

Research Article

DEPRESSIVE AND ANXIETY DISORDERS AND THE ASSOCIATION WITH OBESITY, PHYSICAL, AND SOCIAL ACTIVITIES

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Objective: *There is evidence of more obesity among persons with depressive and depressive and anxiety disorders. However, the nature and the underlying mechanisms of the association are still unclear. This study examines the association between depressive and anxiety disorders and obesity, physical activity, and social activity, and examines whether social and physical activity are potential influencing factors in the association between depressive and anxiety disorders and obesity.*

Method: *Cross-sectional data were used from the Netherlands Study of Depression and Anxiety. A total of 1,854 women and 955 men aged 18–65 years were recruited from the community, general practices, and specialized mental health care. Depressive and anxiety disorders were determined with the Composite International Diagnostic Interview. Body mass index (BMI < 30 kg/m²) was used to determine obesity. Physical and social activities were measured by self-report.*

Results: *The odds of obesity adjusted for covariates was significantly higher among those with a current pure Major Depressive Disorder (MDD; odds ratio [OR] OR:1.43; 95% CI:1.07–1.92) compared to controls. Physical activity and social activities were lower among persons with depressive and anxiety disorders compared to controls. The association between MDD and obesity was influenced by social and physical activities. Conclusion: This study confirmed a link between depressive disorders and obesity that was influenced by lower social and physical activities among the depressed. Depression and Anxiety 27:1057–1065, 2010. © 2010 Wiley-Liss, Inc.*

Key words: *depression; anxiety; obesity; physical activity; social activity*

INTRODUCTION

According to the World Health Organization, depressive and anxiety disorders and obesity are among the leading public health concerns globally,^[1] causing disability and a huge economic burden.^[2–9] Depressive and anxiety disorders are the most common mental disorders, with lifetime prevalences varying across countries between 4.8 and 31.0% for anxiety disorders, and between 3.3 and 21.0% for depressive disorders.^[10] The obesity (body mass index (BMI) > 30 kg/m²) prevalence in Europe varies from 7.0 to 27.0% and has reached up to 32.2% in the United States.^[11]

Recent meta-analyses on both cross-sectional and prospective studies give evidence for an association between depression and obesity^[12,13] and for an association between anxiety and obesity.^[14] Yet to our

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knowledge, has the joint effect of depressive and anxiety disorders on obesity status not been examined so far.

There is growing evidence that depressive and anxiety disorders share common health complications with obesity such as cardiovascular disease and type II diabetes mellitus, which increase the risk of premature death.^[15–19] These health complications could partly be explained by an unhealthy inactive lifestyle which is found to be more common among persons with depressive and anxiety disorders and among persons with obesity.^[20–26] Furthermore, there is evidence that the hypothalamic–pituitary–adrenocortical system, as well as the inflammatory system in both depressed and obese people is dysregulated,^[27–29] providing possible biological explanations for the association between depression and obesity.

Physical activity is suggested as a possible mediator in the association between depression and anxiety with obesity. However, there have only been few studies to date that have explicitly investigated the influence of physical activity on the association between depression and anxiety with obesity.^[30] Recent studies have found that the association between depressive and anxiety disorders with obesity did not disappear after adjusting for physical activity,^[31,32] suggesting that BMI is an independent predictor of depressive and anxiety disorders. Nevertheless, these studies did not explicitly investigate the extent of mediational effect by physical activity on the association between depressive and anxiety disorders with obesity.

In addition to physical activity, accumulating evidence suggests that a much broader range of leisure activities, including social activity, are associated with health benefits such as longevity and functioning.^[33–35] Low levels of social activation have also been associated with obesity.^[36–39] Previous studies have found that depressed persons are engaging less in various social activities.^[40,41] Whether social activity might also have a possible mediational effect in the depression/anxiety–obesity association that has not been examined so far.

In summary, previous research suggests that depression and anxiety might lead to obesity through the adoption of an inactive lifestyle. However because of evidence of a bi-directional association between depression and obesity, the opposite direction is also possible.^[13] Nevertheless, it is unclear so far which specific DSM-IV depressive and anxiety diagnoses are associated with BMI status. Therefore, we choose in the current study BMI as outcome measure and specific depressive and anxiety disorders as independent variables in order to help clarifying who is at risk.

The first aim of the present large-scale study is to investigate in a large sample whether depressive and anxiety disorders are independently associated with obesity. The second aim is to test whether depressive and anxiety disorders are associated with physical activity and social activity levels and whether these activities are possible mediating factors in the association

between depressive and anxiety disorders with obesity. Additionally, we were interested in whether obesity and lower activity levels lasted beyond recovery of depressive and anxiety disorders (scar effect) and examined both current and remitted anxiety and depressive disorders.

MATERIALS AND METHODS

SAMPLE

Data are from the Netherlands Study of Depression and Anxiety (NESDA), a multi-site naturalistic cohort study designed to examine the long-term course of depressive and anxiety disorders. An extensive description of the data collection procedures of NESDA has been reported elsewhere.^[42] The design is a longitudinal cohort study with a total of 2,981 respondents, 1,002 (33.6%) males and 1,979 (66.4%) females aged 18–65 years. A total of 1,701 (57.1%) subjects had a current (6-month recency) anxiety or depressive disorder, 627 (21.0%) subjects had a remitted (lifetime but not current) anxiety or depressive disorder and there were 652 (21.9%) controls without a lifetime depressive or anxiety disorder.

Recruitment of participants took place in three different regions in the Netherlands (Amsterdam, Leiden, and Groningen) between September 2004 and February 2007. Subjects were recruited from the general population, in general practices and in mental health organizations in order to retrieve a sample reflecting various developmental stages of psychopathology. There were uniform procedures for all participants regardless of the region or the recruitment setting. Exclusion criteria of the study were (1) a primary clinical diagnosis of a psychiatric disorder not subject of NESDA: psychotic disorder, obsessive compulsive disorder, or severe addiction disorder and (2) not being fluent in Dutch language. A written informed consent was obtained from all participants. The NESDA study protocol was approved centrally by the Ethical Review Committee of the VU University Medical Center and further by local review boards of each participating center. In our analyses, we used data of 2,809 subjects. A total of 172 persons had missing values on our main outcome variables (BMI, physical activity, and social activity) and had to be excluded.

MEASUREMENTS

All subjects completed a 4-hr assessment containing various physical and mental health aspects. For the current analyses, we used baseline interview and self-reported data of the NESDA study on mental health diagnoses, BMI, physical and social activity, and sociodemographics.

Depressive and anxiety disorders. The DSM-IV Composite International Diagnostic Interview (CIDI, WHO version 2.1) was used to measure depressive and anxiety disorders: major depressive disorder (MDD), dysthymia, generalized anxiety disorder (GAD), social phobia, panic disorder, and agoraphobia. This instrument has proven to be reliable and valid to assess depressive and anxiety disorders.^[43] All the participants were assessed by specially trained clinical research staff.

In our analyses, we used a 5-category indicator to determine depressive and anxiety disorder status classified as: healthy controls, remitted depressive or anxiety disorder (in lifetime but not present in past 6 months), depressive disorder only (in past 6 months), anxiety disorder only (in past 6 months) and comorbid depressive and anxiety disorder (in past 6 months). In order to examine the role of specific disorders we used a three-category indicator for each assessed disorder (MDD, dysthymia, GAD, social phobia, panic disorder, and agoraphobia) classified as: healthy controls, remitted disorder

(in lifetime but not present in the past 6 months) and current disorder (in the past 6 months).

BMI status. BMI was calculated as weight (kg) divided by height in meters squared (m^2). Weight and height were measured by a trained clinical research staff. BMI was classified into four categories according to the guidelines of the WHO expert committee: underweight ($BMI < 18.5 \text{ kg}/m^2$), normal weight ($BMI 18.5\text{--}24.9 \text{ kg}/m^2$), overweight ($BMI 25.0\text{--}29.9 \text{ kg}/m^2$), and obesity ($BMI \geq 30 \text{ kg}/m^2$).^[44] In our analyses, we used both the four category indicator (underweight, normal weight, overweight, and obesity) and a continuous indicator.

Physical activity status. Physical activity was measured with the International Physical Activity Questionnaire (IPAQ), which has proven to be a valid and reliable instrument to measure physical activity.^[45–48] This seven-item self-report questionnaire provides information on the respondents time spent on walking and on vigorous- and moderate physical activity during the last 7 days. The overall energy expenditure was expressed in Metabolic Equivalent Total (MET) units by calculating activity \times frequency of the activity \times MET intensity.^[45,49] The person had to be at least 10 min engaged in the activity for it to be calculated. In brief, the IPAQ calculations are: Walking MET-min/week = $3.3 \times \text{walking minutes} \times \text{walking days}$; Moderate MET-min/week = $4.0 \times \text{moderate-intensity activity minutes} \times \text{moderate days}$; Vigorous MET-min/week = $8.0 \times \text{vigorous-intensity activity minutes} \times \text{vigorous-intensity days}$. Total physical activity MET-min/week = sum of Walking + Moderate + Vigorous MET minutes. The total MET-min per week/1,000 were used as a continuous indicator for physical activity.

Social activity status. The visiting frequency of a total of four social activities were assessed by self-report, (1) cultural events (theater, cinema, or museum); (2) trips to nature or amusement parks or interesting buildings; (3) visiting a bar, restaurant, or dancing; and (4) attending an activity or meeting of a club or association. The frequency of attending a social activity was reported on a scale with the following answering categories: (1) almost never; (2) a couple of times a year; (3) every month; (4) a couple of times a month; (5) every week; and (6) a couple of times a week. A total score summarizing the answers on the four activities (range 4–24) was used as a continuous indicator.

Covariates. We considered the following basic demographics: gender, age (continuous), years of education (continuous). Additionally, we considered psychotropic medication (SSRI: no/yes, TCA: no/yes and other Psychotropic medication: no/yes) because of their association with weight gain.

Statistical analyses. Statistical analyses were conducted using SPSS 14.0 (Inc., Chicago, IL). We described BMI status, physical activity status, social activity status and covariates across depressive and anxiety status using χ^2 and ANOVA analyses. Multinomial logistic regression analyses adjusted for covariates were used to test the association between depressive and anxiety disorders and BMI status, whereas adjusted linear regression analyses tested differences in physical and social activities across depressive and anxiety disorder status.

For all the associations, two separate models were tested. The first one examined the association with a five-category indicator of depressive and anxiety status as classified in: healthy controls, remitted depressive and anxiety status, depressive disorder only, anxiety disorder only, and comorbid depressive and anxiety disorder (model 1). The second one examined the association with specific depressive and anxiety disorder status: MDD, dysthymia, GAD, social phobia, panic disorder, and agoraphobia. Each specific disorder was classified into three categories: no disorder, remitted disorder, and current disorder (model 2).

To test whether physical and social activities level act as possible mediating variables in the association between depression/anxiety and

BMI, the direct and indirect paths between depression/anxiety and BMI were estimated in LISREL 8.71.^[50] Using structural equation modeling (SEM) allowed us to account for the effect of several control variables (sex, age and years of education completed) in the model. The covariance matrices of the observed variables were calculated in R.^[51] As argued by Baron & Kenny,^[52] the mediational effect was tested by testing three sub hypotheses. First, the independent variable should significantly account for variability in the outcome variable. Second, the independent variable should significantly account for variability in the mediator variable. Third, the mediator variable should significantly account for variability in the outcome variable. When the indirect path (second and third steps) is included in the model, the coefficient of the regression of the outcome variable on the independent variable should be reduced significantly. When this coefficient becomes zero, full mediation can be said to occur. When the coefficient does not become zero, but is reduced significantly, partial mediation is said to occur.

RESULTS

The mean age of the 2,809 respondents was 41.8 years (SD : 13.0; range 18–65) and 66.0% were females. Of the total sample, 627 (22.3%) were healthy controls, 592 (21.1%) had a remitted depressive or anxiety disorder, 369 (13.1%) had a depressive disorder only, 515 (18.3%) had an anxiety disorder only, and 706 (25.1%) had a comorbid depressive and anxiety disorder. The mean BMI in the sample was 25.6 (SD : 5.0; range 14.7–58.3), 65 (2.3%) participants were underweight, 1,430 (50.9%) had normal weight, 850 (30.3%) were overweight, and 464 (16.5%) were obese. Respondents with current and remitted depressive and/or anxiety disorders in this sample were more often female, older, lower educated, had a higher BMI, and were less socially active than healthy controls (Table 1). We found significant negative correlations between BMI and social activity ($r = -0.19$, $P < .001$) and a borderline negative correlation between BMI and physical activity ($r = -0.04$, $P = .059$). Physical and social activities level were positively associated ($r = 0.09$, $P < .001$).

BMI AND PSYCHOPATHOLOGY

Adjusted multinomial logistic regression analyses examined whether the depressive and anxiety disorder status indicator was associated with underweight, overweight, and obesity (normal BMI as reference; Table 2). Having a current comorbid depressive and anxiety disorder ($OR = 1.40$; 95% CI : 1.02–1.91) was significantly associated with obesity. Also having current depressive disorder only showed increased—but non-significant - odds for obesity ($OR = 1.42$; 95% CI : 0.98–2.06). Having depressive or anxiety disorders was not significantly associated with the risk of being underweight or being overweight. After an additional adjustment for psychotropic medication, the association between having a current comorbid depressive and anxiety disorder and obesity ($OR = 1.28$; 95% CI : 0.91–1.82) was no longer significant.

TABLE 1. Description of demographics, BMI, and activity across depression and anxiety status groups (N = 2,809)^a

Value	N	%	Controls (N = 627)	Remitted (N = 592)	Depression only (N = 369)	Anxiety only (N = 515)	Comorbid anxiety and depression (N = 706)	P
<i>Demographics</i>								
Gender	1,854	66.0	69.6	69.9	64.5	66.6	67.7	.021
	955	34.0	38.9	30.4	35.5	33.4	32.3	
Age		41.8 (13.0)	40.1 (14.7)	44.4 (12.9)	40.6 (12.2)	41.7 (12.7)	41.1 (12.0)	<.001
Level of education	1,005	35.8	43.1	41.7	36.9	33.0	25.8	<.001
	1,631	58.1	53.6	53.4	57.7	60.8	64.2	
	179	6.2	3.3	4.9	5.4	6.2	10.1	
<i>BMI</i>								
Underweight (BMI < 18.5)	65	2.3	2.4	1.0	3.0	2.3	3.0	.001
Normal weight (BMI: 18.5–24.9)	1,430	50.9	54.1	48.6	50.1	54.4	47.9	
Overweight (BMI: 25–29.9)	850	30.3	30.1	35.0	29.5	28.9	27.8	
Obesity (BMI ≥ 30)	464	16.5	13.4	15.4	17.3	14.4	21.4	
<i>Activity</i>								
Physical activity ^b	Mean (SD)		4.0 (3.1)	3.8 (3.0)	3.4 (3.1)	3.7 (3.0)	3.5 (3.3)	.112
Social activity	Mean (SD)		10.7 (3.0)	10.3 (3.2)	9.5 (3.3)	9.9 (3.2)	8.6 (3.0)	<.001

^aBased on Pearson χ^2 analyses (unadjusted).

^bPhysical activity levels (total MET-min/week/1,000) are measured with IPAQ.

When testing specific depressive or anxiety diagnoses (model 2), only having a current MDD was significantly associated with obesity (OR = 1.43; 95% CI: 1.07–1.92). Remitted agoraphobia was significantly associated with the risk of underweight (OR = 4.44; 95% CI: 1.52–12.93) and current social phobia was significantly negatively associated with the risk of overweight (OR = 0.78; 95% CI: 0.62–1.00). After the additional adjustment for psychotropic medication, the association between current MDD and obesity decreased slightly (OR = 1.38; 95% CI: 1.02–1.86). The association between remitted agoraphobia and underweight increased slightly (OR = 4.47; 95% CI: 1.53–13.07). The association between current social phobia and overweight was no longer significant.

PHYSICAL AND SOCIAL ACTIVITIES AND PSYCHOPATHOLOGY

When testing the depressive and anxiety disorder status indicator in multivariable linear regression analysis (model 1), both current depressive disorder only ($\beta = -0.06$; standard error [SE]:1.66; $P < .01$) and current comorbid depressive and anxiety disorder ($\beta = -0.09$; SE:1.41; $P < .001$) were significantly associated with decreased physical activity compared to controls. Of the specific diagnoses (model 2), only having current Dysthymia was significantly associated with decreased physical activity ($\beta = -0.08$; SE: 1.76; $P < .001$).

As compared to controls, those with a current depressive disorder only ($\beta = -0.12$; SE: 0.19; $P < .001$), a current anxiety disorder only ($\beta = -0.08$; SE: 0.18; $P < .001$), and a current comorbid depressive and anxiety disorder ($\beta = -0.24$; SE: 0.17; $P < .001$) had decreased social activities. Of the specific diagnoses (model 2), having remitted MDD ($\beta = -0.05$; SE: 0.15; $P < .05$), current MDD ($\beta = -0.13$; SE: 0.14; $P < .001$), current dysthymia ($\beta = -1.10$; SE: 0.20; $P < .001$), and current social phobia ($\beta = -0.09$; SE: 0.15; $P < .001$) were all significantly associated with decreased social activities (Table 3).

INFLUENCING EFFECT OF PHYSICAL AND SOCIAL ACTIVITIES ON DEPRESSION-OBESITY ASSOCIATION

As we only observed a significant association between depressive—and not anxiety—disorder with obesity, we conducted mediational analyses focusing on the depression and obesity. Mediational analyses are preferred on continuous outcomes, so we used the continuous BMI variable in this analysis.^[53] Since psychopathology was associated with a non-significant-increased risk of underweight, which can dilute our association of interest, we excluded the small underweight group in these analyses.

First, the total effect of depression on BMI was calculated ($\beta = 0.06$; SE:0.18; $P < .001$). Second, we found a significant direct effect of depression on social activity ($\beta = -1.18$; SE:0.12; $P < .001$) and physical

TABLE 2. The association between mental disorders and underweight, overweight, and obesity^a

	Value	Normal versus underweight ^b			Normal versus overweight ^b			Normal versus obesity ^b		
		OR	95% CI	P	OR	95% CI	P	OR	95% CI	P
<i>Model 1: Mental disorders in general</i>										
Controls		Ref			Ref			Ref		
Remitted disorder		0.60	0.23–1.61	.313	1.18	0.91–1.55	.212	1.18	0.84–1.66	.584
Current depressive disorder only		1.41	0.62–3.21	.408	1.05	0.77–1.43	.772	1.42	0.98–2.06	.131
Current anxiety disorder only		1.07	0.48–2.36	.875	0.89	0.67–1.18	.409	0.93	0.64–1.32	.654
Current comorbid disorder		1.31	0.64–2.66	.458	0.94	0.72–1.22	.626	1.40	1.02–1.91	.024
<i>Model 2: Specific disorders</i>										
Major depressive disorder	No	Ref			Ref			Ref		
	Remitted	0.57	0.25–1.33	.194	1.21	0.95–1.53	.119	1.12	0.82–1.53	.474
	Current	1.06	0.56–2.02	.854	1.12	0.88–1.41	.365	1.44	1.07–1.92	.015
Dysthymia	No	Ref			Ref			Ref		
	Remitted	1.47	0.56–3.83	.431	1.09	0.81–1.47	.551	1.28	0.91–1.82	.161
	Current	1.52	0.67–3.42	.315	0.99	0.70–1.38	.938	1.34	0.93–1.93	.121
Generalized anxiety disorder	No	Ref			Ref			Ref		
	Remitted	0.74	0.24–2.26	.600	0.90	0.66–1.21	.479	0.88	0.61–1.28	.496
	Current	1.14	0.57–2.30	.713	0.95	0.72–1.26	.718	0.91	0.66–1.26	.569
Social phobia	No	Ref			Ref			Ref		
	Remitted	1.61	0.58–4.44	.358	1.03	0.74–1.44	.843	1.07	0.71–1.61	.763
	Current	1.21	0.65–2.25	.558	0.78	0.62–1.00	.049	1.05	0.79–1.38	.760
Panic disorder	No	Ref			Ref			Ref		
	Remitted	0.31	0.04–2.36	.255	0.99	0.67–1.43	.912	1.28	0.83–1.97	.261
	Current	1.02	0.52–2.01	.954	0.98	0.77–1.25	.625	1.03	0.77–1.37	.870
Agoraphobia	No	Ref			Ref			Ref		
	Remitted	4.44	1.52–12.93	.006	1.15	0.69–1.90	.959	1.40	0.78–2.51	.262
	Current	2.07	0.85–5.06	.111	0.86	0.58–1.27	.875	1.09	0.71–1.69	.695

^aBased on multinomial logistic regression analyses, adjusted for gender, age, and years of education.

^bNormal BMI (18.5–24.9) as reference.

P ≤ 0.05 = significant.

activity ($\beta = -0.08$; SE: 1.01; $P < .001$). The indirect effect of depression on BMI mediated by both social and physical activities was significant ($\beta = 0.02$; SE: 0.04; $P < .001$). Also, the effects of social activity ($\beta = -0.11$; SE: 0.03; $P < .001$) and physical activity ($\beta = -0.06$; SE: 0.01; $P < .001$) on BMI were significant. When testing the full-mediation model (Fig. 1), the direct effect of depression on BMI became non-significant when both social and physical activities were incorporated in the model ($\beta = 0.03$; SE: 0.19; $P = .06$). This means that the association between depression and BMI seems to be mediated by social and physical activities. These results remained non-significant after the additional adjustment for psychotropic medication ($\beta = 0.06$; $P = .057$).

Additionally, we incorporated both physical and social activities separately in the model in order to calculate the individual mediating effects. We found that the indirect effect of depression on BMI mediated separately by physical and social activities, were both significant ($\beta = 0.01$; SE: 0.02; $P = .002$) and ($\beta = 0.02$; SE: 0.04; $P < .001$ respectively). These results show that both physical and social activities independently partially mediate the association between depression and BMI, but social activity had the largest mediational effect. These results remained significant after the additional

adjustment for psychotropic medication ($\beta = 0.02$; $P < .001$) and ($\beta = 0.01$; $P = .013$), respectively.

DISCUSSION

This large sample size study showed significantly more obesity among persons with a current MDD compared to healthy controls. Such an effect was not observed for persons with an anxiety disorder only. Remitted agoraphobia was associated with being underweight. There are indications that the link between depression and obesity was partially mediated by lower levels of social and physical activities.

The results of the present study are in line with a recent meta-analysis of cross-sectional studies in finding a link between obesity and depression.^[12] However the results of the meta-analysis showed an 18% increased chance of being obese among depressed persons compared to controls, whereas the present study showed an increased chance of 40% of being obese among depressed persons compared to controls. Our slightly higher odds can be due to the fact that our study focused on DSM-IV classified disorders and not on symptom definitions of depression as used in many prior studies. According to our results, having a remitted MDD was not linked to obesity. Although

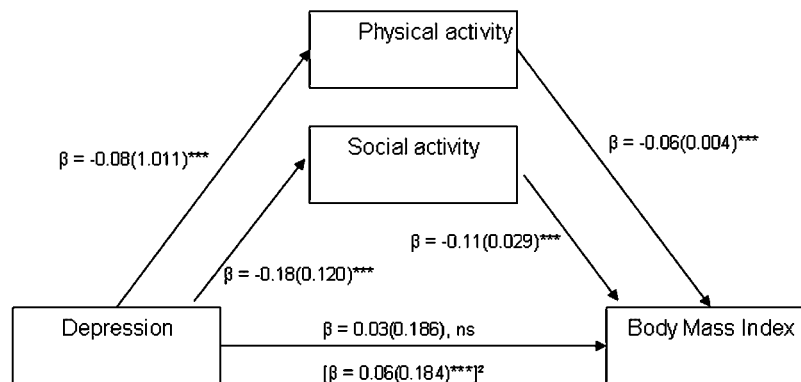
TABLE 3. The association between mental disorders and both physical activity and social activity^a

	Value	Physical activity ^b			Social activity		
		β (stan.)	SE	<i>P</i>	β (stan.)	SE	<i>P</i>
<i>Model 1 mental disorders in general</i>							
Controls		Ref			Ref		
Remitted disorder		0.01	1.46	.716	-0.03	0.17	.116
Current depressive disorder only		-0.06	1.66	.008	-0.12	0.19	<.001
Current anxiety disorder only		-0.02	1.51	.311	-0.08	0.18	<.001
Current co-morbid disorder		-0.09	1.41	<.001	-0.24	0.17	<.001
<i>Model 2 (specific disorders)</i>							
Major depressive disorder	No	Ref.			Ref		
	Remitted	0.02	1.30	.285	-0.05	0.15	.021
	Current	-0.03	1.26	.239	-0.13	0.14	<.001
Dysthymia	No	Ref			Ref		
	Remitted	0.01	1.59	.685	-0.03	0.18	.066
	Current	-0.08	1.76	<.001	-1.10	0.20	<.001
Generalized anxiety disorder	No	Ref			Ref		
	Remitted	0.02	1.64	.278	0.03	0.19	.159
	Current	-0.01	1.47	.633	-0.03	0.17	.183
Social phobia	No	Ref			Ref		
	Remitted	-0.04	1.82	.075	-0.01	0.21	.644
	Current	-0.03	1.26	.208	-0.09	0.15	<.001
Panic disorder	No	Ref			Ref		
	Remitted	-0.01	1.97	.646	0.01	0.22	.590
	Current	0.00	1.29	.856	-0.02	0.15	.263
Agoraphobia	No	Ref			Ref		
	Remitted	0.00	2.67	.816	-0.03	0.31	.051
	Current	0.01	2.04	.741	-0.03	0.24	.163

^aBased on multivariate linear regression analyses, adjusted for gender, age, and years of education.

^bGeneral physical activity is SQRT transformed.

P ≤ 0.05 = significant.



¹ with SE of the regression coefficients in parentheses.

²[Total effect of depression on BMI]

* *p* < 0.05, ** *p* < 0.01, *** *p* < 0.001, ns (not significant). Sex, age and years of education completed were controlled in the equation.

Figure 1. Effect of depression on body mass index, mediated by social and physical activity.

longitudinal research is needed to confirm this, it might be a possible indication that the link with obesity does not last beyond recovery of MDD.

A recent meta-analysis by Garipey et al.^[14] found evidence for a link between anxiety and obesity, which was not entirely inconsistent with our findings.

Although we did find a small trend for increased obesity prevalence among persons with comorbid depression and anxiety, we did not confirm this for persons with anxiety disorder only. The prior meta-analysis result of more obesity among persons with anxiety could be driven by underlying depression, as

depression and anxiety are highly comorbid conditions and are not always adequately distinguished. We found a significant association between having remitted agoraphobia and being underweight; however, as there were only 65 persons with underweight of whom seven had agoraphobia, it is unclear what the clinical significance of this finding is. More research in larger samples is needed to confirm such a link.

In line with our findings, an inverse relationship between physical activity and depression has been reported in previous studies.^[25] Moreover, there is growing evidence that engaging in physical activity might even reduce the risk for mental disorders.^[21] Nevertheless, our results differ from a study examining the association between DSM-IV depressive diagnosis and physical activity, we only found a significant association for dystymia and they found only a significant association for MDD.^[54] Inconsistent with previous studies we did not find an association between pure anxiety disorders and physical activity.^[20,21,54] One would expect an association because of previous evidence of the beneficial effect of physical activity on the reduction of anxiety disorders.^[5,56] The usage of unreliable measures for physical activity might explain the difference between these studies, a recent study using objective assessment of physical activity confirmed an association between psychopathology and physical inactivity.^[57] As expected and in line with previous research, we found lower levels of social activity among people with depressive and anxiety disorders.^[40,41,58] Furthermore, our results showed a strong inverse association between social activity and social phobia which is in concordance with the DSM-IV criteria for Social phobia: people with this disorder tend to avoid social situations and are therefore less socially active.^[59] In addition, we found that persons with remitted MDD had lower levels of social activity, a so-called scar effect. Because low social activity found to be associated with depression, it highlights the importance of increasing social activity in relapse prevention programs.

We found evidence in support of both physical and social activities as possible mediators of the association between depression and obesity. In order to be sure to examine physical and social activities as individual factors and not as components of the severity of the depression, we additionally controlled our analyses for severity of depression, which did not change our results. Previous studies have reported an association between depression and obesity that was independent of physical activity,^[31,32] whereas this study gives evidence for an effect of physical activity on the association between depression and obesity. Since emerging data suggest that physical activity is only one component of an active and healthy lifestyle, our findings extend previous research by confirming social activity as a partially mediating factor in the association between depression and obesity. Indeed if persons with depression are less likely to participate in social

activities outside the home then they are likely to be socially more isolated which is in turn associated with obesity.^[39] It has been previously hypothesized that obese persons are more socially isolated because of their body weight is reducing the ability of activity on one hand and because of the tendency to isolate themselves on the other hand which leads to extensive food consumption for consolation.^[36] In the light of the current findings, it might be interesting to examine whether behavioral activation interventions, such as activity scheduling, an effective intervention against depression in which patients are motivated to increase their daily pleasant activities, are also beneficial for the treatment and prevention of obesity.^[60] Nevertheless, this study considered only one of the many possible pathways that help to explain the link between depression and obesity. For instance, pathophysiological factors, such as HPA-axis disturbance and inflammatory markers, are also possible mediators and were not considered in this study.^[27–29]

Limitations of the study include the cross-sectional design that makes it impossible to determine any causal pathways and mediational effects. According to Baron and Kenny,^[52] mediational effects can only be calculated when the timing of the events is entirely clear. Although we have based on previous literature reason to assume that depression leads to obesity through reduced physical and social activities, the opposite direction is also possible. This highlights the importance of interpreting these results with caution and we suggest future longitudinal research to investigate causal pathways and mediational effects. Physical activity and social activities were self-rated, which can lead to possible bias. In general, people tend to overestimate their activity level, although some research indicates that people with psychopathology may even be more realistic in their reporting.^[61] This might be an explanation for the lower levels in these groups compared to healthy controls.^[62] The use of more objective measures, such as assessment by accelerometry, is suggested for future research.^[63] After the additional adjustment for psychotropic medication our results decreased slightly, however these findings are difficult to interpret. As persons with severe depression are also the ones using psychotropic medication, it is hard to differentiate between the effect of psychotropic medication use and the effect of severity of depression. There is evidence for a dose-response effect of depression on obesity.^[20] Thus, in our opinion, by adjusting for psychotropic medication there is a risk of over adjustment. Longitudinal research in large samples is needed to examine the effect of psychotropic medication on the association between depression and obesity. A strong point of this study is that depressive and anxiety disorders were assessed with a well-validated diagnostic instrument. Another strong point of the study is the large and representative sample. Furthermore, obesity measures were obtained by trained research staff, which makes these data more

reliable than those of studies using self-reported data.^[64] This study extended to most previous work because it gives insight into the several characteristics of the depressive and/or anxiety disorder, such as the specific diagnosis and whether the diagnosis is current or remitted.

CONCLUSIONS

These findings highlight the importance of physical and social activities as influencing factors in the link between depression and obesity. Although further clarification of this link would require longitudinal research designs, the findings suggest important directions for future research and interventions in reducing the massive disease burden of both depression and obesity.

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