score</b>				0.24
0	2693 (28.9)	351 (27.9)	2342 (29.1)	
1	3054 (32.8)	407 (32.4)	2647 (32.9)	
≥2	3562 (38.3)	500 (39.7)	3062 (38.0)	
<b>Smoking</b>				0.75
Non smoker	4578 (49.2)	598 (47.5)	3980 (49.4)	
Ex-smoker	3054 (32.8)	462 (36.7)	2592 (32.2)	
Current smoker	1677 (18.0)	198 (15.7)	1479 (18.4)	
<b>High alcohol intake</b>				0.67
No	7808 (83.9)	1050 (83.5)	6758 (86.6)	
Yes	1501 (16.1)	208 (16.5)	1293 (16.1)	
<b>Self-reported respiratory disease</b>				0.10
No	8573 (92.1)	1173 (93.2)	7400 (91.9)	
Yes	736 (7.9)	85 (6.8)	651 (8.1)	

**Table 2:** Characteristics of participants in phase 1 (1985–1988) of the Whitehall II Study by anxiety and/or depression symptoms.

Variables	Anxiety and/or depression symptoms				P value
	None (N=7454)	Anxiety (N=644)	Depression (N=739)	Combined anxiety and depression (N=472)	
<b>Sex</b>					<0.001***
Men	5182(69.5)	390 (60.6)	522 (70.6)	280 (59.3)	
Women	2272 (30.5)	254 (39.4)	217 (29.4)	192 (40.7)	
<b>Age groups (years)</b>					0.09
≤39	2060 (27.6)	192 (29.8)	182 (24.6)	148 (31.4)	
40-44	1927 (25.9)	173 (26.9)	196 (26.5)	140 (29.7)	
45-49	1518 (20.4)	129 (20.0)	162 (22.0)	83 (17.5)	
≥50	1949 (26.1)	150 (23.3)	199 (26.9)	101 (21.4)	
<b>Ethnicity</b>					0.39
White	6799 (91.2)	603 (93.6)	652 (88.2)	433 (91.7)	
Other	655 (8.8)	41 (6.4)	87 (11.8)	39 (8.3)	
<b>Marital Status</b>					<0.001***
Married/cohabiting	5701 (76.5)	474 (73.6)	477 (64.5)	291 (61.7)	
Other	1753 (23.5)	170 (26.4)	262 (35.5)	181 (38.3)	
<b>Occupational grade</b>					<0.001***
High	2330 (31.3)	205 (31.8)	189 (25.6)	104 (22.0)	
Middle	3613 (48.5)	328 (50.9)	384 (52.0)	248 (52.5)	
Low	1511 (20.3)	111 (17.2)	166 (22.5)	120 (25.4)	
<b>Satisfaction with work</b>					<0.001***
Low	2386 (32.0)	278 (43.2)	353 (47.8)	282 (59.7)	
Intermediate	1910 (25.6)	159 (24.7)	196 (26.5)	98 (20.8)	
High	3158 (42.4)	207 (32.1)	190 (25.7)	92 (19.5)	
<b>Stressful life events score</b>					<0.001***
0	2328 (31.2)	100 (15.5)	202 (27.3)	63 (13.3)	
1	2536 (34.0)	169 (26.2)	228 (30.9)	121 (25.6)	
≥2	2590 (34.7)	375 (58.2)	309 (25.6)	288 (61.0)	
<b>Smoking</b>					0.004**
Non smoker	3704 (49.7)	280 (43.5)	381 (51.6)	213 (45.1)	
Ex-smoker	2457 (33.0)	229 (35.6)	230 (31.1)	138 (29.2)	
Current smoker	1293 (17.3)	135 (17.3)	128 (17.3)	121 (25.6)	
<b>High alcohol intake</b>					0.01*
No	6285 (84.3)	530 (82.3)	618 (83.6)	375 (79.4)	
Yes	1169 (15.7)	114 (17.7)	121 (16.4)	97 (20.6)	
<b>Self-reported respiratory disease</b>					<0.001***
No	6933 (93.0)	581 (90.2)	652 (88.2)	407 (86.2)	
Yes	521 (7.0)	63 (9.8)	87 (11.8)	65 (13.8)	

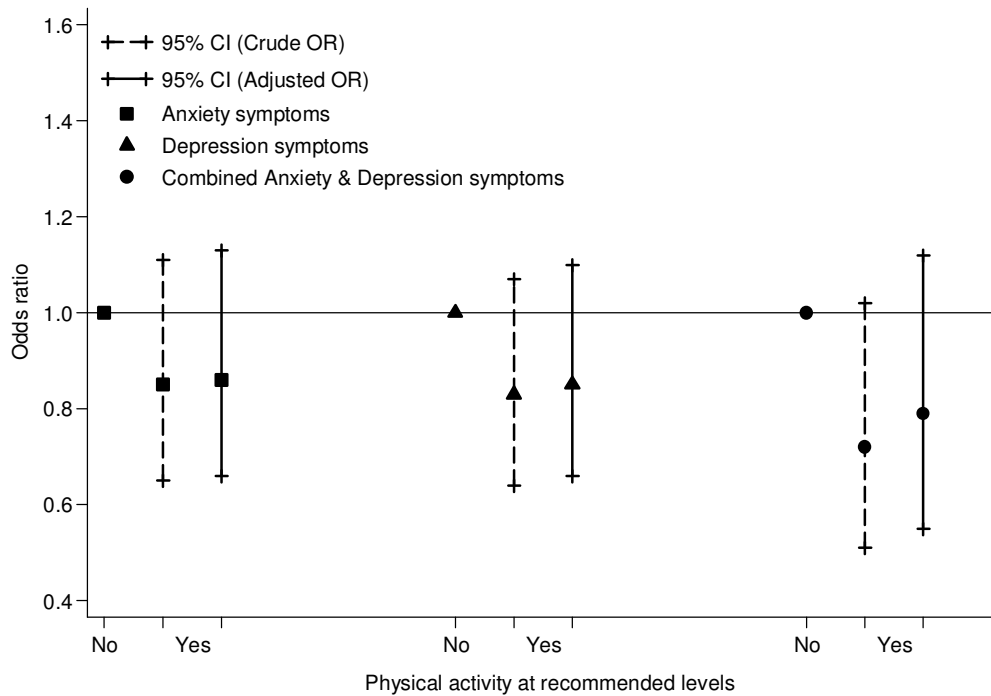
**Table 3:** Cross-sectional associations between physical activity at recommended levels and anxiety and/or depression symptoms at phase 1 (1985-1988) (N=9309)

		OR (CI 95%)	<i>p</i> value
<b>Anxiety symptoms</b>			
<b>Model 1</b>			
Physical Activity			0.01
	Yes	0.71 (0.54, 0.91)	
	No	1 (reference)	
<b>Model 2</b>			
Physical Activity			0.01
	Yes	0.71 (0.55, 0.93)	
	No	1 (reference)	
<b>Depression symptoms</b>			
<b>Model 1</b>			
Physical Activity			<0.001
	Yes	0.63 (0.48, 0.81)	
	No	1 (reference)	
<b>Model 2</b>			
Physical Activity			0.001
	Yes	0.63 (0.49, 0.82)	
	No	1 (reference)	
<b>Combined Anxiety and Depression symptoms</b>			
<b>Model 1</b>			
Physical Activity			0.03
	Yes	0.72 (0.54, 0.97)	
	No	1 (reference)	
<b>Model 2</b>			
Physical Activity			0.05
	Yes	0.74 (0.54, 1.01)	
	No	1 (reference)	

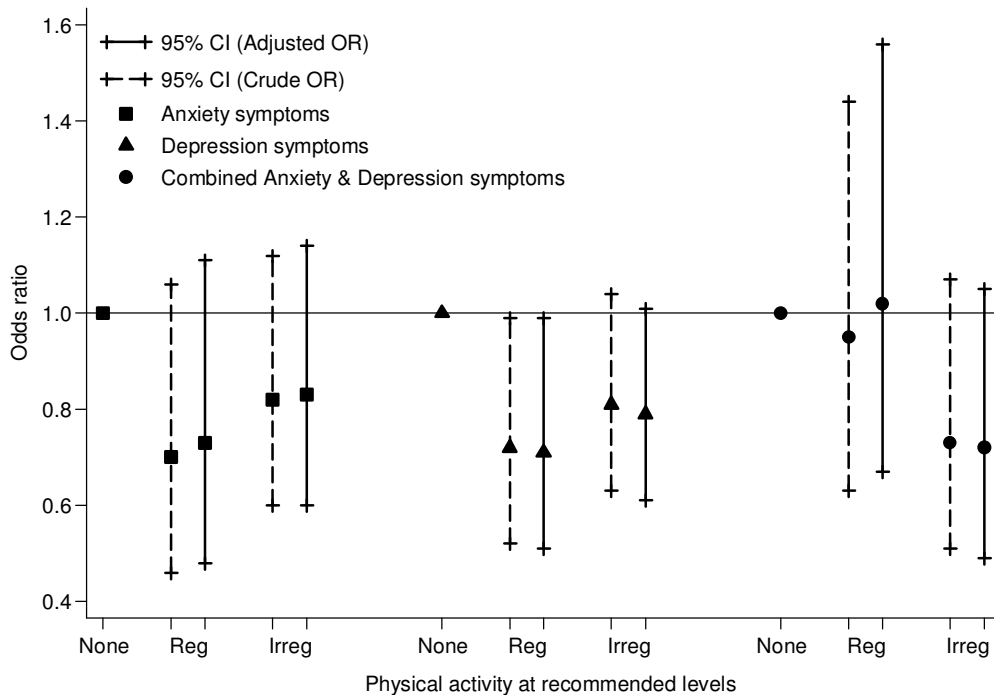
Model 1: Crude ORs

Model 2: ORs adjusted for sex, age, ethnicity, marital status, occupational grade, satisfaction with work, stressful life events score, smoking, alcohol intake and respiratory disease

**Fig. 2** Prospective association between physical activity at recommended levels at phase 1 (1985-1988) and anxiety and/or depression symptoms at phase 2 (1989-1990) and/or 3 (1991-1993) (N=7454). Adjusted ORs were for sex, age, ethnicity, marital status, occupational grade, satisfaction with work, stressful life events score, smoking, alcohol intake and respiratory disease

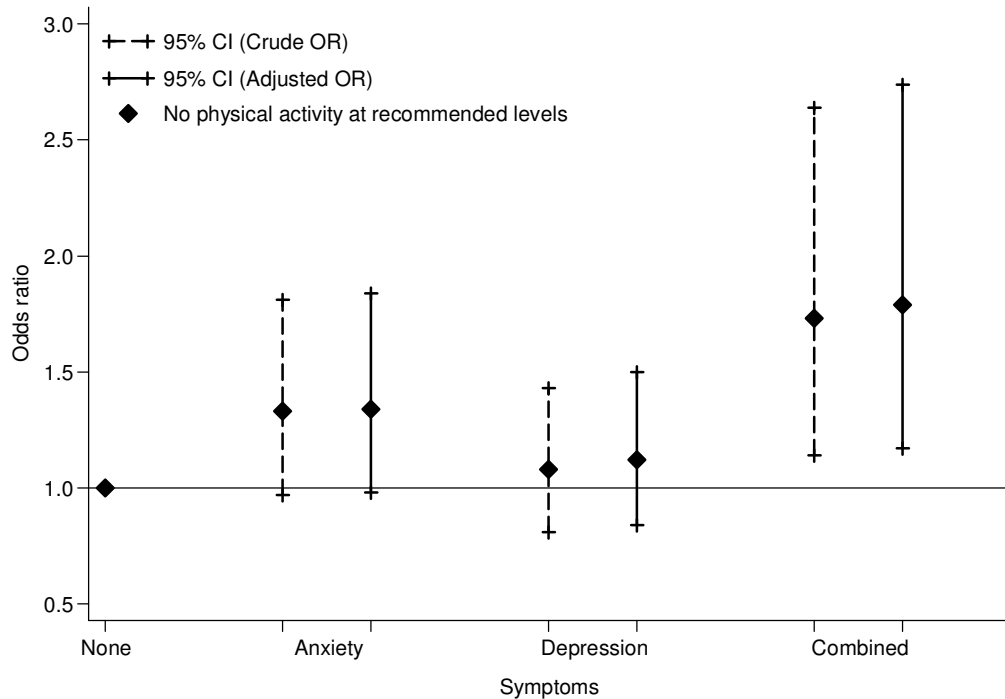


**Fig. 3** Association of cumulative physical activity at recommended levels at phase 1 (1985-1988), 2 (1989-1990) and 3 (1991-1993) and anxiety and/or depression symptoms at phase 3 (N=6280). Adjusted ORs were for sex, age, ethnicity, marital status, occupational grade, satisfaction with work, stressful life events score, smoking, alcohol intake and respiratory disease. Reg and Irreg represent regular and irregular physical activity at recommended levels, respectively





**Fig. 4** Prospective association between anxiety and/or depression symptoms at phase 1 (1985-1988) and physical activity practice at recommended levels at phase 2 (1989-1990) or 3 (1991-1993) among participants with physical activity level under the recommended levels at phase 1 (N=5385). Adjusted ORs were for sex, age, ethnicity, marital status, occupational grade, satisfaction with work, stressful life events score, smoking, alcohol intake and respiratory disease



**Fig. 5** Prospective association between anxiety and/or depression symptoms at phase 1 (1985-1988) and physical activity practice at recommended levels at phase 2 (1989-1990) or 3 (1991-1993) among participants who (N=5385). Adjusted ORs were for sex, age, ethnicity, marital status, occupational grade, satisfaction with work, stressful life events score, smoking, alcohol intake and respiratory disease. none (score 0), episodic (score 1 to 3), frequent (score 4 to 6).

