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Psychological distress is related to poor health behaviours in COPD and non-COPD patients: evidence from the CanCOLD study

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Abbreviations

COPD – Chronic Obstructive Pulmonary Disease

PA – Physical Activity

HADS - Hospital Anxiety Depression Scale

HADS-D - Depression Score from the Hospital Anxiety Depression Scale

HADS-A - Anxiety Score from the Hospital Anxiety Depression Scale

CHAMPS - Community Healthy Activities Model Program for Seniors (CHAMPS) questionnaire

BMI – Body Mass Index

CanCOLD - Canadian Cohort Obstructive Lung Disease

GOLD - Global Initiative for Chronic Obstructive Lung Disease

FEV_1 – Forced Expiratory Volume in 1 second

FVC – Forced Vital Capacity

Abstract:

Background: Patients with psychiatric disorders (depression, anxiety) are more likely to have poor health behaviours, including higher smoking and lower physical activity (PA) levels. Smoking is a major risk factor for Chronic Obstructive Pulmonary Disease (COPD), and PA is critical for COPD management. However, no studies have assessed associations between psychological distress and these behaviours among patients with vs without COPD. This is a sub-analysis of the CanCOLD study that assessed the relationships between psychological disorders (depression, anxiety) and poor health behaviours (smoking, PA).

Methods: 717 COPD and 797 matched non-COPD individuals from the CanCOLD study, completed the Hospital Anxiety Depression Scale (HADS) to assess anxiety and depression. Smoking behaviour was self-reported pack-years smoking. The CHAMPS PA questionnaire determined calorific expenditure as a PA measure. Regressions determined relationships between anxiety/depression and health behaviours, adjusting for age, sex, BMI, GOLD stage and COPD status.

Results: Across the whole sample, we observed relationships between depression (β=1.107 ± 0.197; 95%CI=0.691 – 1.462; *p*<.001) and anxiety (β=0.780 ± 0.170; 95%CI=0.446 – 1.114; *p*<.001) and pack years. Higher depression (β=-0.220 ± 0.028; 95%CI=-0.275 – -0.165; *p*<.001) and anxiety (β=-0.091 ± 0.025; 95%CI= -0.139 – -0.043; *p*<.001) scores were related to lower PA. These associations were comparable across COPD and non-COPD patients.

Conclusions: Results showed that higher levels of anxiety and depression were related to higher cumulative smoking and lower levels of PA in patients with and without COPD, suggesting symptoms of psychological distress is similarly associated with poorer health behaviours in COPD and non-COPD individuals. Future studies need to determine if treating symptoms of psychological distress can improve health behaviours and outcomes in this population.

Introduction

Chronic obstructive pulmonary disease (COPD) is characterized by chronic, not completely reversible airway obstruction, and is predicted to become the 3rd leading cause of death by 2030 [1]. COPD and subsequent exacerbations are associated with important health and financial burdens including frequent hospitalizations, increased medication usage and functional physical impairment [2, 3]. Additionally, COPD is associated with significant psychological consequences. Studies have shown that there is an increased prevalence of psychological distress among patients with COPD, with up to 55% of patients suffering from a clinical diagnosis of anxiety and/or depression [4].

The presence of significant psychological distress has important implications for the adoption and maintenance of healthy behaviours. Non-COPD patients with psychiatric disorders (such as depressive and anxiety disorders) typically have worse health behaviours, including higher rates of smoking [5, 6] and lower levels of physical activity (PA) [7]. These poor health behaviours have important consequences for individuals in general and those with COPD. The most important causal factor of COPD is smoking, with greater cumulative smoking leading to an increase likelihood of chronic airway obstruction [8]. Additionally, exercise is a cornerstone of pulmonary rehabilitation, and engaging in regularly PA has been linked to improve symptoms, quality of life and lower risk of COPD exacerbation [9, 10]. Though studies have examined the relationship between psychological distress and health behaviours in patients with asthma.[11], no studies have assessed the association between psychological distress and health behaviours among COPD patients or those at high risk for developing COPD.

This aim of this study was to assess relationships between levels of psychological distress (depression, anxiety) and poor health behaviours (smoking, reduced PA) in individuals with and at risk for COPD in the Canadian Cohort Obstructive Lung Disease (CanCOLD) study. We hypothesized that higher levels of depression and anxiety would be associated with higher

cumulative smoking levels and lower levels of PA, and that these relationships would be stronger in patients with versus without COPD.

Methods and Materials:

Sample

Our sample of participants was taken from the baseline assessment of participants in the CanCOLD study. CanCOLD is a pan-Canadian, prospective longitudinal cohort study, which consists of balanced cohorts of COPD (classified as GOLD ≥2 and GOLD 1) (Total N = 717) and non-COPD participants (Total N = 797), who have normal post bronchodilator spirometry (ever smoker for those at-risk and never-smoker for the healthy controls). Details regarding the full study design, protocol and ethical approval can be found and described in full detail elsewhere [12].

COPD characterisation

Questionnaires determined sociodemographic information and COPD-related health measures such as the exacerbation incidence and exposure to fumes, vapours and dust. Spirometry and assessments of lung function were conducted according to standard techniques, as described elsewhere [12]. GOLD 1-4 classification was used to determined disease severity based on post-bronchodilator airflow obstruction [13]. Subjects with a FEV_1/FVC post bronchodilator < 0.7 were determined to have COPD (N=717); those with a FEV_1/FVC post bronchodilator > 0.70 were considered non-COPD (N=797). Further, severity of COPD was define as GOLD 1, 2 ,3 [14].

Assessment of psychological distress

Depression and anxiety were assessed using the Hospital Anxiety and Depression Scale (HADS).[15] The HADS is a 14-item scale that yields was used to determine the level of depressive (HADS-D) and anxiety (HADS-A) symptoms. Scores range from 0-21 for each subscale, with higher scores denoting higher levels of depression and anxiety. The HADS demonstrates excellent internal consistency (HADS-A=0.83; HADS-D=0.82) and test-retest reliability (HADS-A=0.89; HADS-D=0.92) [15, 16].

Assessment of smoking behaviours

Smoking behaviours were assessed by self-reported questionnaire to determine smoking status and smoking volume. Smoking status was classified as “Ever-smoker” and “Never-smoker”. Smoking volume was determined by smoking pack years, per the standard definition of multiplying the number of packs of cigarettes smoked per day by the number of years the person has smoked [17].

Assessment of Physical Activity (PA)

Levels of PA were determined by the Community Healthy Activities Model Program for Seniors (CHAMPS) questionnaire [18], and has been used cross-culturally in Canada [19]. The questionnaire was chosen given its age appropriateness for the sample (mean age 66.71 ± 9.83). The CHAMPS is a 40-item questionnaire that assesses both the weekly frequency and calorific expenditure associated with physical activities in an older population [18]. The CHAMPS allows for determination of 4 categories of activity: 1) the caloric expenditure per week of activities of a moderate intensity or greater (MET value >/= 3.0); 2) the caloric expenditure

per week of all activities (including lower intensity activity); 3) the weekly frequency of activities of a moderate intensity or greater (MET value >/= 3.0); 4) the weekly frequency of all activities (including lower intensity activity). This was then used to determine levels of all PA and moderate PA only. The CHAMPS has a correlation between frequency and caloric expenditure of 0.73 for moderate intensity PA, and of 0.55 for all activity [18].

Statistical analysis

Analyses were undertaken using SAS version 9.4. Significance was set at $p < .05$. Occasional missing data are reflected in the degrees of freedom. One-way general linear models and χ^2 analyses were used to compare baseline sociodemographic and clinical characteristics by COPD group. Analysis of psychological distress symptoms (measured continuously) per group (COPD risk [categorised as Never-smoker, Ever-smoker, and COPD GOLD stage >1]; GOLD stage; and current smoking status) were analysed using GLM, with Tukey post-hoc tests. The relationships between psychological distress and smoking behaviour, and between psychological distress and PA were examined using a series of linear regressions, which were adjusted for age, sex, body mass index (BMI), GOLD stage and COPD group. For each health behaviour (smoking, PA), Model 1 examined the relationship to depression, Model 2 the relationship to anxiety. Analyses were conducted to examine possible interactions between health behaviours and depression/anxiety levels and COPD group with Model 3 examining the interaction between COPD group and depression level, and Model 4 examining the interaction between COPD group and anxiety level. Finally, to determine if there was a difference in the impact of comorbid depression and anxiety in individuals with and without COPD, a series of 3-way interactions were completed. Identical analyses were completed as supplementary content to determine the impact of COPD risk group (i.e., never smokers, ever smokers and GOLD Stage >1) on the above behaviours.

Results

Sample characteristics

Sample characteristics are displayed in Table 1 for the whole sample and for subjects with and without COPD. Across our sample, individuals with COPD were more likely to be men, older, have a higher cumulative exposure of smoking as measured by pack years, be former or current smokers, have more COPD exacerbations in the previous year, a higher rate of physician diagnosed asthma and chronic bronchitis, and greater medication prescribed (both short-acting, long-acting and ICS) compared to those without COPD (all *p's* < .05). Unsurprisingly, individuals with COPD also had worse spirometry profiles with lower FEV_1 and FVC recordings than in those without COPD (*p's* < .001). There were no significant differences in the mean depression and anxiety scores between individuals with and without COPD.

We also explored the degree of depression and anxiety symptoms within our sample (Table 2). These results showed that there were trend effects of COPD risk on HADS-D (F = 2.6, *p* = .074) and HADS-A (F = 2.48, *p* = .084). There were main effects of GOLD stage for HADS-D (F = 5.84, *p* < .001) where post-hoc analysis showed elevated depression symptoms in patients at GOLD Stage 3 compared to those at GOLD stage 1 or 2 plus those who were not categorised as having a GOLD score. No effect was observed for HADS-A (F = 1.44, *p* = .22). There were main effects of current smoking status for both HADS-D (F = 27.2, *p* < .001) and HADS-A (F = 14.05, *p* < .001). For both of these main effects the highest scores were observed in current smokers (Table 2) and were significantly higher than scores for never and ever (past) smokers (*p's* < .05). There were no differences in scores between never and ever smokers (*p's* > .05).

The relationships between depression, anxiety and health behaviours

Smoking (pack years)

As shown in Table 3, analyses revealed that there were positive relationships between depressive symptoms and cumulative smoking as measured by pack years (β = 1.107 ± 0.197; 95%CI = 0.691 – 1.462; *p*<.001) where higher smoking volume was seen in patients with higher depression symptoms. A similar relationship was seen between levels of anxiety and smoking (β = 0.780 ± 0.170; 95%CI = 0.446 – 1.114; *p*<.001) with higher levels of anxiety seen in patients with higher smoking volume. As seen in Figure 1, there were no interactions between depressive symptoms and COPD group (β = 0.380 ± 0.413; 95%CI = -0.430 – 1.19; *p* = .358) or anxiety symptoms and COPD group (β = 0.558 ± 0.337; 95%CI = -0.102 – 1.218; *p* = .098). Supplemental analysis examining the effects of COPD risk group mirrored the main findings, with the exception of the interaction effects between depression and COPD risk (β = 0.609 ± 0.265; 95%CI = 0.089 – 1.129; *p* = .022) and between anxiety and COPD risk (β = 0.476 ± 0.217; 95%CI = 0.050 – 0.901; *p* = .029). However, given that COPD risk was determined based on smoking status, these interaction effects were to be expected.

Physical activity

Analyses revealed that there were negative relationships between depressive symptoms and all PA (β = -0.220 ± 0.028; 95%CI = -0.275 – -0.165; *p* < .001) where lower PA levels were evident in subjects with higher depression symptoms. A similar relationship between levels of anxiety and PA was apparent (β = -0.091 ± 0.025; 95%CI = -0.139 – -0.043; *p* <.001) with higher levels of anxiety seen in subjects with lower levels of PA. No interactions were seen between COPD group and depression/anxiety symptoms (Table 4; Figure 2). Our analyses also show negative associations between depressive symptoms and moderate activity (β = -0.176 ± 0.022; 95%CI = -0.219 – -0.134; *p* < .001) where lower PA levels were evident in subjects with higher depression symptoms. A similar relationship was also observed for anxiety (β = -0.073 ±

0.019; 95%CI = -0.111 – -0.036; *p*<.001) (Figure 3). Again, no interactions were observed between COPD group and depression or anxiety (Table 5). Supplemental analysis examining the impact of COPD risk group yielded similar results as the main analysis.

Interactions between depression and anxiety and health behaviours

Further analysis was undertaken to examine the possible impact of comorbid depression and anxiety on health behaviours. As can be seen in Table 6 no depression by anxiety interactions was observed for pack years (β = 0.005 ± 0.045; 95%CI = -0.083 – 0.093; *p* = .91), All PA (β = 0.009 ± 0.006; 95%CI = -0.003 – 0.022; *p* = .15) or Moderate PA levels (β = 0.007 ± 0.005; 95%CI = -0.003 – 0.017; *p* = .15).

Discussion

We assessed the relationship between symptom levels of psychological distress (depression, anxiety) and poor health behaviours (smoking and reduced PA) in individuals with or at risk for COPD in the CanCOLD study. Our results showed that higher symptoms of depression and anxiety were related to higher smoking volume and lower level of PA. These relationships were observed in both COPD and non-COPD individuals, and there was no interaction between depression and anxiety on health behaviours. Our results mirror those in other respiratory populations which demonstrate a relationship between psychiatric disorders (i.e., depressive and anxiety) and poor health behaviours (i.e., higher rates of smoking, lower level of leisure-time PA) in patients with asthma [11, 20]. However, to our knowledge, no studies have assessed the association between symptom levels of psychological distress and these health behaviours among patients with or at risk for COPD.

Depressive and anxiety disorders have been linked with worse COPD outcomes in previous studies; depression (as measured by the HADS) was associated with an increased risk of symptom-based exacerbations (51% increase), event-based exacerbations (56% increase), and hospitalization (72% increase) compared with COPD patients who were not depressed [21]. Given that our analysis shows that higher symptoms of psychological distress are linked to health behaviours that are important determinants of COPD risk (smoking) and management (PA – which is the aim of pulmonary rehabilitation programs), this study appears to highlight a possible mechanism linking high levels of depression and anxiety to worse COPD outcomes.

Non-COPD patients with higher levels of depression and anxiety typically have worse health behaviours than their non-psychiatric counterparts, including higher rates of smoking [5, 6] and lower levels of PA [7]. Therefore, given the high prevalence of psychological distress in patients with COPD [4], and the potential impact of these negative mood states on smoking behaviours and PA levels, screening for psychological distress and developing interventions that target these health risk behaviours in this population may be important for improving management and outcomes. High levels of anxiety and depression has been linked to worse health behaviours across a variety of populations. Smoking is linked to increases in emotional self-regulation to reduce negative emotions [22-25], as evidenced by instances when smokers engage in smoking when under periods of stress to help deal with the stressful episode [26-30]. Patients with high psychological distress may also be more vulnerable to addictive behaviours and addictive properties of smoking including nicotine [31, 32]. This can be further exacerbated by the psychological distress associated with physiological withdrawal during quit attempts (or failed attempts to quit) smoking [33], making it more difficult for to quit smoking, which further augments the risk of COPD [8]. Similarly, our study demonstrated that symptoms of psychological distress were linked to lower levels of PA. Continued engagement in regular bouts of PA requires sustained motivation and effort. In patients with depressive symptoms, lowered

motivation and lack of energy are key symptoms [34], which may be a mechanism through which higher levels of depressive symptoms distress are linked to lower PA levels. Importantly, failure to engage in regular PA may be a proxy for lack of motivation or social functioning, which may then subsequently lead to depression [35]. In patients with high anxiety symptomology, there may be the presence of exaggerated fears of negative consequences of PA/exercise, including symptoms that are specific to PA such as increased fatigue, pain, breathlessness, exacerbation or symptoms. This may lead to PA avoidance in both COPD and those with pre-clinical symptoms. This would lead to further deconditioning, avoidance of rehab, and worse outcomes [9, 10]. Taken together, these results highlight the importance of developing health behaviour change interventions that are flexible enough to allow for adaptation in patients who experience high levels of psychological distress, which are important determinants of health risk behaviours.

Another interesting question that arises from these results is whether clinicians and researchers should aim to treat the symptoms of psychological distress or the health behaviour first. It appears that in the case of PA, it may be possible to focus on improving the behaviour first, given that increases in PA can lead to reduced psychological distress in patients with [36] and without [37] clinical levels of depression and anxiety. Similarly, reductions in smoking can also lead to reductions in psychological distress [38], but as depression severity is related to the likelihood of cessation success [38], there may be a need to treat the psychological distress in parallel with smoking cessation. The addition of psychosocial support to smoking cessation interventions has been shown to increase long-term cessation rates in smokers with depression in contrast to smoking cessation alone [39]. However, the question of what to treat first (psychological distress versus health risk behaviours) to optimize behavioural and clinical outcomes clearly requires further investigation.

Interestingly, we did not see an interaction between psychological distress levels and COPD status for either smoking behaviours or PA, which would suggest the magnitude and direction of these relationships are seen in both patients with and at risk for COPD. Given that smoking is a risk factor for COPD, the presence of depression/anxiety in patients at risk for COPD could lead to an accelerated progression to COPD due to higher smoking rates in this subgroup of patients. Our results provide further support for the notion that depression and anxiety are potential risk factors for COPD development. However, as our analysis is only cross-sectional, we are unable to determine the temporal association between psychological distress, health behaviours, and COPD onset. Nonetheless, our results suggest that early identification high levels of psychological distress may lead to early intervention and improved outcomes.

We did not observe any interactions between depression and anxiety for either smoking volume or for any measure of PA. This suggests that there might not be a cumulative worsening of health behaviours with high levels of comorbid anxiety and depression, nor is there a differential effect of depression and anxiety on smoking and PA. However, while for smoking we did observe comparable main effects of depression and anxiety when both measures were included in our regression analysis (as reported in Table 5), for PA we observed a main effect of depression and no longer a main effect for anxiety. This would seem to suggest that depression may be of greater importance in determining PA than anxiety, but this needs further investigation.

There are some limitations regarding the study design that should be acknowledged. As we are examining data from the baseline assessments of the CanCOLD study, data are cross-sectional so we are unable to determine the temporal association between depression/anxiety and poor health behaviours. Future research should examine the bi-directional relationships between these variables using longitudinal designs. We are also unable to link the observed

relationships to an increased risk of exacerbations and hospitalisations in patients with COPD. This too represents an important avenue for future research.

Despite these limitations, this study also has several notable strengths. First, this study includes a large sample of very well characterized participants, providing a unique opportunity to compare both COPD and non-COPD patients. Similarly, we used the HADS questionnaire to determine depression and anxiety symptoms, which has excellent psychometric properties and has been used in several previous studies of COPD cohorts. It has also been shown to be a potentially reliable screening tool when using cut-off scores of 8 or higher on each of the subscales [16]. However, caution is warranted as these cut-offs may underestimate rates of depression in COPD patients [40].

In conclusion, this is the first study to show significant and important relationships between high levels of psychological distress (depression, anxiety) and both higher smoking rates and lower PA levels in individuals with and at risk for COPD. This provides support for the hypothesis that psychological distress, via its association with two key health behaviours important for COPD development and treatment, may plays an important role in COPD management. Future studies are needed to determine if treating psychological distress can improve health behaviours and in turn, result in more favourable outcomes in this population.

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Table 1. Sample characteristics

Variable	Mean (SD) or N (%)	No COPD (N=797)	COPD (N=717)	F/X^2	p	Missing N
Sex (Women)	662 (46.23)	362 (50.28)	280 (41.67)	10.37	.0013	40
Age (years)	66.71 (9.83)	66.05 (9.55)	67.46 (10.08)	7.21	.0074	40
BMI (kg/m^2)	27.57 (5.03)	27.82 (5.22)	27.20 (4.81)	5.38	.0205	44
Years of School	15.57 (3.67)	15.79 (3.43)	15.37 (3.92)	4.46	.0348	43
Smoking Pack Years	18.25 (23.31)	12.29 (19.47)	24.24 (25.08)	99.11	<.0001	40
CHAMPS scores (Kilocalories/week), all activities	4.08 (3.12)	4.16 (3.24)	4.07 (3.02)	0.32	.57	40
CHAMPS scores (Kilocalories/week), moderate activities	2.27 (2.44)	2.34 (2.54)	2.26 (2.37)	0.40	.53	40
Post-bronchodilator FEV_1 (L)	2.52 (0.81)	2.72 (0.78)	2.30 (0.78)	101.98	<.0001	40
Post-bronchodilator FVC (L)	3.65 (1.08)	3.54 (1.02)	3.76 (1.12)	13.74	.0002	40
HADS - Anxiety Score (HADS-A)	3.98 (3.24)	4.08 (3.32)	3.84 (3.13)	1.86	.17	47
Proportion with HADS-A ≥ 8	128 (8.94)	68 (9.44)	54 (8.04)	0.86	.35	40
HADS - Depression Score (HADS-D)	2.84 (2.74)	2.78 (2.84)	2.82 (2.54)	0.10	.75	46
Proportion with HADS-D ≥ 8	59 (4.12)	33 (4.58)	23 (3.42)	1.21	.27	40
Occupational Status				4.04	.54	41
Retired	865 (60.53)	423 (58.75)	420 (62.59)			
Full time	303 (21.20)	162 (22.50)	132 (19.67)			
Part time	173 (12.11)	93 (12.92)	75 (11.18)			
Disability Insurance	38 (2.66)	20 (2.78)	17 (2.53)			
Unemployed Insurance	13 (0.91)	6 (0.83)	7 (1.04)			

Home	37 (2.59)	16 (2.22)	20 (2.98)			
Education Level				14.24	.0066	41
Primary	23 (1.61)	7 (0.97)	15 (2.24)			
Middle	47 (3.28)	16 (2.22)	31 (4.62)			
High	261 (18.24)	117 (16.25)	133 (19.82)			
Some college	366 (25.58)	193 (26.81)	163 (24.29)			
University	734 (51.29)	387 (53.75)	329 (49.03)			
Smoking status				48.17	<.0001	40
Never	456 (38.13)	336 (46.67)	195 (29.02)			
Ex-smokers	659 (46.02)	299 (41.53)	350 (52.08)			
Current smokers	227 (15.85)	85 (11.81)	127 (18.90)			
Medical characteristics and history						
GOLD status				1393.00	<.0001	40
Normal	336 (24.14)	336 (46.67)	0 (0)			
At risk	384 (27.59)	384 (53.33)	0 (0)			
GOLD1	373 (26.80)	0 (0)	373 (55.51)			
GOLD2	259 (18.61)	0 (0)	259 (38.54)			
GOLD3	40 (2.87)	0 (0)	40 (5.95)			
Physician diagnosed asthma	334 (23.32)	116 (16.11)	210 (31.25)	44.42	<.0001	40
Cardiovascular Disease diagnosis	219 (15.29)	99 (13.75)	110 (16.37)	1.87	.17	40
Diabetes diagnosis	144 (10.06)	74 (10.28)	63 (9.38)	0.32	.57	40
Any musculoskeletal disorder	477 (33.31)	236 (32.78)	227 (33.78)	0.16	.69	40

Chronic Bronchitis	193 (13.49)	70 (9.74)	112 (16.67)	14.67	<.0001	41
Taking Short Acting Broncho Dilator (SABD)	57 (3.98)	9 (1.25)	47 (6.99)	29.70	<.0001	40
Taking Long Acting Beta-Agonists (LABA) or Long Acting Muscarinic Antagonists (LAMA)	20 (1.40)	5 (0.69)	15 (2.23)	5.80	.0160	40
Taking Inhaled Corticosteroid (ICS)	89 (6.22)	35 (4.86)	51 (7.59)	4.46	.0346	40
Taking ICS combined with LABA/LAMA	167 (11.67)	32 (4.44)	129 (19.20)	73.95	<.0001	40
Regularly exposed to Dust during job	116 (8.11)	61 (8.47)	52 (7.74)	0.25	.62	40
Regularly exposed to Fumes during job	48 (3.36)	26 (3.61)	20 (2.98)	0.44	.50	40
Regularly exposed to Vapours during job	31 (2.17)	16 (2.22)	14 (2.08)	0.032	.86	40
Regularly exposed to Gases during job	23 (1.61)	14 (1.94)	8 (1.19)	1.27	.26	40
Experienced a COPD exacerbation during the past 12 months						
Number of Exacerbations in last 12 months	68 (4.75)	19 (2.64)	45 (6.70)	14.92	.0049	40
0	1363 (95.25)	701 (97.36)	628 (93.45)			
1	40 (59.70)	12 (1.67)	25 (3.72)			
2	13 (19.40)	5 (0.69)	8 (1.19)			
3	7 (10.45)	0 (0)	6 (0.89)			
4 or more	7 (10.45)	2 (0.28)	5 (0.74)			

Note: BMI = Body Mass Index; CHAMPS = Community Healthy Activities Model Program for Seniors; HADS = Hospital Anxiety Depression Scale; SABD = Short Acting Broncho Dilator (SABD); LABA = Long Acting Beta-Agonists; LAMA = Long Acting Muscarinic Antagonists; ICS = Inhaled Corticosteroid; GOLD = Global Initiative for Chronic Obstructive Lung Disease;

Table 2. Group differences in depression and anxiety scores by level of COPD risk, GOLD stage and Current smoking status

	HADS-D Score	**HADS-A Score**
Level of COPD risk	Main effect: F = 2.6, *p* = .0743	Main effect: F = 2.48, *p* = .0844
Never smoker	2.54 ± 2.65	3.85 ± 3.14
At risk	2.99 ± 2.98	4.28 ± 3.47
COPD (GOLD >1)	2.82 ± 2.55	3.84 ± 3.13
GOLD stage	Main effect: F = 5.84, *p* < .001	Main effect: F = 1.44, *p* = .22
Never smoker	2.54 ± 2.65^{+}	3.85 ± 3.14
At risk	2.99 ± 2.98^{+}	4.28 ± 3.47
GOLD 1	2.61 ± 2.39^{+}	3.85 ± 3.26
GOLD 2	2.87 ± 2.39^{+}	3.76 ± 2.89
GOLD 3+	4.50 ± 3.97	4.25 ± 3.45
Current smoking status	Main effect: F = 27.2, *p* < .001	Main effect: F = 14.05, *p* < .001
Never smoker	2.44 ± 2.47*	3.69 ± 2.99*
Ever smoker	2.77 ± 2.61*	3.88 ± 3.20*
Current smoker	4.00 ± 3.35	5.00 ± 3.71

Note: Scores presented as Mean ± SD. $^{+}$ indicates significantly different from GOLD stage >3, (*p* < .05); *indicates significantly different from current smokers (*p* < .05)

Table 3. Impact of depression and anxiety on smoking behaviours.

MAIN EFFECTS: Pack Years				**INTERACTION EFFECTS: Pack Years**			
Model 1	**β ± SE**	**95%CI**	**p**	**Model 3**	**β ± SE**	**95%CI**	**p**
HADS-D	1.107 ± 0.197	0.691 – 1.462	< .001	HADS-D	0.914 ± 0.263	0.397 – 1.430	.0005
COPD Group	-14.15 ± 2.24	-18.55 – -9.752	< .001	COPD Group	-15.10 ± 2.415	-19.83 – -10.36	< .001
				HADS-D by COPD Group Interaction	0.380 ± 0.413	-0.430 – 1.19	.358
Model 2	**β ± SE**	**95%CI**	**p**	**Model 4**	**β ± SE**	**95%CI**	**p**
HADS-A	0.780 ± 0.170	0.446 – 1.114	<.001	HADS-A	0.528 ± 0.227	0.085 – 0.973	.0196
COPD Group	-14.83 ± 2.251	-19.25 – -10.42	<.001	COPD Group	-17.04 ± 2.604	-22.15 – -11.94	< .001
				HADS-A by COPD Group Interaction	0.558 ± 0.337	-0.102 – 1.218	.0975

Note: All analyses adjusted for sex, age, BMI and GOLD stage. HADS-D = Depression Score from the Hospital Anxiety Depression Scale; HADS-A = Anxiety Score from the Hospital Anxiety Depression Scale;

Table 4. Impact of depression and anxiety on physical activity (PA) levels.

MAIN EFFECTS: All PA				**INTERACTION EFFECTS: All PA**			
Model 1	**β ± SE**	**95%CI**	**p**	**Model 3**	**β ± SE**	**95%CI**	**p**
HADS-D	-0.220 ± 0.028	-0.275 – -0.165	<.001	HADS-D	-0.232 ± 0.037	-0.304 – -0.159	<.001
COPD Group	0.135 ± 0.309	-0.471 – 0.742	.66	COPD Group	0.069 ± 0.338	-0.595 – 0.732	.84
				HADS-D by COPD Group Interaction	0.027 ± 0.057	-0.084 – 0.138	.64
Model 2	**β ± SE**	**95%CI**	**p**	**Model 4**	**β ± SE**	**95%CI**	**p**
HADS-A	-0.091 ± 0.025	-0.139 – -0.043	.0002	HADS-A	-0.097 ± 0.033	-0.161 – -0.032	.0035
COPD Group	0.290 ± 0.314	-0.326 – 0.905	.36	COPD Group	0.241 ± 0.366	-0.475 – 0.957	.51
				HADS-A by COPD Group Interaction	0.012 ± 0.050	-0.084 – 0.108	.80

Note: All analyses adjusted for sex, age, BMI and GOLD stage. HADS-D = Depression Score from the Hospital Anxiety Depression Scale; HADS-A = Anxiety Score from the Hospital Anxiety Depression Scale;

Table 5. Impact of depression and anxiety on moderate physical activity (PA) levels.

MAIN EFFECTS: Moderate PA				**INTERACTION EFFECTS: Moderate PA**			
Model 1	**β ± SE**	**95%CI**	**p**	**Model 3**	**β ± SE**	**95%CI**	**p**
HADS-D	-0.176 ± 0.022	-0.219 – -0.134	<.001	HADS-D	-0.184 ± 0.029	-0.240 – -0.127	<.001
COPD Group	0.226 ± 0.241	-0.247 – 0.699	.35	COPD Group	0.181 ± 0.264	-0.337 – 0.699	.49
				HADS-D by COPD Group Interaction	0.018 ± 0.044	-0.068 – 0.104	.68
Model 2	**β ± SE**	**95%CI**	**p**	**Model 4**	**β ± SE**	**95%CI**	**p**
HADS-A	-0.073 ± 0.019	-0.111 – -0.036	<.001	HADS-A	-0.010 ± 0.026	-0.120 – -0.020	.0063
COPD Group	0.349 ± 0.245	-0.132 – 0.830	.15	COPD Group	0.376 ± 0.258	-0.183 – 0.936	.188
				HADS-A by COPD Group Interaction	-0.007 ± 0.038	-0.081 – 0.067	.86

Note: All analyses adjusted for sex, age, BMI and GOLD stage. HADS-D = Depression Score from the Hospital Anxiety Depression Scale; HADS-A = Anxiety Score from the Hospital Anxiety Depression Scale;

Table 6. Interactions between depression and anxiety on health behaviours

MAIN EFFECTS: Pack Years				**INTERACTION EFFECTS: Pack Years**			
Model 1	**β ± SE**	**95%CI**	**p**	**Model 2**	**β ± SE**	**95%CI**	**p**
HADS-D	0.832 ± 0.232	0.377 – 1.288	.0003	HADS-D	0.804 ± 0.344	0.129 – 1.479	.0197
HADS-A	0.405 ± 0.201	0.012 – 0.798	.0435	HADS-A	0.385 ± 0.268	-0.141 – 0.91	.15
				HADS-D by HADS-A Interaction	0.005 ± 0.045	-0.083 – 0.093	.91
MAIN EFFECTS: All PA				**INTERACTION EFFECTS: All PA**			
Model 1	**β ± SE**	**95%CI**	**p**	**Model 2**	**β ± SE**	**95%CI**	**p**
HADS-D	-0.227 ± 0.033	-0.291 – -0.163	<.001	HADS-D	-0.279 ± 0.049	-0.375 – -0.183	<.001
HADS-A	0.011 ± 0.028	-0.045 – 0.067	.69	HADS-A	-0.025 ± 0.038	-0.010 – 0.049	.51
				HADS-D by HADS-A Interaction	0.009 ± 0.006	-0.003 – 0.022	.15
MAIN EFFECTS: Moderate PA				**INTERACTION EFFECTS: Moderate PA**			
Model 1	**β ± SE**	**95%CI**	**p**	**Model 2**	**β ± SE**	**95%CI**	**p**
HADS-D	-0.181 ± 0.025	-0.231 – -0.131	<.001	HADS-D	-0.223 ± 0.038	-0.297 – -0.148	<.001
HADS-A	0.009 ± 0.022	-0.035 – 0.052	.70	HADS-A	-0.020 ± 0.030	-0.078 – 0.038	.50
				HADS-D by HADS-A Interaction	0.007 ± 0.005	-0.003 – 0.017	.15

Note: All analyses adjusted for sex, age, BMI, GOLD stage and COPD Group. HADS-D = Depression Score from the Hospital Anxiety Depression Scale; HADS-A = Anxiety Score from the Hospital Anxiety Depression Scale;

Supplemental tables: Psychological distress is related to poor health behaviours in COPD and non-COPD patients: evidence from the CanCOLD study

Supplement Table 1. Analyses to examine the impact of depression and anxiety on smoking behaviours, with examination of COPD risk group (categorized as never smokers, ever smokers and GOLD Stage >1), which has been included as a main and interaction effect.

MAIN EFFECTS: Pack Years				**INTERACTION EFFECTS: Pack Years**			
Model 1	**β ± SE**	**95%CI**	**p**	**Model 3**	**β ± SE**	**95%CI**	**p**
HADS-D	1.187 ± 0.199	0.797 – 1.578	<.001	HADS-D	0.449 ± 0.378	-0.292 – 1.191	.23
COPD Risk Group	2.420 ± 1.772	-1.053 – 5.893	.17	COPD Risk Group	1.200 ± 1.856	-2.438 – 4.837	.52
				HADS-D by COPD Risk Group Interaction	0.609 ± 0.265	0.089 – 1.129	.0217
Model 2	**β ± SE**	**95%CI**	**p**	**Model 4**	**β ± SE**	**95%CI**	**p**
HADS-A	0.798 ± 0.173	0.459 – 1.136	<.001	HADS-A	0.207 ± 0.318	-0.417 – 0.831	.52
COPD Risk Group	1.605 ± 1.779	-1.882 – 5.093	.37	COPD Risk Group	-0.182 ± 1.958	-4.019 – 3.656	.93
				HADS-A by COPD Risk Group Interaction	0.476 ± 0.217	0.050 – 0.901	.0286

Note: All analyses adjusted for sex, age, BMI and GOLD stage. HADS-D = Depression Score from the Hospital Anxiety Depression Scale; HADS-A = Anxiety Score from the Hospital Anxiety Depression Scale;

Supplement Table 2. Analyses to examine the impact of depression and anxiety on physical activity (PA) levels, with examination of COPD risk group (categorized as never smokers, ever smokers and GOLD Stage >1), which has been included as a main and interaction effect.

MAIN EFFECTS: All PA				**INTERACTION EFFECTS: All PA**			
Model 1	**β ± SE**	**95%CI**	**p**	**Model 3**	**β ± SE**	**95%CI**	**p**
HADS-D	-0.217 ± 0.028	-0.271 – -0.162	<.001	HADS-D	-0.215 ± 0.052	-0.318 – -0.113	<.001
COPD Risk Group	0.588 ± 0.246	0.105 – 1.071	.017	COPD Risk Group	0.590 ± 0.257	0.088 – 1.093	.0214
				HADS-D by COPD Risk Group Interaction	-0.001 ± 0.036	-0.072 – 0.070	.98
Model 2	**β ± SE**	**95%CI**	**p**	**Model 4**	**β ± SE**	**95%CI**	**p**
HADS-A	-0.093 ± 0.025	-0.141 – -0.045	.0002	HADS-A	-0.056 ± 0.046	-0.145 – 0.034	.22
COPD Risk Group	0.726 ± 0.250	0.237 – 1.216	.0036	COPD Risk Group	0.839 ± 0.275	0.300 – 1.378	.0023
				HADS-A by COPD Risk Group Interaction	-0.030 ± 0.031	-0.091 – 0.031	.33

Note: All analyses adjusted for sex, age, BMI and GOLD stage. HADS-D = Depression Score from the Hospital Anxiety Depression Scale; HADS-A = Anxiety Score from the Hospital Anxiety Depression Scale;

Supplement Table 3. Analyses to examine the impact of depression and anxiety on moderate physical activity (PA) levels, with examination of COPD risk group (categorized as never smokers, ever smokers and GOLD Stage >1), which has been included as a main and interaction effect.

MAIN EFFECTS: Moderate PA				**INTERACTION EFFECTS: Moderate PA**			
Model 1	**β ± SE**	**95%CI**	**p**	**Model 3**	**β ± SE**	**95%CI**	**p**
HADS-D	-0.175 ± 0.022	-0.217 – -0.132	<.001	HADS-D	-0.171 ± 0.040	-0.250 – -0.091	<.001
COPD Risk Group	0.420 ± 0.192	0.044 – 0.797	.0287	COPD Risk Group	0.427 ± 0.200	0.034 – 0.819	.0331
				HADS-D by COPD Risk Group Interaction	-0.003 ± 0.028	-0.059 – 0.052	.91
Model 2	**β ± SE**	**95%CI**	**p**	**Model 4**	**β ± SE**	**95%CI**	**p**
HADS-A	-0.075 ± 0.019	-0.112 – -0.037	<.001	HADS-A	-0.032 ± 0.035	-0.102 – 0.037	.36
COPD Risk Group	0.532 ± 0.195	0.150 – 0.913	.0063	COPD Risk Group	0.660 ± 0.214	0.239 – 1.080	.0021
				HADS-A by COPD Risk Group Interaction	-0.034 ± 0.024	-0.081 – 0.013	.157

Note: All analyses adjusted for sex, age, BMI and GOLD stage. HADS-D = Depression Score from the Hospital Anxiety Depression Scale; HADS-A = Anxiety Score from the Hospital Anxiety Depression Scale;

Supplement Table 4. Interactions between depression and anxiety on health behaviours

MAIN EFFECTS: Pack Years				**INTERACTION EFFECTS: Pack Years**			
Model 1	**β ± SE**	**95%CI**	**p**	**Model 2**	**β ± SE**	**95%CI**	**p**
HADS-D	0.971 ± 0.235	0.510 – 1.432	<.001	HADS-D	0.936 ± 0.349	0.251 – 1.620	.0074
HADS-A	0.358 ± 0.203	-0.040 – 0.756	.0778	HADS-A	0.334 ± 0.271	-0.198 – 0.866	.22
				HADS-D by HADS-A Interaction	0.006 ± 0.045	-0.083 – 0.095	.89
MAIN EFFECTS: All PA				**INTERACTION EFFECTS: All PA**			
Model 1	**β ± SE**	**95%CI**	**p**	**Model 2**	**β ± SE**	**95%CI**	**p**
HADS-D	-0.221 ± 0.033	-0.285 – -0.157	<.001	HADS-D	-0.272 ± 0.049	-0.368 – -0.177	<.001
HADS-A	0.007 ± 0.028	-0.048 – 0.063	.80	HADS-A	-0.028 ± 0.038	-0.103 – 0.046	.46
				HADS-D by HADS-A Interaction	0.009 ± 0.006	-0.003 – 0.021	.16
MAIN EFFECTS: Moderate PA				**INTERACTION EFFECTS: Moderate PA**			
Model 1	**β ± SE**	**95%CI**	**p**	**Model 2**	**β ± SE**	**95%CI**	**p**
HADS-D	-0.178 ± 0.025	-0.228 – -0.128	<.001	HADS-D	-0.219 ± 0.038	-0.293 – -0.144	<.001
HADS-A	0.006 ± 0.022	-0.037 – 0.049	.78	HADS-A	-0.022 ± 0.030	-0.080 – 0.036	.46
				HADS-D by HADS-A Interaction	0.007 ± 0.005	-0.003 – 0.017	.15

Note: All analyses adjusted for sex, age, BMI, GOLD stage and COPD Risk Group. HADS-D = Depression Score from the Hospital Anxiety Depression Scale; HADS-A = Anxiety Score from the Hospital Anxiety Depression Scale;

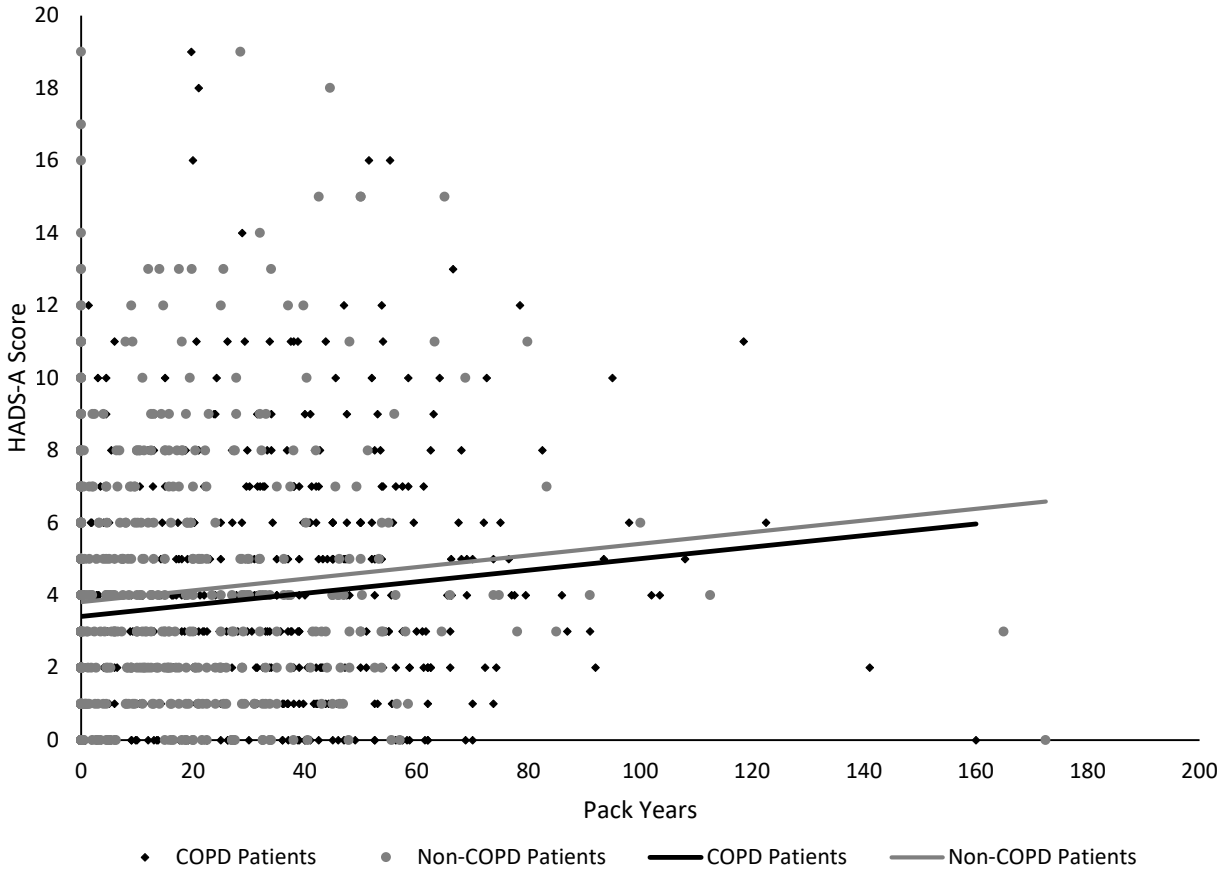
Figure Legends:

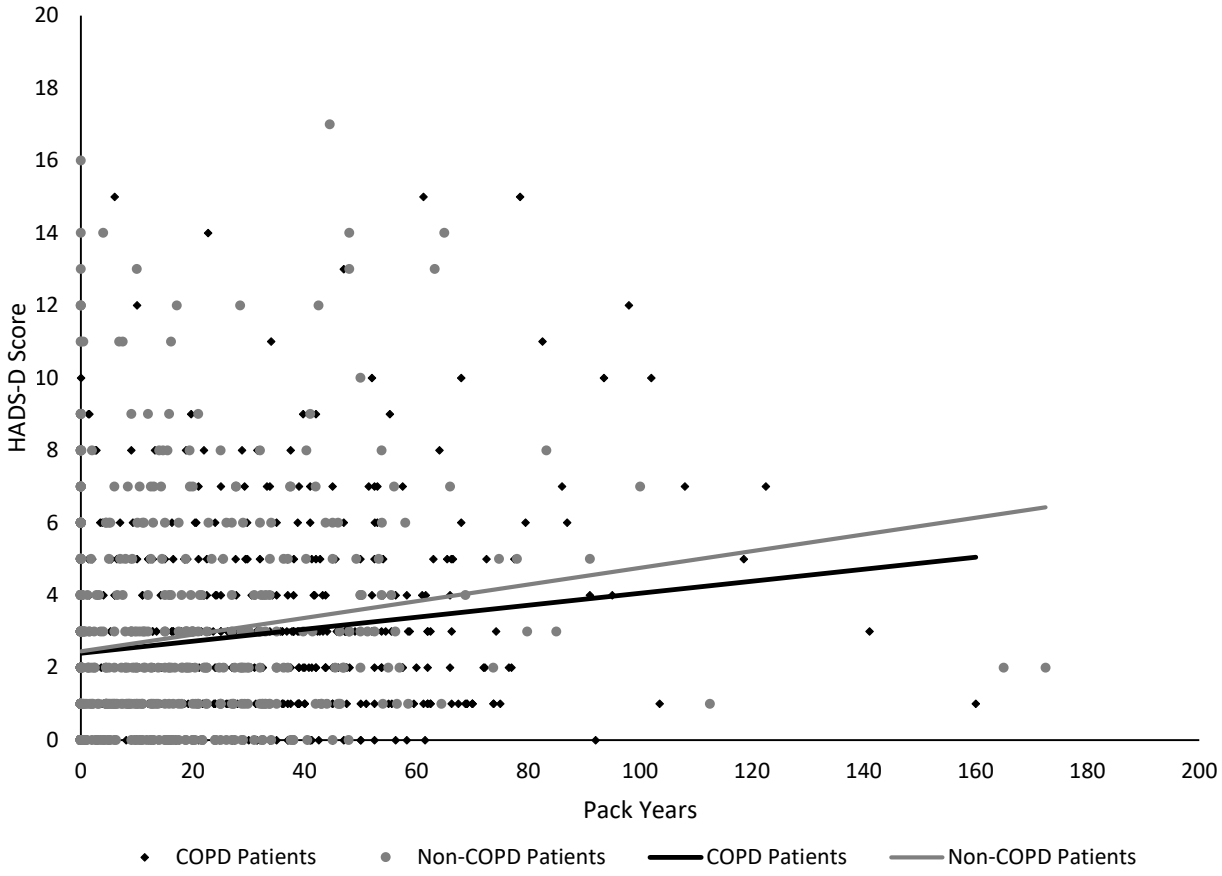
Figure 1, illustrating the relationships between smoking volume (pack years) and anxiety (left) and depression (right)

Figure 2, illustrating the relationships between all physical activity and anxiety (left) and depression (right)

Figure 3, illustrating the relationships between moderate physical activity and anxiety (left) and depression (right)

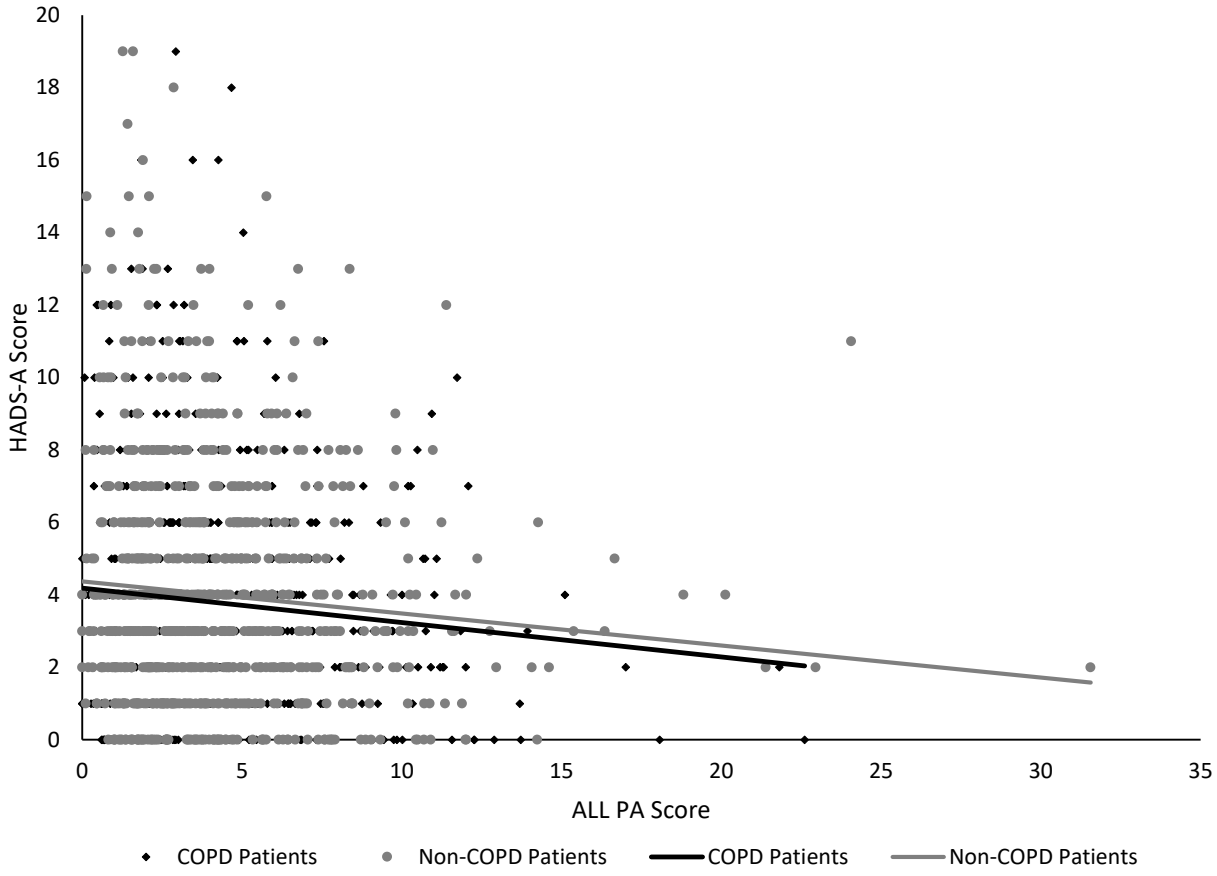
Figure 1, illustrating the relationships between smoking volume (pack years) and anxiety (left) and depression (right)

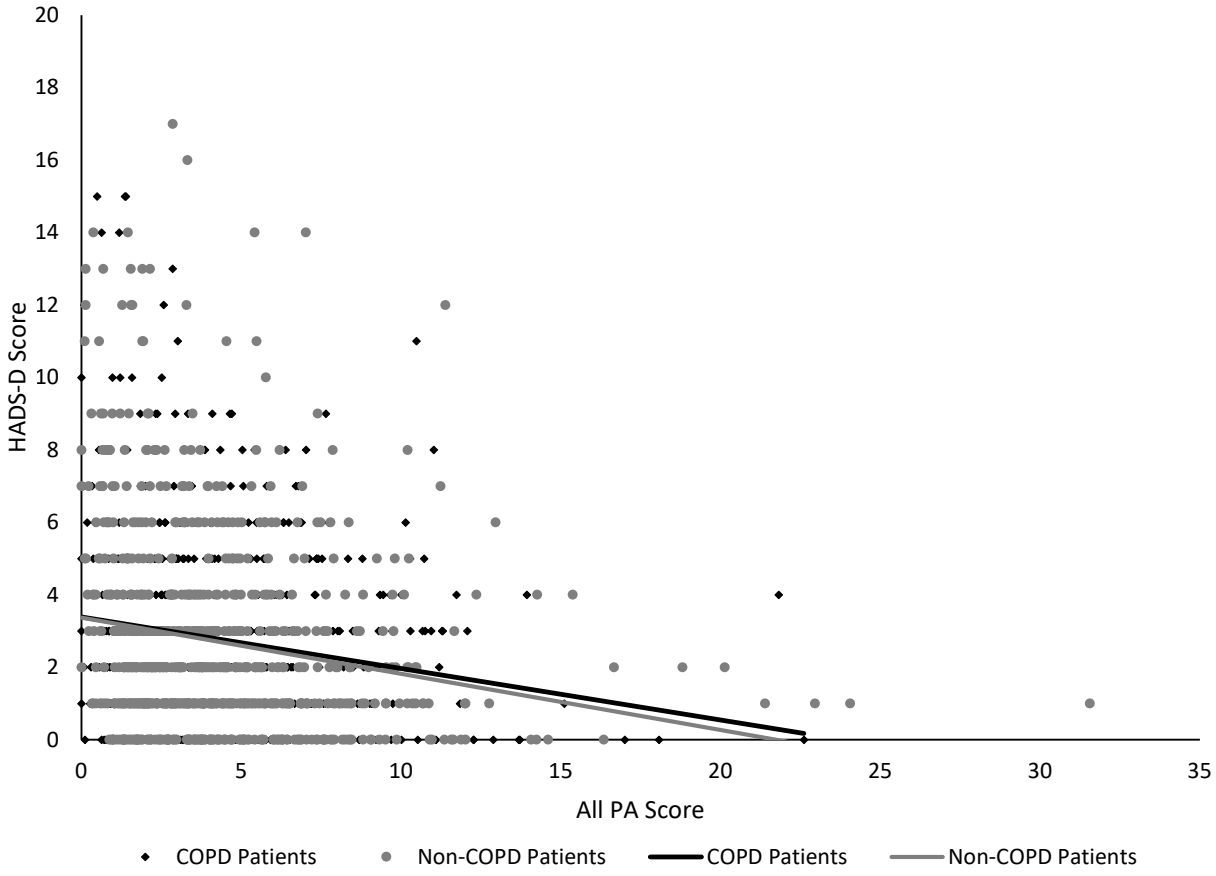




Note: Figures produced from raw, unadjusted data

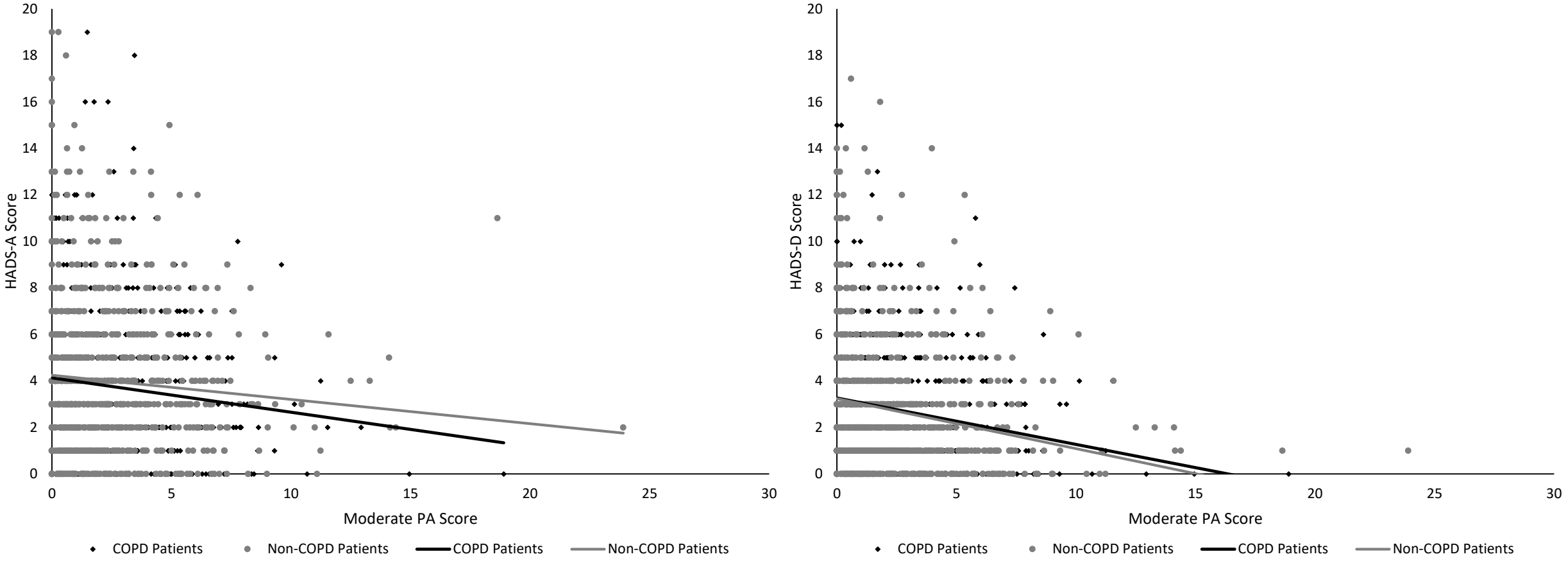
Figure 2, illustrating the relationships between all physical activity and anxiety (left) and depression (right)





Note: Figures produced from raw, unadjusted data

Figure 3, illustrating the relationships between moderate physical activity and anxiety (left) and depression (right)



Note: Figures produced from raw, unadjusted data

This is the first study to show significant and important relationships between high levels of psychological distress (symptoms of depression and anxiety) and both higher smoking habits and lower physical activity levels in individuals with and at risk for COPD. This cohort of COPD patients is extremely well characterised in terms of clinical characteristics, as well as being one of the largest cohorts of COPD patients.

The clinical relevance of this paper is that clinicians will be able to screen for depression and anxiety symptoms, in order to inform likelihood of uptake and maintenance of positive health behaviours such as physical activity which are key cornerstones of COPD treatment and management plans.