Associations between lifestyle and depressed mood: Longitudinal results from the Maastricht Aging Study

Associations Between Lifestyle and Depressed Mood: Longitudinal Results From the Maastricht Aging Study

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Objectives. We examined whether healthy lifestyles are associated with absence of depressed mood.

Methods. A sample of 1169 adult participants in the Maastricht Aging Study provided baseline and 6-year follow-up data on smoking, alcohol use, physical exercise, body mass index, and mood. We examined associations between lifestyles and depressed mood using longitudinal analyses controlling for baseline depressive symptoms and covariates.

Results. Reports of excessive alcohol use at baseline predicted depressed mood at follow-up (relative risk [RR] = 2.48; 95% confidence interval [CI] = 1.08, 5.69), and reports of more than 30 minutes of physical exercise per day at baseline were associated with an absence of depressed mood at follow-up (RR = 0.52; 95% CI = 0.29, 0.92). Reports of being engaged in physical exercise throughout the 6-year follow-up period were also associated with absence of depressed mood (RR = 0.56; 95% CI = 0.34, 0.93).

Conclusions. In this relatively healthy population sample, certain lifestyles either predicted or protected against depressed mood. Adopting or maintaining healthy lifestyles might be a starting point in preventing or treating depressed mood over time. (*Am J Public Health.* 2006;96:887–894. doi:10.2105/AJPH.2004.053199)

Depressed mood is presumed to be caused by a variety of physical, psychological, and socioenvironmental factors.[1] For example, unhealthy lifestyles such as smoking, excessive alcohol use, low levels of physical exercise, or being overweight or obese may provoke chronic diseases[2,3] or worsen one's health status over time.[4] Chronic diseases frequently coincide with increased symptoms of depression,[5] and feelings of depression may in turn result in unhealthy lifestyles.[6] Potentially intensifying this "downward spiral," unhealthy lifestyles might elicit or exacerbate feelings of depression,[7,8] and depression may subsequently provoke or worsen the consequences associated with chronic diseases.[9,10] However, it is not unequivocally clear how unhealthy lifestyles and the emergence of depressed mood (i.e., a clinically relevant level of depressive symptoms[11]) are associated over time.

Although research has consistently established that there is a cross-sectional association between smoking and depressed mood,[12–14] little evidence is available regarding whether there is a longitudinal association, that is, whether smoking precedes or follows depressed mood. It has been shown that, in general, heavy alcohol use is associated with depressed mood.[15,16] Moreover, depressed mood is more often secondary to alcoholism than primary (i.e., clinicians more often treat individuals with alcoholism who have also developed depressed mood as a secondary reason for treatment than vice versa).[15] Physical activity seems to help counteract prevalent depressive symptoms and protect against subsequent depression, but longitudinal studies are necessary to further unravel this association.[17,18] The relation between being overweight or obese and being depressed is controversial; different studies have revealed negative, positive, and no associations between these conditions.[19–22]

If healthy lifestyles are associated with the absence of depressed mood or protect against the emergence of depressed mood, this common and debilitating condition might be prevented or treated in the future through promoting healthy lifestyles. We sought to determine whether healthy lifestyles are associated, over time, with absence of depressed mood in the general population.

METHODS

Design and Study Population

We used data from the longitudinal Maastricht Aging Study, an ongoing investigation examining determinants of normal cognitive aging. Questionnaires were sent to 3449 individuals, aged 24 to 81 years, who were free of medical conditions that interfered with their normal cognitive functioning at their entry into the study. This population was drawn from the Registration Network Family Practices,[23,24] a primary care research sampling frame consisting of 9919 individuals whose native language is Dutch. Our randomly recruited sample was stratified according to general ability level (defined as level of occupational achievement, including degree of complexity associated with professional occupations and knowledge and experience required[25]); women and older individuals were oversampled to ensure adequate representation of these groups in follow-up measurements.

Between 1993 and 1995 (baseline), 1823 respondents returned the questionnaire and underwent cognitive and physical examinations.[26] Six years after completing their baseline assessments, these 1823 participants were invited to take part in follow-up examinations. A total of 294 respondents refused further participation, 116 had died, and 37 had been lost to follow-up; thus, 1376 participants underwent reassessments. Ultimately, 1169 (33.9%) of the 3449 respondents were included in our study sample (207 respondents were lost to subsequent analyses owing to incomplete data on relevant variables at baseline or follow-up).

Measures

Baseline depressive symptoms were assessed with the self-report Symptom Checklist 90 Depression Scale.[27,28] The 16 items on this instrument are rated in 5 categories ranging

from no complaint (1) to maximal complaints (5). Scores can range from 16 to 80, with higher scores indicating a higher number of depressive symptoms. At follow-up, we used the self-report Center for Epidemiologic Studies Depression Scale (CES-D),[29] an instrument that has demonstrated good psychometric qualities in epidemiological studies involving older populations.[30] The CES-D's 20 items are rated in 4 categories ranging from no complaint (0) to maximal complaints (3). Scores can range from 0 to 60, again with higher scores indicating a higher number of depressive symptoms. We used a CES-D threshold score of 16 or above in screening for depressed mood.[29] Strong correlations between these 2 depression instruments have been found,[31] and the predictive validity of both scales has been reported elsewhere.[32]

On the basis of respondents' reports of their current and former smoking behavior, they were grouped into the following categories at baseline and follow-up: current smoker (the reference category), former smoker, and never smoker. Transitions in smoking behavior over time were categorized as (1) respondent still does not smoke, (2) respondent quit smoking, (3) respondent initiated smoking, and (4) respondent still smokes (reference category).

Mean alcohol consumption at baseline and follow-up was calculated according to participants' reports of the number of glasses of alcohol (representing approximately 10 g of alcohol in conformance with the unit of alcohol system) they drank per day on average (more than 10 glasses, between 7 and 10 glasses, between 3 and 6 glasses, 1 or 2 glasses, none) and the average number of days per week they consumed alcohol (every day, 5 or 6 days, 3 or 4 days, 1 or 2 days, less than 1 day). These measures were used to group participants into the following categories: nondrinkers (the reference category), those consuming up to 2 drinks per day on average, and those consuming 3 or more drinks per day on average (excessive alcohol use). Transitions in alcohol use over time were categorized as (1) respondent still drinks alcohol, (2) respondent initiated alcohol use, (3) respondent quit drinking alcohol, and (4) respondent still does not drink alcohol (reference category).

Mean numbers of minutes spent daily on physical exercise at baseline and follow-up were computed on the basis of the number of hours participants reported spending each week, on average, engaging in light activities such as ball sports, aerobic exercise, walking, and biking. These measures were used to group participants into the following categories: those not engaging in physical exercise (the reference category), those engaging in physical exercise for up to 30 minutes per day on average, and those engaging in physical exercise for more than 30 minutes per day on average. Transitions in physical exercise over time were categorized as (1) respondent still engages in physical exercise, (2) respondent initiated physical exercise, (3) respondent discontinued physical exercise, and (4) respondent still does not engage in physical exercise (reference category).

Members of the study staff assessed respondents' body weight and height at baseline and follow-up. We used body mass index (weight in kilograms divided by height in meters squared) cutoff scores of 27.8 or above for men and 27.3 or above for women to distinguish between respondents who were (at least) overweight (the reference category) and those who were not.[33] These values corresponded with weights that were roughly 20% or more above the desired weights listed in the 1983 Metropolitan Life Insurance Company tables. Transitions in overweight status over time were categorized as (1) respondent is still not overweight, (2) respondent is no longer overweight, (3) respondent became overweight, and (4) respondent is still overweight (reference category).

Previous research has shown that age, gender, marital status, educational level, ability to engage in instrumental activities of daily living (IADLs), and chronic disease are associated with both lifestyle[34–36] and depression.[10,37–39] We included these variables in our analyses as covariates. Data on marital status, age, gender, and educational level were obtained from the questionnaire completed by the respondents. Marital status was categorized as widowed, not married or no longer married, and married or living with a partner. Educational level was categorized as low (primary education at most), intermediate (junior vocational training), or high (senior vocational or academic training).

The questionnaire asked respondents to indicate whether they needed assistance in the following IADLs as a result of their physical condition: grocery shopping, housekeeping, preparing meals, maintaining personal hygiene, and getting dressed. If respondents answered no on these questions, their IADL status was not considered to be impaired. If they responded yes to 1 or more of these items, their IADL status was considered impaired. Finally, in an interview conducted by a trained research assistant, respondents were given the opportunity to indicate whether a medical doctor had ever diagnosed them with 1 or more of 37 chronic diseases.

Statistical Analyses

After comparing individuals who did not take part in the study or were lost to follow-up with study participants (using t tests and χ^2 analyses), analyzing the characteristics of the sample at baseline, and comparing study variables at baseline and follow-up, we examined associations between sociodemographic variables and baseline lifestyle domains and follow-up depressive symptoms. In addition, we examined associations between transitions in lifestyle domains and depressed mood at follow-up. We used cross-sectional and longitudinal techniques in our analyses, specifically paired-samples t tests, χ^2 analyses, and McNemar tests; analyses of variance; and multivariate logistic regression models in which transitions in the various lifestyle domains were independent variables and follow-up depressed mood was the outcome variable. SPSS software (SPSS Inc, Chicago, Ill) was used in analyzing the data. The unhealthy lifestyle components served as reference categories, and longitudinal analyses were adjusted for baseline depressive symptoms and covariates.

RESULTS

As can be seen in Table 1, attrition analyses at baseline demonstrated that the 2280 individuals who either were lost to follow-up (n=654) or did not take part in the study (n=1626) were significantly older (mean=55.1 years, SD=17.6) than the 1169 study

TABLE 1—Baseline Characteristics of Sample Participants and Comparisons on Key Variables at Baseline and Follow-Up: Maastricht Aging Study

	Nonrespondent or Lost to Follow-Up (n = 2280[a])	Sample (n = 1169)	
		Baseline[b]	Follow-Up[c]
Age group, y, %			
24-44	32.2	41.9***	...
45-64	32.3	40.7	...
65-81	35.5	17.4	...
Mean age (continuous), y (SD)	55.1 (17.6)	48.9 (14.7)***	...
Gender, %			
Male	44.2	52.4***	...
Female	55.8	47.6	...
Marital status, %			
Married/living together	74.2	81.3***	...
Not married/no longer married	13.5	13.7	...
Widowed	12.3	5.0	...
Education level, %[d]			
High	21.6	28.8***	...
Intermediate	26.8	34.0	...
Low	51.6	37.2	...
IADL status, %			
Not impaired	79.9	92.6***	...
Impaired	20.9	7.4	...
No. of chronic diseases, %			
None	23.6	33.4***	...
1	27.3	33.8	...
2 or more	49.1	32.8	...
Mean no. of chronic diseases (continuous) (SD)	1.9 (1.8)	1.3 (1.3)***	...
Smoking status, %			
Never smoker	34.4	35.0	37.6***
Former smoker	36.6	38.3	40.4
Current smoker	29.0	26.7	22.0
Average daily alcohol intake, %			
None	24.0	13.8***	15.5*
Up to 2 drinks	68.9	79.4	76.2
3 or more drinks	7.1	6.8	8.3
Mean no. of drinks per week (continuous) (SD)	6.1 (8.9)	6.1 (9.5)	6.2 (8.9)
Average amount of time spent daily on physical exercise, %			
More than 30 min	15.6	22.2***	12.1***
Up to 30 min	23.3	28.4	25.1
None	61.1	49.4	62.8
Mean no. of minutes of physical exercise per day (continuous) (SD)	13.6 (27.3)	18.2 (28.3)***	10.6 (20.5)***
Overweight, %			
No	60.2	67.1**	60.4***
Yes	39.8	32.9	39.6
Mean body mass index (continuous) (SD)	27.1 (4.4)	26.5 (4.1)**	27.0 (4.2)***

Continued

respondents (mean=48.9 years, SD=14.7). In addition, they were more likely to be female (55.8% vs 47.6%) or widowed (12.3% vs 5.0%), to be at low levels of education (51.6% vs 37.2%), to report impairments in IADLs (20.9% vs 7.4%), and to be overweight (39.8% vs 32.9%). Finally, they reported more chronic diseases (mean=1.9, SD=1.8, and mean=1.3, SD=1.3, respectively), fewer minutes of physical activity per day (mean=13.6, SD=27.3, and mean=18.2, SD=28.3, respectively), and more symptoms of depression (mean=22.0, SD=7.9, and mean=20.5, SD=6.1, respectively).

Table 1 also presents data on lifestyle at follow-up. Between baseline and follow-up, the percentage of respondents who reported smoking decreased significantly (from 26.7% to 22.0%). The percentage of respondents who reported not drinking alcohol at all increased significantly during this period (from 13.8% to 15.5%; Table 1), as did the percentage reporting that they consumed 3 or more drinks per day on average (from 6.8% to 8.3%).

The percentage of respondents who reported not engaging in physical exercise increased significantly from 49.4% at baseline to 62.8% at follow-up. In addition, average number of minutes spent daily on physical exercise decreased significantly from 18.2 (SD=28.3) at baseline to 10.6 (SD=20.5) at follow-up. Not only did the average body mass index in the sample exhibit a significant increase from 26.5 kg/m^2 (SD=4.1) to 27.0 kg/m^2 (SD=4.2) between baseline and follow-up, the percentage of overweight respondents also increased significantly (from 32.9% at baseline to 39.6% at follow-up). Finally, 14.0% of the respondents had a score of 16 or above (the threshold score for depressed mood) on the CES-D Scale at follow-up (Table 1).

Results of univariate longitudinal analyses focusing on follow-up depressive symptoms, stratified according to baseline sociodemographic variables and lifestyle domains, are shown in Table 2. Respondents aged 65 through 81 years had higher follow-up mean depression scores than respondents in the other age categories. Also, women had significantly higher mean depression scores at follow-up than men, and respondents at low

TABLE 1—*Continued*

Depressive symptomatology			
Mean Symptom Checklist 90 score (continuous) (SD)	22.0 (7.9)	20.5 (6.1)***	...
Mean CES-D score (continuous) (SD)	...	...	7.9 (6.6)
CES-D score < 16, %	...	...	86.0
CES-D score ≥ 16, %	...	...	14.0

Note. IADL = instrumental activity of daily living; CES-D = Center for Epidemiologic Studies Depression Scale. Continuous variables were compared via paired samples *t* tests and univariate analyses of variance; subcategories were compared via χ^2 analyses; and changes in lifestyle categories between baseline and follow-up were tested with McNemar tests for paired observations.
[a]Nonresponse and loss to follow-up numbers varied from 2280 for sociodemographic characteristics, smoking behavior, alcohol intake, physical exercise, and Symptom Checklist 90 Depression Scale score to 654 for body mass index and number of chronic diseases.
[b]Significance values refer to comparisons with nonrespondents or individuals lost to follow-up.
[c]Significance values refer to differences from baseline.
[d]Educational level was categorized as low (primary education at most), intermediate (junior vocational training), or high (senior vocational or academic training).
*P < .05; **P < .01; ***P < .001.

education levels had higher follow-up depression scores than respondents at intermediate or high education levels.

In addition, respondents with impairments in IADLs at baseline had higher follow-up mean depression scores than respondents with no IADL impairments. Respondents reporting 2 or more chronic diseases at baseline had higher follow-up depression scores than respondents reporting no chronic diseases or no more than 1 chronic disease, and those who reported not engaging in physical exercise at baseline had higher follow-up scores than those in the other physical activity groups. Finally, respondents who were overweight at baseline had higher follow-up mean depression scores than respondents who were not overweight at baseline (Table 2).

Post hoc interaction analyses revealed that neither gender nor age had a modifying effect on the associations between the baseline lifestyle domains assessed and follow-up depressive symptoms (data not shown). Hence, analyses were not carried out separately for women and men or for different age groups.

Table 3 shows relative risks (RRs) and 95% confidence intervals (CIs) derived from longitudinal multivariate logistic regression models with baseline lifestyle domains as determinants of follow-up depressed mood. In comparison with respondents who reported no alcohol use at baseline, those who reported excessive alcohol use at baseline were roughly 2.5 times as likely to be depressed at follow-up (RR=2.48; 95% CI=1.08, 5.69). Also, each glass of alcohol consumed on average per day at baseline was associated with a 17% increased risk of depressed mood at follow-up (RR=1.17; 95% CI=1.03, 1.32). Both of these analyses were adjusted for covariates (Table 3).

Respondents who reported engaging in physical exercise for more than 30 minutes per day on average at baseline had a 48% lower risk of being depressed at follow-up than respondents who reported not engaging in physical exercise at baseline (RR=0.52; 95% CI=0.29, 0.92). Also, each minute of physical exercise per day reported at baseline was associated with a 1% decreased risk of depressed mood at follow-up (RR=0.99; 95% CI=0.98, 1.00). Both analyses were adjusted for covariates (Table 3).

Table 4 shows relative risks and 95% confidence intervals derived from longitudinal multivariate logistic regression models with transitions in lifestyle domains as determinants of follow-up depressed mood. Analyses adjusted for covariates demonstrated that respondents who initiated alcohol use between baseline and follow-up were at lower risk of being depressed at follow-up than respondents who reported no alcohol use at baseline or follow-up (RR=0.18; 95% CI=0.04, 0.76; Table 4). Post hoc analyses revealed that none of the 47 respondents who initiated alcohol use between baseline and follow-up exceeded 11 alcoholic drinks per week on average (data not shown). Finally, analyses adjusted for covariates demonstrated that respondents who reported engaging in physical exercise at baseline as well as at follow-up decreased their risk of being depressed at follow-up by 44% compared with respondents who did not engage in physical exercise throughout the 6-year period (RR=0.56; 95% CI=0.34, 0.93; Table 4).

DISCUSSION

In assessing longitudinal associations between lifestyle domains and depressed mood, we found that excessive alcohol use at baseline (compared with abstinence) predicted depressed mood at follow-up and that engaging in more than 30 minutes of physical exercise on average per day at baseline (compared with not exercising) was associated with an absence of depressed mood at follow-up. In addition, we found that those who initiated alcohol use were at reduced odds of depressed mood at follow-up relative to steady nondrinkers and that those who persistently engaged in physical exercise were less likely to be depressed at follow-up than those who persistently did not engage in physical exercise.

Our results did not show any longitudinal associations between smoking behavior and depressed mood. The increase between baseline and follow-up in the percentage of respondents who reported never having smoked (Table 1) indicates some inconsistency in questionnaire responses over the 6-year period, and this may have diminished the reliability of our data on smoking behavior and weakened the observed associations between smoking behavior and depressive symptoms.

Our finding of a significant longitudinal predictive effect of excessive alcohol use at baseline on the presence of depressed mood at follow-up is in accord, to some extent, with the results of Aneshensel and Huba.[8] In their study involving 742 adults in the Los Angeles metropolitan area, they found contradictory cross-sectional and longitudinal effects of alcohol use on depression. They inferred that high levels of alcohol use were associated with low scores for depressive symptoms (cross sectional) but that high initial levels of alcohol use were associated with subsequent increased depressive symptoms (longitudinal).

TABLE 2—CES-D Depression Scores at Follow-Up (n = 1169) and Comparisons Stratified by Baseline Sociodemographic and Lifestyle Variables: Maastricht Aging Study

	No.	Mean Depression Score[a] (SD)	Depressed[b] (n = 164), Mean (SD) or %	Nondepressed (n = 1005), Mean (SD) or %[c]
Age, y			50.8 (14.5)	48.6 (14.7)*
24–44	490	6.9 (6.5)***	12.4	87.6
45–64	476	8.4 (6.9)	14.7	85.3
65–81	203	8.9 (6.0)	16.3	83.7
Gender				
Male	612	7.0 (5.7)***	9.2	90.8***
Female	557	8.9 (7.3)	19.4	80.6
Marital status				
Married/living together	951	7.9 (6.7)	13.9	85.7
Not married/no longer married	160	7.6 (6.1)	14.4	85.6
Widowed	58	8.6 (6.0)	15.5	84.5
Education level				
High[d]	337	6.8 (6.1)***	11.3	88.7**
Intermediate	398	7.5 (6.4)	10.8	89.2
Low	434	9.1 (7.0)	19.1	80.9
IADL status				
Not impaired	1082	7.6 (6.4)***	12.8	87.2***
Impaired	87	11.3 (7.8)	28.7	71.3
No. of chronic diseases			1.5 (1.5)	1.2 (1.3)*
None	390	6.8 (6.6)***	11.5	88.5*
1	396	7.8 (6.3)	12.9	87.1
2 or more	383	9.0 (6.7)	17.8	82.2
Smoking behavior				
Never smoked	409	7.4 (6.1)	12.0	88.0
Formerly smoked	448	8.1 (6.6)	14.3	85.7
Currently smokes	312	8.2 (7.2)	16.3	83.7
Average daily alcohol intake				
None	161	8.8 (7.7)	18.0	82.0
Up to 2 alcoholic drinks	928	7.7 (6.4)	13.1	86.9
3 or more alcoholic drinks	80	7.7 (6.4)	16.2	83.8
Mean no. of alcoholic drinks per week (SD)			6.1 (10.6)	6.0 (9.3)
Average amount of time spent daily on physical exercise				
More than 30 min	259	6.5 (5.4)***	7.7	92.3**
Up to 30 min	332	7.9 (6.3)	14.5	85.5
None	578	8.5 (7.2)	16.6	83.4
Mean no. of minutes of physical exercise per day (SD)			12.3 (24.3)	19.2 (29.0)**
Overweight				
No	784	7.5 (6.4)**	13.1	86.9
Yes	385	8.6 (7.0)	15.8	84.2
Mean body mass index, kg/m^2 (SD)			26.4 (4.1)	26.5 (4.1)

Note. CES-D = Center for Epidemiologic Studies Depression Scale; IADL = instrumental activity of daily living. Continuous variables were assessed via *t* tests and univariate analyses of variance; categorical variables were assessed via χ^2 analyses.
[a]Significance values refer to subcategory comparisons.
[b]CES-D score of 16 or above.
[c]Significance values refer to differences between depressed and nondepressed participants.
[d]Educational level was categorized as low (primary education at most), intermediate (junior vocational training), or high (senior vocational or academic training).
*P < .05; **P < .01; ***P < .001.

However, we are uncertain about the validity of the observed association between alcohol use initiation and absence of depressed mood at follow-up. Because of the relatively small size of the group initiating alcohol use (n = 47) compared with the other groups, the fact that nonrespondents reported more depressive symptoms at baseline than respondents, and the fact that none of the respondents initiating alcohol use between baseline and follow-up exceeded an average of 2 glasses of alcohol per day, we cannot rule out that this finding was a statistical artifact attributable to selection bias.

Our finding of a significant longitudinal protective effect of baseline physical exercise (at recommended levels) on subsequent depressed mood is in line with the results of Strawbridge and colleagues.[17] In a 5-year follow-up investigation, they found that high levels of physical activity were associated with absence of depression and were protective against subsequent depression among 1947 community-dwelling adults aged 50 through 94 years. They used a measure of physical activity focusing on usual frequency (never, sometimes, often) of exercise, taking part in active sports, taking long walks, and swimming.

Furthermore, the protective effect of physical exercise on subsequent depression reported by Strawbridge et al.[17] was confirmed in our analyses examining the effects of physical exercise behavior over time: Respondents who reported engaging in physical activity at both baseline and follow-up were at 44% lower risk of subsequent depression than those who reported not engaging in physical exercise at either baseline or follow-up. Thus, it can be cautiously suggested not only that physical exercise may be an effective element in the treatment of depression[40] but that maintenance of regular physical exercise over a relatively long period of time may protect against the emergence of clinically relevant levels of depressive symptoms. The inhibitory effect of exercise on levels of inflammatory and cardiovascular risk factors may be part of the explanatory pathway through which exercise protects against depression,[41] in that the presence of high levels of these risk factors has also been associated with the presence of high levels of depressive symptoms.[42,43]

TABLE 3—Multivariate Logistic Regression Models for Baseline Lifestyle Domains as Determinants of Depressed Mood at Follow-Up (n = 1169)

Baseline Lifestyle Domain	No.	Depression at Follow-Up: Adjusted RR 1[a] (95% CI)	Depression at Follow-Up: Adjusted RR 2[b] (95% CI)
Smoking behavior			
Currently smokes	312	Reference	Reference
Formerly smoked	448	0.89 (0.57, 1.40)	0.88 (0.56, 1.40)
Never smoked	409	0.73 (0.46, 1.17)	0.67 (0.41, 1.09)
Average daily alcohol intake			
None	161	Reference	Reference
Up to 2 alcoholic drinks	928	0.92 (0.55, 1.54)	1.15 (0.68, 1.96)
3 or more alcoholic drinks[c]	80	1.49 (0.68, 3.24)	2.48 (1.08, 5.69)*
Mean no. of alcoholic drinks per day (continuous)[d]	1169	1.07 (0.95, 1.21)	1.17 (1.03, 1.32)*
Average amount of time spent daily on physical exercise			
None	578	Reference	Reference
Up to 30 min	332	0.86 (0.57, 1.30)	0.87 (0.56, 1.33)
More than 30 min[c]	259	0.43 (0.24, 0.76)**	0.52 (0.29, 0.92)*
Mean no. of minutes of physical exercise per day (continuous)[d]	1169	0.99 (0.98, 1.00)**	0.99 (0.98, 1.00)*
Overweight			
Yes	385	Reference	Reference
No	784	0.90 (0.62, 1.33)	1.03 (0.69, 1.54)
Body mass index (continuous)[d]	1169	0.99 (0.95, 1.04)	0.98 (0.93, 1.02)

Note. RR = relative risk; CI = confidence interval.
[a]Adjusted for baseline depressive symptomatology.
[b]Adjusted for baseline depressive symptomatology, age, gender, marital status, educational level, instrumental activities of daily living status, and number of chronic diseases.
[c]Significance levels refer to differences from reference category.
[d]Values refer to the odds of subsequent depressed mood associated with each 1-unit increase in the continuous lifestyle variable.
*$P < .05$; **$P < .01$.

This study was limited by the considerable attrition because of nonresponse and loss to follow-up. The 6-year follow-up period may have been a key source of selection bias, potentially resulting in the sample included here being less representative of the overall study population than desired. However, this is a frequently encountered problem in longitudinal aging studies and is difficult to avoid.[10,44] In addition, according to Kempen and Van Sonderen, attrition has more adverse effects in the case of descriptive measurements than in the case of measures focusing on longitudinal associations, such as those used in our study.[45]

Bias may also have been introduced through the use of mainly self-report measures. In general, research involving the use of self-reported measures is inexpensive, easy to conduct, and not affected by interrater variability. A downside of such research, however, is the risk of inaccurate recollection of past events and response bias. These factors, if present, may have led to a certain degree of distortion of our findings.

Finally, a pair of suboptimal conditions of our study need to be mentioned. First, CES-D scores were not available at baseline. Therefore, we used Symptom Checklist 90 Depression Scale baseline scores to control our statistical analyses for initial level of depressive symptoms. Because these 2 instruments have been shown to be valid and highly correlated,[31] we believe that our analyses were adequately controlled; however, this may be open to debate. Second, we did not adjust for broad socioeconomic factors, such as unemployment, major life events, and work stressors, that might be associated with both unhealthy lifestyles and depression. Thus, control for educational level alone may not have been sufficient and could have resulted in residual confounding by these broader socioeconomic conditions. These limitations should be considered in interpreting our results and formulating public health recommendations.

We believe that our study involved a number of strengths as well. We comprehensively examined the effects of 4 lifestyle domains on depressive symptoms using longitudinal analysis techniques. The pivotal findings of this study were that (1) excessive alcohol use at baseline predicted depressed mood at follow-up; (2) physical exercise at recommended levels predicted absence of depressed mood at follow-up; and (3) physical exercise over a relatively long period of time was associated with absence of depressed mood.

Our results indicate that the potential downward spiral mentioned in the introduction might be halted through adoption or maintenance of healthy lifestyles, which could prevent the deterioration or even occurrence of depressed mood over time and, in turn, the worsening of chronic disease symptoms. In addition to the role of behavior change, adoption or maintenance of healthy lifestyles might be facilitated by the creation of health-promotive environments[46] in both homes and workplaces (e.g., through offering only low-fat, high-fiber meals in company and school cafeterias or lowering sales taxes on memberships in health and physical fitness clubs), reducing barriers to engaging in healthy behaviors and motivating people to engage in these behaviors. Future research could assess the effects of implementing such health-promotive environments on lifestyle alterations and subsequent changes in both overall health and mental health. ■

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TABLE 4—Multivariate Logistic Regression Models for Transitions in Lifestyle Domains Between Baseline and Follow-Up as Determinants of Depressed Mood at Follow-Up (n = 1169)

Lifestyle Transition	No.	Depression at Follow-Up: Adjusted RR 1[a] (95% CI)	Depression at Follow-Up: Adjusted RR 2[b] (95% CI)
Smoking behavior			
Still does not smoke	826	0.78 (0.50, 1.22)	0.74 (0.46, 1.17)
Quit smoking	86	0.89 (0.40, 1.95)	0.90 (0.40, 2.00)
Initiated smoking	31	1.09 (0.37, 3.20)	1.23 (0.42, 3.60)
Still smokes	226	Reference	Reference
Alcohol intake			
Still drinks alcohol	941	0.63 (0.37, 1.09)	0.80 (0.45, 1.41)
Initiated alcohol use	47	0.17 (0.04, 0.73)*	0.18 (0.04, 0.76)*
Quit drinking alcohol	67	1.35 (0.60, 3.01)	1.29 (0.57, 2.91)
Still does not drink alcohol	114	Reference	Reference
Physical exercise			
Still engages in physical exercise	328	0.50 (0.31, 0.82)**	0.56 (0.34, 0.93)**
Initiated physical exercise	107	0.64 (0.32, 1.27)	0.66 (0.32, 1.33)
Discontinued physical exercise	263	0.78 (0.49, 1.24)	0.80 (0.50, 1.30)
Still does not engage in physical exercise	471	Reference	Reference
Body mass index			
Still not overweight	661	0.92 (0.61, 1.40)	1.05 (0.68, 1.62)
No longer overweight	45	1.40 (0.57, 3.41)	1.46 (0.58, 3.67)
Became overweight	123	1.07 (0.56, 2.05)	1.20 (0.62, 2.32)
Still overweight	340	Reference	Reference

Note. RR = relative risk; CI = confidence interval. Significance values refer to differences from reference category.
[a]Adjusted for baseline depressive symptomatology.
[b]Adjusted for baseline depressive symptomatology, age, gender, marital status, educational level, instrumental activities of daily living status, and number of chronic diseases.
*$P < .05$; **$P < .01$.

Contributors

C.H. van Gool and G.I.J.M. Kempen formulated the hypothesis. C.H. van Gool analyzed the data, interpreted the findings, and drafted the article. G.I.J.M. Kempen, H. Bosma, M.P.J. van Boxtel, J. Jolles, and J.T.M. van Eijk assisted with interpretation of findings and critical revision of the article.

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Human Participant Protection

This study was approved by the medical ethics committee of the University Hospital Maastricht. Participants provided written informed consent.

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