論文名	Associations between lifestyle and depressed mood: longitudinal results from the Maastricht Aging Study						
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対象の内訳		ヒト	動物	地 域	欧米	研究の種類	縦断研究
	対象	一般健常者	空白		( )		コホート研究
	性別	男女混合	( )		( )		( )
	年齢	24-81(52.5歳)	[redacted]		( )		前向きコホート
	対象数	1000～5000			( )		( )
調査の方法	質問紙	( )					
アウトカム	予 防	なし	なし	なし	なし		( )
	維持・改善	な し	な し	な し	心理的指標改善	( )	( )

図 表

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.
*$P<.05$; **$P<.01$.

図表掲載箇所	
概 要 (800字まで)	<目的>運動と気分の落ち込みとの関係を検討した。コホート名:Maastricht Aging Study、対象者数:1169人、追跡期間:6年、因子評価方法詳細:運動量を週あたり平均して1日あたり何分間、球技、有酸素運動、歩行、自転車などの中強度の身体活動に取り組んでいますか？との質問で把握した結果、運動習慣なし、30分/日未満、30分/日以上の3群に分類。運動の単位:分/日。<結果>運動時間と気分の落ち込み発生のリスクとの関係は、分位1:1、分位2:0.87(0.56-1.33)、分位3:0.52(0.29-0.92)であった。その他の要因として飲酒も気分の落ち込みのリスクと関係があった。
結 論 (200字まで)	中強度の運動に30分/日以上取り組みは、低い気分の落ち込みの発症のリスクと関連している。
エキスパートによるコメント (200字まで)	うつの前段階としての気分の落ち込みの予防に運動が有効である可能性を示唆した意義深い研究である。

担当者 宮地元彦

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Original Contribution

Physical Activity and Common Mental Disorder: Results from the Caerphilly Study

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The authors examined associations between leisure-time and occupational physical activity and common mental disorder (CMD), defined as anxiety and depression, using data from a cohort of middle-aged men in Caerphilly, South Wales, United Kingdom, who were followed for 5 years (1989–1993) and 10 years (1993–1997). CMD was measured using the General Health Questionnaire. Total leisure-time activity and percentage of time spent in heavy-intensity activity were estimated from self-reports (Minnesota Leisure Time Physical Activity Questionnaire). Men were classified into four classes of occupational activity. Among 1,158 men with complete data, those who participated in any heavy-intensity leisure-time activity had reduced odds of CMD 5 years later (below median vs. none: adjusted odds ratio (OR_{adj}) = 0.61, 95% confidence interval (CI): 0.40, 0.93); median or above vs. none: OR_{adj} = 0.54, 95% CI: 0.35, 0.83). Analyses using multiple imputation to deal with missing data found weaker evidence for an association (OR_{adj} = 0.79 (95% CI: 0.54, 1.15) and OR_{adj} = 0.73 (95% CI: 0.49, 1.09), respectively). There was little evidence that men in the most physically demanding jobs had reduced odds of CMD after 5 years, and there was no association between physical activity and CMD 10 years later. Among these men, heavy-intensity leisure-time physical activity was associated with a small reduction in CMD over 5 years.

anxiety; depression; exercise; mental disorders; physical fitness

Abbreviations: CI, confidence interval; GHQ-30, 30-item General Health Questionnaire; MICE, multiple imputation by chained equation; OR, odds ratio.

In addition to the established benefits of physical activity for chronic diseases (1), increased activity improves subjective well-being (2). Despite the increasing burden of common mental disorders (anxiety and depression) in society (3), there are few data on the relation between physical activity and mental health. The authors of several reviews have concluded that physical activity is associated with a reduction in depressive symptoms (4–6), but these reviews included cross-sectional studies, from which the temporal nature of the association could not be determined, and experimental studies examining only short-term effects.

Longitudinal epidemiologic studies have produced conflicting results (7–14). In the First National Health and Nutrition Examination Survey, engaging in little or no recreational activity was associated with twofold increased odds of incident depression after 8 years in women, but no such increase was seen for men (7). In the Alameda County Study, men and women who reported low levels of physical

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activity had 70 percent increased odds of incident depression over a period of 9 years (8), with greater physical activity reducing depressive symptoms later in life (14). Similarly, in an older Finnish cohort, persons who became more active over a period of 8 years had fewer depressive symptoms (11). Former female college athletes have been found to be at lower risk of depression in later life than nonathletes (13), but such findings may not be generalizable. In a study of college alumni, Paffenbarger et al. (9) also reported a reduced risk of depression among the more physically active. In another study, Morgan and Bath (10) reported a very small effect, but they did not exclude prevalent cases of depression at baseline, which would have resulted in underestimation of any true benefit of physical activity. Sexton et al. (12) observed an association only among persons with sedentary occupations. In the Upper Bavarian Field Study, Weyerer (15) found a cross-sectional association between low levels of physical activity and depressive disorder, but this was not supported by analysis of 5-year follow-up data. Similarly, in the Rancho Bernardo Study, Kritz-Silverstein et al. (16) did not find a longitudinal association over a period of 8 years. In a study of former medical students, Cooper-Patrick et al. (17) found no evidence for a link between physical inactivity and future depression over 2 or 15 years of follow-up.

While differences in follow-up, adjustment for confounders, and selection bias may contribute to the conflicting evidence, the most significant limitation of previous studies has been the measurement of physical activity. Often the measurement of physical activity is restricted to only one or two questions (7, 12, 15–17), and it is frequently confined to leisure-time activities (8–10, 14, 15). Accurate measurement of physical activity should comprise information on the frequency, duration, and intensity of all such activity (18), including both occupational and leisure-time activities. Paffenbarger et al. (9) recorded more detailed activity information that was converted into energy expenditure, which provided some evidence for a dose-response effect, suggestive of causality, but adjustment for confounders was limited to age.

In previous studies, investigators have used self-report measures of common mental disorders (10, 12), with a focus on depressive symptoms (7, 8, 16) or recall of physician diagnoses (9, 13, 17). Because many persons with psychiatric problems have symptoms of both anxiety and depression, we use the term "common mental disorder" to refer to both depressive disorders and anxiety disorders. We aimed to examine the association between physical activity and common mental disorder in a longitudinal population-based cohort study of men with detailed leisure and occupational physical activity data and to determine whether there was any evidence for a dose-response effect.

MATERIALS AND METHODS

Caerphilly Study cohort

We used data from the Caerphilly Prospective Study, a cohort study of middle-aged men in Caerphilly, South Wales, United Kingdom. Detailed information on the cohort is available elsewhere (http://www.epi.bris.ac.uk/caerphilly/caerphillyprospectivestudy.htm) (19). Briefly, in the initial survey (phase I: 1979–1983), men aged 45–59 years living in Caerphilly and the surrounding area were invited to participate in a study of the determinants of coronary heart disease. Eighty-nine percent of those eligible ($n = 2{,}512$) took part. In phase II (1984–1988), men who had taken part in phase I were recontacted, and men who had moved into the study area were invited to participate (total $n = 2{,}398$). The phase II cohort was subsequently followed at 5-year intervals (phase III: 1989–1993; phase IV: 1993–1997). In each phase, participants attended a clinic at which they completed a questionnaire, had anthropometric measurements and an electrocardiogram taken, and provided fasting blood samples. Measurements from the phase II assessment were used for the cross-sectional analyses and formed the baseline data for the longitudinal analyses presented here.

Phases I–III of the Caerphilly Study were approved by the Cardiff Local Research Ethics Committee, and later phases were approved by the Gwent Research Ethics Committee.

Measurement of common mental disorder

Common mental disorder was measured in phases II–IV using the 30-item General Health Questionnaire (GHQ-30) (20), a screening instrument for psychiatric disorders. In a validation study ($n = 97$), men with common mental disorder were identified using the Clinical Interview Schedule, which was administered by a psychiatrist blinded to GHQ-30 scores (21). On the basis of receiver operating characteristic curves, a case of common mental disorder was defined as having a GHQ-30 score greater than or equal to 5 (sensitivity = 71.4 percent; specificity = 71.0 percent).

Measurement of physical activity

In phase II (baseline), data on leisure-time physical activity were collected using questions derived from the Minnesota Leisure Time Physical Activity Questionnaire (22). Participants were asked whether they had undertaken a variety of activities during the last 12 months, as well as the frequency and average duration of each activity. Each activity was assigned an intensity code, and therefore energy expenditure was calculated both in total and for each level of intensity (light, moderate, and heavy) (19). The percentage of energy expended in heavy-intensity activity (e.g., running, playing soccer) was also calculated.

Physical activity at work was assessed on the basis of self-report questions (time spent walking, sitting, and lifting/carrying) modified from the Health Insurance Plan questionnaire (23). Each participant was categorized into one of four occupational physical activity classes based on quartiles (class 1 = least active; class 4 = most active). In phase II, 53 percent of the men in the study were employed. For the remaining men, these questions referred to physical activity in the last job held. No data were collected on how long a participant had been out of work or retired. For the main analyses, all men with data on work-related physical activity (current/last job) were included in order to maximize the number of participants in the analyses and to ensure that the sample remained representative of the population of middle-aged men from which the sample was drawn. Sensitivity analyses were restricted to those employed at baseline.

Statistical analysis

All analyses were conducted in Stata, version 8.2 (24).

For leisure-time physical activity, total energy expenditure (kcal/day) was divided into tertiles (low, medium, and high). The percentage of leisure-time physical activity of heavy intensity was divided into three categories: none, low, and high (for the latter, dichotomizing at the median). Occupational physical activity was modeled in four job classes (as described above).

Logistic regression was used to examine the cross-sectional relation between physical activity and common mental disorder. The independent effects of leisure-time and occupational physical activity were examined. Odds ratios and their 95 percent confidence intervals are reported. In univariable models, results were adjusted for the following possible confounders: age (years), social class (Registrar General's occupational classification (25); six groups), marital status (married, single, widowed, or divorced/separated), employment status (employed, unemployed, self-employed, or retired (due or not due to ill health)), smoking habits (never smoker, ex-smoker, cigar or pipe smoker, or current smoker by number of cigarettes smoked per day ($<$15, 15–24, or $\geq$25)), alcohol consumption (units/week; 1 unit = 8 g of ethanol), social support, body mass index (weight (kg)/height (m)^2), job satisfaction, demands, and latitude (based on the method of Karasek (26)), and biologic measures (levels of high density lipoprotein cholesterol (mmol/liter) and triglycerides (mmol/liter)).

In longitudinal analyses, we examined the short-term (phases II–III; 5-year follow-up) and longer-term (phases II–IV; 10-year follow-up) effects of physical activity on mental health. Participants with prevalent common mental disorder in phase II (GHQ-30 score $\geq$5) and noncases (GHQ-30 score $<$5) who were taking antidepressant medication were excluded from the cohort for longitudinal analyses. As before, unadjusted and adjusted results (with additional adjustment for phase II GHQ-30 score and change in triglyceride level (phases II–III or phases II–IV)) were examined.

Analyses were repeated classifying persons who had a GHQ-30 score greater than or equal to 5 or were taking antidepressants in phase III (or IV) as incident cases and, similarly, classifying persons who were taking antidepressants or daytime (nonsedative) anxiolytics (often prescribed for common mental disorder in the 1980s/1990s) in phase III (or IV) as incident cases.

In sensitivity analyses, we examined the influence of missing data on the findings. The method of multiple imputation by chained equation (MICE) (27) was used to impute the missing data (Stata *ice* procedure v.30.08.05). The imputation model included physical activity measurements, all potential confounders, GHQ-30 scores, and use of antidepressants/daytime anxiolytics at all time points. We generated 25 data sets and undertook 10 switching procedures.

Data sets

Of the phase II cohort (n = 2,398), 2,201 persons (91.8 percent) had completed the GHQ-30. A total of 1,995 men had data on both leisure-time and occupational physical activity in phase II and complete data on confounders, thus comprising the data set for cross-sectional analyses.

Of the 2,201 men who completed the phase II GHQ-30, 498 men were excluded (GHQ-30 score $\geq$5 or use of antidepressants), leaving 1,703 men to form the cohort for longitudinal analyses. A total of 1,158 men completed the GHQ-30 in phases II and III, had data on leisure-time and occupational physical activity, and had complete data on confounders (short-term outcome). A total of 1,016 men comprised the data set for longer-term outcome (phases II–IV).

RESULTS

Description of cohort

In phase II, the men were, on average, aged 57 years (standard deviation, 4.5); 87.5 percent were married, and two thirds were from the lower social classes (IIIM–V). Just over half of the men were employed, 15 percent were unemployed, and 32 percent were retired.

The men expended a median of 254 kcal/day on leisure-time physical activity (interquartile range, 122–476), and 68 percent participated in heavy-intensity leisure-time physical activities. However, among those undertaking heavy-intensity activity, this only accounted for a median of 8.7 percent (interquartile range, 2.6–24.0) of their total leisure-time energy expenditure.

Cross-sectional analysis

Men in the highest third of total leisure-time physical activity had 34 percent reduced odds of common mental disorder compared with those in the lowest third (table 1). After adjustment for confounders, men who undertook any heavy-intensity leisure-time physical activity were approximately 30 percent less likely to report common mental disorder (table 1). There was no evidence of a dose-response effect. Men in the most active jobs (class 4) were less likely to report common mental disorder, although the 95 percent confidence interval spanned unity (table 1). In analyses that used multiple imputation to deal with possible bias due to missing data, the effect estimates did not differ substantively.

Employment status, job decision latitude, demands, and satisfaction, and social class were the main contributors to the change in odds ratio observed from the unadjusted analysis to the fully adjusted analysis. Unemployed men and men who had retired because of ill health were less active at heavy intensity in their leisure time but had been more physically active in their last job and had increased odds of common mental disorder.

In analyses restricted to men who were employed (n = 1,091), there was some evidence that those who were most physically active at work had reduced odds of common

TABLE 1. Results of a cross-sectional analysis (phase II) assessing the independent effects of leisure-time and work-related physical activity on common mental disorder (GHQ-30* score ≥5) among participants in the Caerphilly Study, South Wales, United Kingdom†

Physical activity measure	No. of participants	Unadjusted‡ estimate (n = 1,995)		Fully adjusted§ estimate from complete case analysis (n = 1,995)		Fully adjusted§ estimate using the MICE* method to impute missing values (n = 2,201)	
		OR*	95% CI*	OR	95% CI	OR	95% CI
Total leisure-time activity							
Low	648	1.00		1.00		1.00	
Medium	676	1.01	0.77, 1.30	0.96	0.72, 1.27	0.94	0.72, 1.23
High	671	0.78	0.59, 1.03	0.66	0.49, 0.89	0.64	0.48, 0.86
Percentage of leisure time spent in heavy-intensity activity							
None	614	1.00		1.00		1.00	
Low	696	0.64	0.49, 0.84	0.68	0.51, 0.91	0.70	0.53, 0.93
High	685	0.58	0.44, 0.76	0.65	0.49, 0.88	0.66	0.50, 0.88
Job class (increasing activity↓)							
Class 1	578	1.00		1.00		1.00	
Class 2	534	1.11	0.83, 1.49	1.11	0.81, 1.53	1.01	0.74, 1.37
Class 3	453	1.25	0.92, 1.68	1.20	0.85, 1.69	1.19	0.86, 1.65
Class 4	430	0.97	0.71, 1.34	0.78	0.54, 1.13	0.76	0.54, 1.08

* GHQ-30, 30-item General Health Questionnaire; MICE, multiple imputation by chained equation; OR, odds ratio; CI, confidence interval.

† Data were obtained as part of the Caerphilly Study, a cohort study (based in Caerphilly, South Wales, United Kingdom) of the determinants of coronary heart disease in middle-aged men. The cohort was established in 1979–1983, and data on physical activity were collected in phase II (1984–1988). Data on common mental disorder were collected in phase II and after 5 years (phase III: 1989–1993) and 10 years (phase IV: 1993–1997).

‡ Three physical activity exposure variables were entered in one regression model, but results were not adjusted for any other factors.

§ Adjusted for age, social class, marital status, employment status, smoking habits, alcohol consumption, social support, body mass index, high density lipoprotein cholesterol and triglyceride levels, and phase II Karasek (26) job demand variables (job decision latitude, job demands, and job satisfaction).

mental disorder (class 4 vs. class 1: odds ratio (OR) = 0.63, 95 percent confidence interval (CI): 0.34, 1.18). Total leisure-time physical activity was not important (medium vs. low: OR = 1.05, 95 percent CI: 0.69, 1.58; high vs. low: OR = 0.91, 95 percent CI: 0.57, 1.45), and only those who undertook high levels of leisure-time physical activity at a heavy intensity had reduced odds of common mental disorder (low vs. none: OR = 0.92, 95 percent CI: 0.58, 1.45; high vs. none: OR = 0.64, 95 percent CI: 0.41, 1.01).

Longitudinal analysis

5-year follow-up. In the short term, after adjustment for confounders, men who undertook any heavy-intensity leisure-time physical activity were less likely to report common mental disorder (table 2). There was little evidence of a dose-response effect. Total leisure-time physical activity was not associated with a reduction in the odds of common mental disorder. Persons in the most physically active jobs (class 4) had slightly reduced odds of common mental disorder, but the 95 percent confidence interval was wide (table 2). Restricting analyses to those who were employed at baseline produced similar results (n = 707; data not shown).

10-year follow-up. There was no association between leisure-time physical activity and common mental disorder at 10 years of follow-up (table 3). Greater physical activity at work was associated with approximately 70 percent *increased* odds of common mental disorder at 10 years after adjustment for confounders, and this relation was evident, although attenuated, in the analysis that included imputed data. Restricting the analyses to men who were employed at baseline showed that those in the more physically active jobs had slightly elevated odds of common mental disorder, but there were no other differences (n = 652; data not shown).

Similar results were obtained when the incident case definition included persons who were taking antidepressants/anxiolytics (data not shown).

Missing data

From the longitudinal cohort (n = 1,703), 442 and 606 participants were missing outcome data in phases III and IV,

TABLE 2. Independent effects of leisure-time and work-related physical activity in phase II on common mental disorder (GHQ-30* score ≥5) at 5 years among participants in the Caerphilly Study, United Kingdom†

Physical activity measure	No. of participants	Unadjusted‡ estimate (n = 1,158)		Fully adjusted§ estimate from complete case analysis (n = 1,158)		Fully adjusted§ estimate using the MICE* method to impute missing values (n = 1,703)	
		OR*	95% CI*	OR	95% CI	OR	95% CI
Total leisure-time activity							
Low	361	1.00		1.00		1.00	
Medium	385	1.29	0.86, 1.93	1.34	0.88, 2.03	1.23	0.85, 1.79
High	412	1.18	0.78, 1.78	1.16	0.75, 1.80	1.04	0.70, 1.56
Percentage of leisure time spent in heavy-intensity activity							
None	320	1.00		1.00		1.00	
Low	419	0.59	0.40, 0.88	0.61	0.40, 0.93	0.79	0.54, 1.15
High	419	0.56	0.37, 0.83	0.54	0.35, 0.83	0.73	0.49, 1.09
Job class (increasing activity↓)							
Class 1	344	1.00		1.00		1.00	
Class 2	309	1.20	0.79, 1.84	1.33	0.83, 2.13	1.23	0.80, 1.91
Class 3	250	1.18	0.75, 1.86	1.11	0.67, 1.84	1.18	0.75, 1.85
Class 4	262	0.91	0.57, 1.45	0.81	0.47, 1.39	0.94	0.59, 1.48

* GHQ-30, 30-item General Health Questionnaire; MICE, multiple imputation by chained equation; OR, odds ratio; CI, confidence interval.

† Data were obtained as part of the Caerphilly Study, a cohort study (based in Caerphilly, South Wales, United Kingdom) of the determinants of coronary heart disease in middle-aged men. The cohort was established in 1979–1983, and data on physical activity were collected in phase II (1984–1988). Data on common mental disorder were collected in phase II and after 5 years (phase III: 1989–1993) and 10 years (phase IV: 1993–1997).

‡ Three physical activity exposure variables were entered in one regression model, but results were not adjusted for any other factors.

§ Adjusted for age, social class, marital status, employment status, smoking habits, alcohol consumption, social support, body mass index, phase II GHQ-30 score, phase II high density lipoprotein cholesterol level, change in triglyceride level between phase II and phase III, and phase II Karasek (26) job demand variables (job decision latitude, job demands, and job satisfaction).

respectively. Imputation of missing data using the MICE method suggested that persons whose data were imputed were more likely to have higher GHQ-30 scores in phases III and IV and to be taking antidepressants/anxiolytics (table 4). Analyses including imputed data suggested a more conservative estimate for the effect of participating in any heavy-intensity leisure-time physical activity on common mental disorder at 5 years (in complete-case analysis, the reduction in the odds of common mental disorder was approximately 40 percent; with inclusion of imputed data, the reduction was approximately 20 percent). The evidence in support of an association was also weaker, as the 95 percent confidence interval included the null value (table 2).

DISCUSSION

Principal findings

In cross-sectional analyses, middle-aged men who undertook leisure-time physical activity at a heavy intensity and those in the top third of total leisure-time physical activity had approximately 30 percent reduced odds of common mental disorder. There was also weak evidence suggesting that men in the most physically demanding jobs had slightly reduced odds of common mental disorder. In the short term (over 5 years), there was some evidence that the association between heavy-intensity leisure-time physical activity and common mental disorder persisted. There was no evidence to support a dose-response effect or an association between leisure-time physical activity and incident common mental disorder after 10 years.

Strengths and limitations

The Caerphilly Study cohort is a representative population-based sample of men residing in South Wales, United Kingdom, in the 1980s. The main strength of this cohort study is the collection of detailed data on leisure-time physical activity (based on the Minnesota Leisure Time Physical Activity Questionnaire (28)) together with data on physical

TABLE 3. Independent effects of leisure-time and work-related physical activity in phase II on common mental disorder (GHQ-30* score ≥5) at 10 years among participants in the Caerphilly Study, United Kingdom†

Physical activity measure	No. of participants	Unadjusted‡ estimate (n = 1,016)		Fully adjusted§ estimate from complete case analysis (n = 1,016)		Fully adjusted§ estimate using the MICE* method to impute missing values (n = 1,703)	
		OR*	95% CI*	OR	95% CI	OR	95% CI
Total leisure-time activity							
Low	306	1.00		1.00		1.00	
Medium	344	1.28	0.85, 1.93	1.34	0.87, 2.08	1.14	0.77, 1.70
High	366	1.17	0.77, 1.77	1.15	0.73, 1.79	1.06	0.71, 1.59
Percentage of leisure time spent in heavy-intensity activity							
None	267	1.00		1.00		1.00	
Low	370	1.04	0.69, 1.57	1.07	0.68, 1.67	1.12	0.76, 1.66
High	379	0.92	0.61, 1.40	0.96	0.60, 1.52	1.03	0.67, 1.58
Job class (increasing activity↓)							
Class 1	317	1.00		1.00		1.00	
Class 2	273	2.14	1.39, 3.31	2.41	1.48, 3.92	2.10	1.37, 3.21
Class 3	227	1.50	0.93, 2.42	1.56	0.90, 2.69	1.40	0.86, 2.25
Class 4	207	1.87	1.17, 3.01	1.85	1.06, 3.23	1.65	1.00, 2.71

* GHQ-30, 30-item General Health Questionnaire; MICE, multiple imputation by chained equation; OR, odds ratio; CI, confidence interval.

† Data were obtained as part of the Caerphilly Study, a cohort study (based in Caerphilly, South Wales, United Kingdom) of the determinants of coronary heart disease in middle-aged men. The cohort was established in 1979–1983, and data on physical activity were collected in phase II (1984–1988). Data on common mental disorder were collected in phase II and after 5 years (phase III: 1989–1993) and 10 years (phase IV: 1993–1997).

‡ Three physical activity exposure variables were entered in one regression model, but results were not adjusted for any other factors.

§ Adjusted for age, social class, marital status, employment status, smoking habits, alcohol consumption, social support, body mass index, phase II GHQ-30 score, phase II high density lipoprotein cholesterol level, change in triglyceride level between phase II and phase IV, and phase II Karasek (26) job demand variables (job decision latitude, job demands, and job satisfaction).

activity at work (23). This contrasts with previous studies in which only information on leisure-time physical activity was collected, often using a single question. However, we acknowledge that activity levels could be measured more accurately using objective measures rather than self-reports.

We adjusted for a large number of potential confounders but cannot rule out residual confounding. For example, while we adjusted for social class (based on occupation), no data were available on other markers of socioeconomic position (e.g., housing tenure). Participants who were physically active in their leisure time may have led a healthier lifestyle, and unmeasured confounders could explain our findings.

Only half of the men were employed at the time of the phase II survey; the remainder reported on physical activity in their last job, and no data were available on time since last employment. Those who were employed may have been a select group; thus, to maintain the representativeness of our sample, in our main analyses we included all men with data on physical activity (current/most recent job). We may have underestimated these effects. However, sensitivity analyses restricted to participants who were employed at the baseline assessment suggested few differences for the longitudinal analyses.

The questions about occupational physical activity were relatively crude, and data on physical activity were only recorded at one time point, so misclassification in exposure status may have biased our estimates. Furthermore, common mental disorder frequently has a relapsing course, so our single measurement of mental disorder at 5 and 10 years is unlikely to have captured all cases that occurred during the intervening period. Assuming that such misclassification was nondifferential, this would have attenuated any association. Finally, since the cohort comprised only men, we cannot generalize our findings to women.

The finding of *increased* odds of common mental disorder in the longer term among persons in more physically demanding jobs was unexpected. In post-hoc analyses, we hypothesized that persons in more physically demanding occupations may have less control over the demands of their

TABLE 4. Results from comparison of observed and imputed data for the 1,703 participants forming the cohort for longitudinal analyses, Caerphilly Study, United Kingdom*

	Observed data		Imputed data†,‡	
	No. of participants§	Median	No. of participants§	Median
GHQ-30¶ score				
Phase III	1,261	1	442	1
Phase IV	1,097	1	606	1
GHQ-30 score ≥5 (%)				
Phase III	1,261	15.6	442	18.1
Phase IV	1,097	18.2	606	21.8
Use of antidepressants (%)				
Phase III	1,469	0.5	234	3.4
Phase IV	1,366	1.8	337	3.9
Use of anxiolytics (%)				
Phase III	1,469	1.1	234	5.8
Phase IV	1,366	0.9	337	3.8

* Data were obtained as part of the Caerphilly Study, a cohort study (based in Caerphilly, South Wales, United Kingdom) of the determinants of coronary heart disease in middle-aged men. The cohort was established in 1979–1983, and data on physical activity were collected in phase II (1984–1988). Data on common mental disorder were collected in phase II and after 5 years (phase III: 1989–1993) and 10 years (phase IV: 1993–1997).

† Value across 25 imputation data sets. The method of multiple imputation by chained equation (MICE) (27) was used to impute missing values.

‡ Additional variables included in the imputation model: alcohol consumption, body mass index, Karasek (26) job demand variables (job decision latitude, job demands, and job satisfaction), social class, employment status, smoking status, leisure-time and occupational physical activity, high density lipoprotein cholesterol and triglyceride levels, and phase II GHQ-30 score.

§ Number of persons with observed data or for whom data were imputed. Where fewer than 25 observations were imputed, data are not presented.

¶ GHQ-30, 30-item General Health Questionnaire.

work, which may adversely affect their long-term mental health and consequently counterbalance any benefit of greater physical activity; however, adjustment for indicators of job control did not substantially attenuate this effect. Alternatively, in persons who are physically active but who stop such activity, this change may have a greater influence on their mental health than having never undertaken such activity. However, we cannot explore this hypothesis given the lack of activity data in later years. This requires clarification in future studies.

Differences between participants who were followed in phases III and IV and those who were lost to follow-up may have biased the findings from the complete-case analysis. Therefore, in sensitivity analyses, we examined the influence of missing data on the findings. Comparing observed data and imputed data, we found that participants with missing data had higher GHQ-30 scores and were therefore more likely to have had common mental disorder at the time of follow-up. In order for our effect estimate to have been attenuated compared with findings from the complete-case data set, the effect of physical activity would have had to be weaker in this group. The validity of the imputed data is dependent on correct specification of the imputation model, but this cannot be tested empirically. We included all of the variables that we believed would be strongly associated with the likelihood of a subsequent value's being missing, including age and severity of common mental disorder (GHQ-30 score) at earlier (and later) time points. The conclusions we have drawn from the analysis including imputed data and the complete-case analysis do not differ substantially. Heavy-intensity leisure-time physical activity was associated with a small reduction in the odds of common mental disorder in the short term (over 5 years). However, results from the analysis including data imputed by the MICE method suggested that the size of the effect was smaller (compared with the complete-case analysis) and, given that the 95 percent confidence interval surrounding the effect estimate included unity, provided weaker evidence to support an association. The possibility of no association cannot be ruled out. In order to obtain a more precise estimate of such a small effect, we would require a much larger sample.

Comparison with existing data

In previous studies, investigators have found associations in persons with sedentary occupations (12) or have analyzed select groups (9, 13, 17) from which it is difficult to make generalizations. The evidence from previous population-based cohort studies (7, 8, 14–16) is mixed.

Two of four previous population studies supported an association between physical activity and mental health. In the First National Health and Nutrition Examination Survey, Farmer et al. (7) found that women had increased odds of incident depression over a period of 8 years (after adjustment for age, physical health, and markers of socioeconomic status, OR = 1.9, 95 percent CI: 1.1, 3.2), but no such increase was seen for men (adjusted OR = 1.3, 95 percent CI: 0.5, 3.1). More detailed information on leisure-time physical activity was recorded in the Alameda County Study (8). Men and women undertaking low levels of activity had 70 percent increased odds of incident depression after adjustment for confounders. A beneficial effect of physical activity on mental health over a period of 5 years was reported in later follow-up of this cohort when participants were, on average, aged 63 years (14). In contrast, among older persons (mean age = 71 years) in the Rancho Bernardo Study, change in Beck Depression Inventory score over 8 years was not significantly different for participants who had and had not undertaken regular strenuous exercise (16). Physical activity was assessed by means of a single question in the Rancho Bernardo Study, and thus misclassification of exposure status may have attenuated any effect. Weyerer (15) also found little longitudinal evidence to support an association over 5 years of follow-up, but detailed exposure data were lacking.

To our knowledge, only one previous study (7) considered nonrecreational physical activity, but this was limited to a single question. Women who undertook little or no activity apart from recreation had twofold increased odds of depression cross-sectionally, but there was little evidence to support an association for men (7). The role of nonrecreational activity was not explored in the longitudinal analyses.

Mechanisms underlying an association between physical activity and common mental disorder

Our findings are consistent with evidence from randomized controlled trials suggesting that physical activity is, in the short term, an effective treatment for mild-to-moderate depression (29). Possible biologic explanations for an association between physical activity and common mental disorder are poorly understood. Reductions in hippocampal volume and the number of glial cells in the prefrontal cortex and amygdala have been implicated in the pathophysiology of depression (30). Substances such as brain-derived neurotrophic factor promote cell survival, and indirect regulation of such substances may explain some of the effectiveness of antidepressants (30). Animal studies suggest that exercise raises levels of brain-derived neurotrophic factor (31), promotes cell proliferation (32), and stimulates 5-hydroxytryptamine release (33). There is also some evidence that physical activity reduces cortisol levels (34). Other investigators have focused on the relation between physical activity and changes in psychosocial factors (e.g., body image (35), self-esteem (36)) which may affect mental health, and there is interest in the role of social support in physical activity (37).

Implications of this study

Official reports from both the United States (38) and the United Kingdom (1) recommend that people undertake at least 30 minutes of physical activity on at least 5 days of the week. Such guidance is particularly challenging, as many people who engage in physical activity do not maintain this. With sedentary occupations increasingly becoming the norm, the role of leisure-time physical activity is becoming increasingly important. The widespread encouragement to lead a physically active lifestyle in order to gain the recognized benefits for physical health may also have modest short-term benefits for mental health.

Conclusions and directions for future research

In summary, heavy-intensity leisure-time physical activity among these middle-aged men was associated with a small reduction in the likelihood of common mental disorder over 5 years. There was no evidence for an association over the longer term. In future research, investigators should examine cohorts of men and women followed regularly with repeated measures of both leisure-time physical activity and activity undertaken in the workplace, in order to ascertain the independent effects of these physical activity components on mental health. Investigators in future studies should also pay closer attention to the potential mechanisms underlying any possible association.

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対象の内訳		ヒト	動物	地域	欧米	研究の種類	縦断研究
	対象	一般健常者	空白		(USA)		コホート研究
	性別	男性	( )		( )		( )
	年齢	なし			( )		前向きコホート
	対象数	1000～5000			( )		( )
調査の方法	実測	( )					
アウトカム	予防	なし	なし	なし	なし		( )
	維持・改善	なし	なし	なし	心理的指標改善	( )	( )

図表

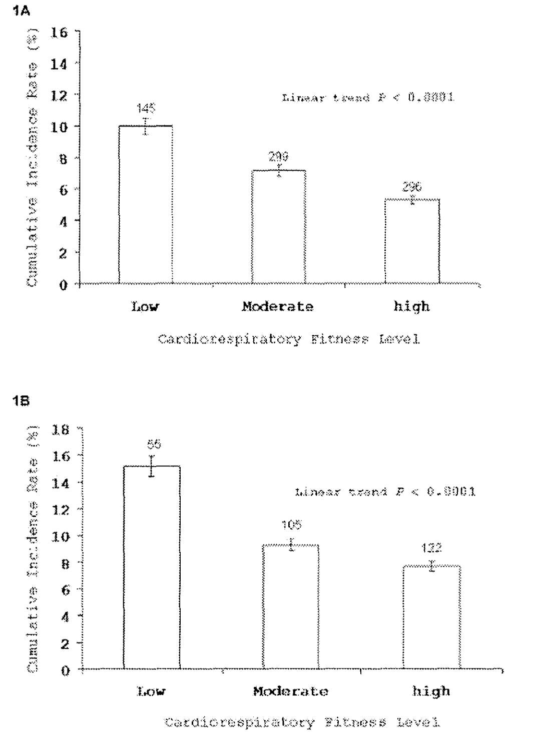

Fig. 1.
Incidence of depressive symptoms by cardiorespiratory fitness categories among men (1A) and women (1B). Bars indicate 95% confidence intervals. The number of cases is shown above the bars.

図表掲載箇所	
概要(800字まで)	＜目的＞ケアフィリー、サウスウェールズ州、イギリスの中年男性のコホートのデータを使用して、著者らは、余暇時間や職業身体活動と不安や抑うつのよう精神障害（CMD）との関連を5年間と10年間の前向き研究で検討した。＜方法＞ CMDは、一般健康調査票を用いて判定した。余暇身体活動量はミネソタ余暇時間の身体活動アンケートから推定した。男性は職業活動で4つの分位に分類された。＜結果＞完全なデータが揃った1158男性の間で、任意の高強度余暇活動に参加者の5年後のCMD発症調整オッズ比（OR）は非参加者と比較して 0.61（95％の信頼区間を（CI）：0.40、0.93）であった。最も多く高強度余暇身体活動に参加する者は非参加者と比較してORが 0.54（95％CI：0.35、0.83）であった。欠落したデータに対処するために複数の補完を用いた解析では、有意でないが弱い関係が見られた。最も職業身体活動の多い男性は5年後も10年後もCMD発症が低いことはなかった。
結論(200字まで)	男性の高強度余暇身体活動は、5年間のCMD発症リスクが低いことと関連していた。
エキスパートによるコメント(200字まで)	うつや不安などの精神疾患の予防には、就労での身体活動よりも余暇身体活動が重要であることを示唆した貴重な研究。

担当者　宮地元彦

Leisure Time Physical Activity in Relation to Depressive Symptoms in the Black Women's Health Study

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ABSTRACT

Background: *A growing body of evidence suggests that physical activity might reduce the risk of depressive symptoms, but there are limited data on Black women.* ***Purpose:*** *The objective was to evaluate the association between leisure time physical activity and depressive symptoms in U.S. Black women.* ***Methods:*** *Participants included 35,224 women ages 21 to 69 from the Black Women's Health Study, a follow-up study of African American women in which data are collected biennially by mail questionnaire. Women answered questions on past and current exercise levels at baseline (1995) and follow-up (1997). The Center for Epidemiologic Studies Depression Scale (CES-D) was used to measure depressive symptoms in 1999. Women who reported a diagnosis of depression before 1999 were excluded. We used multivariate logistic regression models to compute odds ratios (ORs) and 95% confidence intervals (CIs) for physical activity in relation to depressive symptoms (CES-D score ≥ 16) with control for potential confounders.* ***Results:*** *Adult vigorous physical activity was inversely associated with depressive symptoms. Women who reported vigorous exercise both in high school (≥ 5 hr per week) and adulthood (≥ 2 hr per week) had the lowest odds of depressive symptoms (OR = 0.76, 95% CI = 0.71–0.82) relative to never active women; the OR was 0.90 for women who were active in high school but not adulthood (95% CI = 0.85–0.96) and 0.83 for women who were inactive in high school but became active in adulthood (95% CI = 0.77–0.91). Although walking for exercise was not associated with risk of depressive symptoms overall, there was evidence of a weak inverse relation among obese women (Body Mass Index ≥ 30).* ***Conclusions:*** *Leisure time vigorous physical activity was associated with a reduced odds of depressive symptoms in U.S. Black women.*

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INTRODUCTION

Major depression is one of the most common illnesses in industrialized countries and is projected to become the world's second leading cause of disability and mortality by 2020 (1). The prevalence of depression is greater in women than in men (2), and has been shown to be greater in African Americans than in other ethnic groups in some (2–4), but not all (5–7), studies. Established risk factors for depression include low income, low educational attainment, young age, and never having been married (8).

A growing body of evidence from largely White populations suggests that physical activity might reduce the risk of depressive symptoms. Of the 15 prospective observational studies that have examined physical activity and risk of subsequent depression, 11 found an inverse association (9–20) and 5 were null (21–25). In the only two prospective observational studies that included Black women (9,17), results were either not stratified by race (17) or were limited due to small sample size (9). Thus, there are virtually no published data on the relation of physical activity to depression in Black women.

Levels of physical activity are lower among Black women compared with other populations in the United States (26,27). If low levels of physical activity increase the risk of depressive symptoms, this may contribute to the excess burden of depression among U.S. Black women. This observational study investigates the relation of leisure time physical activity to depressive symptoms in a large cohort of U.S. Black women. We hypothesized that regular physical activity would be inversely associated with depressive symptoms. Plausible biological mechanisms to support a protective effect of physical activity on depression are increased cortical blood flow, the release of endorphins, and increased epinephrine and norepinephrine synthesis (28). Physical activity may also serve as a buffer against stressful events, enhance self-efficacy and self-esteem, and decrease social isolation.

METHODS

Study Population

The Black Women's Health Study (BWHS) is an ongoing prospective cohort study designed to examine risk factors for major illnesses in African American women. In 1995, approximately 59,000 Black women ages 21 to 69 years were enrolled through questionnaires mailed to subscribers of *Essence* magazine, members of Black professional organizations, and friends and relatives of respondents (29). The 1995 (baseline) questionnaire elicited information on demographic and behavioral characteristics, anthropometric factors, health care utilization, and medical conditions. BWHS participants represent various geographic regions of the United States, with the majority residing in California, New York, Illinois, Michigan, Georgia, and New Jersey. The cohort is followed every 2 years by postal questionnaire; the 1997 and 1999 follow-up questionnaires were completed by 90% and 87% of the original cohort, respectively.

Assessment of Depressive Symptoms

The 1999 follow-up questionnaire included the 20-item Center for Epidemiologic Studies Depression Scale (CES-D), an instrument used to assess depressive symptoms in community samples and population-based studies (30). Respondents were asked to rate each item, indicating the frequency of various feelings experienced during the previous week on a 4-point scale ranging from "rarely or none of the time" to "most or all of the time." The measure included items such as "I felt sad," "I felt lonely," "I felt depressed," and "I enjoyed life." Total scores ranged from 0 to 60. The validity and reliability of the CES-D has been repeatedly documented (2,30–34), including among African American women (31,34).

Assessment of Physical Activity and Covariates

On the 1995 and 1997 questionnaires, women reported the average number of hours (none, < 1, 1, 2, 3–4, 5–6, 7–9, and ≥ 10) they spent each week during the past year engaged in "walking for exercise" and "vigorous exercise (such as basketball, swimming, running, aerobics)." A separate variable was included on the 1995 questionnaire to assess "vigorous exercise during high school," using the same frequency categories as noted earlier.

The test–retest reliability of physical activity reported on the 1997 questionnaire was assessed among a subset of 1,123 BWHS participants who inadvertently completed the 1997 questionnaire twice. The weighted kappas were 0.57 for walking for exercise (hours per week) and 0.69 for vigorous physical activity (hours per week). These kappas were similar to those reported in the Women's Health Initiative observational study of recreational physical activity in relation to breast cancer (35).

Data on height, weight, cigarette smoking, alcohol consumption, preexisting health conditions, energy intake, education, occupation, marital status, child care responsibilities, and geographic region were ascertained on the baseline survey and were considered as potential confounders or effect modifiers. Body mass index (BMI) was calculated as kilograms divided by meters squared.

Exclusion Criteria

Among the 51,170 women who completed the 1999 questionnaire (87% of original cohort), 40,795 women provided complete information on the CES-D items (80%) and were eligible for inclusion. We excluded 2,860 women who reported physician-diagnosed depression on the baseline or 1997 questionnaires, because their physical activity levels may have been influenced by depression, and 2,711 women with missing data on physical activity or covariates. The 35,224 women included in the analytic sample were similar to those not included with respect to physical activity levels (vigorous exercise: 2.0 vs. 1.9 hr per week; walking for exercise: 2.1 vs. 2.2 hr per week), age (mean years: 38.2 vs. 40.6), geographic region (% living in Northeast: 26.7 vs. 28.4; % living in South: 31.1 vs. 29.7; % living in Midwest: 23.6 vs. 22.9; and % living in West: 18.6 vs. 18.7), education (mean years: 14.9 vs. 14.5), BMI (mean kg/m^2: 27.9 vs. 28.2), energy intake (mean kilocalories per day: 1,507 vs. 1,475), alcohol consumption (mean number of drinks per week: 1.4 vs. 1.5), cigarette smoking (% current: 15.2 vs. 18.2; % former: 18.9 vs. 20.1), child care responsibilities (44.5% vs. 48.5%), marital status (% married: 40.0 vs. 39.5), and occupation (% professional: 45.5 vs. 41.3).

Data Analysis

Women were divided into subgroups based on their self-reported frequency of walking for exercise or vigorous physical activity (none, < 1, 1, 2, 3–4, 5–6, ≥ 7 hr per week). To represent physical activity in adulthood as accurately as possible, we created an average measure of physical activity from the 1995 and 1997 questionnaires (36). The self-reported physical activity variables were positively and significantly correlated across the 1995 and 1997 questionnaires: Spearman correlation coefficients were 0.51 for vigorous physical activity ($p < .001$) and 0.43 for walking for exercise ($p < .001$). We also examined changes in vigorous activity from past (high school) to present (adulthood), using a four-level variable: active in high school (≥ 5 hr per week) and adulthood (≥ 2 hr per week), active in high school but not adulthood, inactive in high school but active in adulthood, and inactive both in high school and adulthood.

We computed percentages for various characteristics associated with physical activity levels standardized to the age distribution of the cohort at baseline. Logistic regression was used to compute odds ratios (ORs) and 95% confidence intervals (95% CI) for the association of physical activity with depressive symptoms as measured by a CES-D score of 16 or higher, a standard cutoff used to identify clinical depression in community samples (30,37–40). In addition to the unadjusted models, we constructed two multivariate models. The first model controlled for known or suspected confounders of the physical activity and depression association, selected from a set of variables associated with vigorous physical activity in our cohort (Table 1). Based on these criteria, we adjusted for age (5-year intervals), geographic region (West vs. non-West), and measures of socioeconomic status, including education (≤ 12, 13–15, 16, 17+ years), occupation (professional or managerial, sales or clerical, service, crafts, operative, farmer, other), and marital status (single, divorced, separated, or widowed, married or partnered). The second model further controlled for factors that may be intermediates of the association between physical activity and depression, including BMI (< 20, 20–24, 25–29, 30+ kg/m^2), preexisting health conditions (cardiovascular disease, diabetes, or cancer vs. none) and child care responsibilities (yes vs. no), or potential downstream effects of depression, including energy intake (< 1,000, 1,000–1,499, 1,500+ kilocalories per day), alcohol consumption (drinks per week), and smoking (current, past, never). Both forms of physical activity, walking and vigorous exercise, were mutually adjusted for each other.

To evaluate the presence of a dose-response relation, we conducted tests for trend by including in the regression model a single continuous term coded as the midpoint of each physical activity category (assigning 11 hr per week to the top category) (41). Tests for trend excluded the zero-level exposure category. Analyses were stratified by age (< 40, 40+), BMI (< 30, 30+ kg/m^2), education (≤ 12, 13–16, 17+ years), and geographic region, because the relation between physical activity and depressive symptoms may be modified by these variables. To formally test for interaction on the multiplicative scale, we computed the likelihood ratio test for the comparison of models with and without interaction terms. All analyses were carried out using SAS statistical software version 8.02 (42).

RESULTS

Twenty-four percent of women reported no vigorous physical activity and 10% reported 5 hr or more of vigorous physical activity on average per week (Table 1). Consistent with published results from a study of physical activity correlates in the BWHS (43), vigorous physical activity was most strongly associated with younger age, greater education, not smoking, living in the West, and the absence of preexisting health conditions. Walking for exercise (reported by 11% of women at levels of 5 hr or more per week) was positively associated with education, not smoking, and living in the West (data not shown).

An inverse association was observed between adult vigorous physical activity and depressive symptoms (Table 2). Compared with women who reported no adult vigorous physical activity, the multivariate OR for women reporting 7 hr or more per week was 0.75 (95% CI = 0.65–0.87). Although there was a statistically significant test for trend among vigorous exercisers, visual inspection of the ORs did not show evidence of a monotonic inverse relation. The ORs decreased with increasing vigorous physical activity up until 3 to 4 hr per week, after which they did not decrease further. Walking for exercise was not associated with depressive symptoms in multivariate analyses.

When we examined vigorous physical activity levels across the life span, women who were active both in high school (≥ 5 hr per week) and adulthood (≥ 2 hr per week) had the lowest odds of depressive symptoms (OR = 0.76, 95% CI = 0.71–0.82) relative to never active women; the OR was 0.90 (95% CI = 0.85–0.96) for women who were active in high school but not adulthood, and 0.83 (95% CI = 0.77–0.91) for women who were inactive in high school but active in adulthood.

Associations between physical activity and depressive symptoms within different age and BMI strata are presented in Table 3. In analyses stratified by age, associations with depressive symptoms of adult vigorous physical activity and walking for exercise were similar within both age strata. Despite the different time lags between high school and adult vigorous physical activity among the various age groups (ranging from approximately 2 to 51 years), the ORs representing lifetime vigorous physical activity in relation to depressive symptoms were similar in older and younger women. In analyses stratified by BMI (< 30 vs. 30+), the ORs comparing adult vigorous physical activity categories of 5 hr or more per week versus none were slightly stronger in nonobese than obese women, but the associations were not statistically different (p value, test for BMI interaction = .28). In contrast, the association between walking for exercise and depressive symptoms appeared to depend on BMI (p value, test for interaction = .02): walking for exercise was weakly inversely associated with depressive symptoms among obese women (p value, test for trend = .007), but there was no association among nonobese women (p value, test for trend = .94). Associations between physical activity and depressive symptoms were uniform within strata of educational attainment and geographic region of residence (data not shown).

Some women changed their levels of physical activity between 1995 and 1997. Although most women (n = 28,585, 81%) remained within two categories of vigorous physical activity, 19% (n = 6,709) reported a change in vigorous physical activity of more than two categories (e.g., reported 2 hr per week in 1995 and none in 1997). Among these women, 28% increased their activity levels and 72% decreased their activity levels. A decrease in physical activity was significantly associated with younger age, lower BMI, lower educational attainment, and having higher baseline levels of adult vigorous physical activity and walking. An increase in physical activity was significantly associated with younger age and having lower baseline levels of adult vigorous physical activity. When we confined the analyses to women who remained within two categories of their reported vigorous physical activity between 1995 and 1997, the results were virtually identical to those presented herein (data not shown).

Results were similar to those presented in Tables 2 and 3 when we used physical activity data from 1995 only or when we repeated the analysis using a more stringent cutoff for depressive symptoms (CES-D ≥ 25; data not shown). Multivariate linear regression analyses in which a continuous CES-D outcome variable was used were consistent with the models that used a binary cutoff (data not shown).

DISCUSSION

In this observational study of Black women, vigorous physical activity in adulthood was inversely associated with depressive symptoms. The biggest decrease in the odds of depressive symptoms was observed among women who were active in both high school and adulthood. Women who were active in high school only or adulthood only still had significantly lower odds of depressive symptoms relative to women who were never active.

Walking for exercise was not associated with risk of depressive symptoms overall, but there was some evidence of an in-

TABLE 1
Baseline Characteristics of 35,224 Women According to Vigorous Physical Activity, the Black Women's Health Study

		Vigorous Physical Activity		
Characteristic	*No. of Women*	*None*[a]	*< 5 hr/week*[b]	*5+ hr/week*[c]
Age, years (%)				
< 30	8,469	14.0	73.8	12.2
30–39	12,212	19.1	69.2	11.7
40–49	9,493	28.4	63.1	8.5
50–59	3,773	40.9	53.0	6.1
60+	1,277	52.8	41.7	5.5
Education, years (%)[d]				
≤ 12	4,879	37.4	54.5	8.1
13–15	12,737	25.7	64.0	10.3
16	8,890	20.7	68.4	10.9
17+	8,517	17.2	72.7	10.1
Occupational category (%)				
Professional/Managerial	20,660	20.6	68.9	10.5
Sales/Clerical	8,772	28.0	63.0	9.0
Service/Crafts/Operative/Farmer	3,291	32.8	57.4	9.8
Other	2,501	27.9	59.4	12.7
Marital status (%)				
Married/Living with partner	14,203	24.6	66.7	8.7
Separated/Widowed/Divorced	8,339	24.7	64.1	11.2
Single	12,682	24.4	64.6	11.0
Body mass index, kg/m^2 (%)				
< 20	2,119	27.0	64.1	8.9
20–24	12,009	18.4	67.9	13.7
25–29	10,955	22.0	67.9	10.1
30+	10,141	31.4	62.5	6.1
Energy intake, kilocalories/day (%)[d]				
< 1,000	7,742	22.6	66.3	11.1
1,000–1,499	10,394	22.0	67.9	10.1
1,500+	15,002	24.7	65.5	9.8
Child care responsibilities (%)				
Yes	15,604	26.3	64.5	9.2
No	19,620	22.3	66.6	11.1
Smoking history (%)				
Current	5,115	31.7	59.4	8.9
Former	6,504	23.0	66.2	10.8
Never	23,605	22.9	67.0	10.1
Current alcohol consumption (%)				
Yes	8,752	21.6	67.6	10.8
No	26,472	24.8	65.3	9.9
Preexisting health condition (%)				
Yes	1,882	31.5	61.0	7.5
No	33,342	23.5	66.4	10.3
Geographic region of residence (%)				
Northeast	9,553	24.8	64.9	10.3
South	10,905	25.0	65.8	9.2
Midwest	8,266	24.9	65.6	9.5
West	6,500	19.8	67.9	12.3

Note. Characteristics (with exception of age) are standardized to age distribution of women at baseline and are reported as row percentages. Vigorous physical activity is averaged over 1995 and 1997 questionnaires.
[a]n = 8,437. [b]n = 23,219. [c]n = 3,568. [d]Numbers do not sum to total due to missing values for education (n = 201) and energy intake (n = 2,086).

TABLE 2
Odds Ratios for Depressive Symptoms in 1999 (CES–D 16+) in Relation to Leisure Time Physical Activity

Type of Physical Activity	*No.*	*CES–D ≥ 16 (%)*	*Crude OR (95% CI)*	*Model 1 OR (95% CI)*[a]	*Model 2 OR (95% CI)*[b]
Adult vigorous activity, hr/week					
None	8,437	29.5	1.00[c]	1.00[c]	1.00[c]
<1	8,852	28.0	0.93 (0.87–1.00)	0.86 (0.80–0.92)	0.89 (0.83–0.95)
1	5,900	26.8	0.88 (0.81–0.94)	0.80 (0.74–0.87)	0.85 (0.78–0.92)
2	4,692	23.8	0.75 (0.69–0.81)	0.69 (0.63–0.75)	0.74 (0.68–0.81)
3–4	3,775	23.3	0.73 (0.66–0.79)	0.66 (0.60–0.73)	0.72 (0.66–0.80)
5–6	2,139	26.3	0.85 (0.77–0.95)	0.75 (0.66–0.84)	0.81 (0.72–0.92)
7+	1,429	25.0	0.80 (0.70–0.91)	0.67 (0.58–0.77)	0.75 (0.65–0.87)
Test for continuous trend[d]			$p < .001$	$p < .001$	$p < .001$
Adult walking for exercise, hr/week					
None	3,392	29.8	1.00[c]	1.00[c]	1.00[c]
< 1	10,486	29.2	0.97 (0.89–1.05)	1.09 (0.99–1.18)	1.08 (0.99–1.18)
1	6,628	26.3	0.84 (0.77–0.92)	0.97 (0.88–1.07)	0.97 (0.88–1.07)
2	6,122	24.7	0.77 (0.70–0.85)	0.96 (0.87–1.05)	0.95 (0.86–1.06)
3–4	4,717	23.8	0.74 (0.67–0.81)	0.94 (0.85–1.05)	0.94 (0.84–1.05)
5–6	2,390	25.4	0.80 (0.71–0.90)	1.01 (0.89–1.14)	0.99 (0.87–1.12)
7+	1,489	27.4	0.89 (0.77–1.02)	1.14 (0.98–1.31)	1.09 (0.94–1.26)
Test for continuous trend[d]			$p < .001$	$p = .57$	$p = .25$
Lifetime vigorous activity[e], hr/week					
Never active	15,537	28.7	1.00[c]	1.00[c]	1.00[c]
Active in high school, inactive in adulthood	8,762	26.8	0.91 (0.86–0.96)	0.93 (0.88–0.99)	0.90 (0.85–0.96)
Inactive in high school, active in adulthood	3,840	24.6	0.81 (0.75–0.88)	0.78 (0.72–0.85)	0.83 (0.77–0.91)
Always active	5,797	23.9	0.78 (0.73–0.84)	0.74 (0.69–0.79)	0.76 (0.71–0.82)

Note. CES–D = Center for Epidemiologic Studies–Depression Scale; OR = odds ratio; CI = confidence interval.
[a]Adjusted for age (5-year intervals), education (≤ 12, 13-15, 16, 17+ years), occupation (professional/managerial, sales/clerical, service/crafts/operative/farmer, other), marital status (single, divorced/separated/widowed, married/partnered), and geographic region (West vs. non-West), and mutually adjusted for each form of physical activity (in categories above). [b]Adjusted for Model 1 covariates and body mass index (< 20, 20-24, 25-29, 30+), preexisting health conditions (cardiovascular disease, diabetes, or cancer vs. none), energy intake (< 1000, 1000-1499, 1500+), smoking (current, past, never), current alcohol consumption (drinks/week), and child care responsibilities (yes vs. no). [c]Reference group. [d]Excludes zero-level exposure category. [e]Active = 5+ hr in high school or 2+ hr in adulthood. Excludes women with missing data on high school physical activity (n = 1,288, 3.7% nondepressed; n = 101, 3.8% depressed).

verse association, albeit weak, among obese women (BMI 30+). Although obese women were less likely to be active in general, those who were active were more likely to engage in walking as opposed to vigorous physical activity. If causal, the association of walking with fewer depressive symptoms in obese women may have important public health implications, because few obese individuals appear able to perform or sustain high levels of vigorous physical activity. Moreover, physiologically, based on perceived and measured exertion, brisk walking among obese individuals might be equivalent to "vigorous" physical activity (44,45).

Our findings agree with 11 prospective observational studies that have reported a protective effect of physical activity on depressive symptoms (9–20). Five other studies found no association (21–25). To our knowledge, none of these studies stratified by BMI to assess whether certain forms of physical activity might be more beneficial in obese compared with nonobese women. One study reported an inverse association between walking and depressive symptoms among people ages 65 and older (14); small numbers of women (n = 455) limited our ability to examine the influence of walking in that age group. Our finding of an inverse association of depressive symptoms with vigorous physical activity in high school is compatible with three studies of young athletes (12,18,19). Our findings also agree with most secondary prevention clinical trials of exercise in the treatment of depression (46,47).

The BWHS is the first large study of U.S. Black women to assess the relation between physical activity and depressive symptoms. We used the average of two physical activity variables measured at two separate points in time (1995 and 1997), which may provide a more valid measure of long-term physical activity than a measure taken at a single point in time (36). Data on physical activity during high school allowed us to examine changes in exercise patterns over time.

Several limitations to this study are worth considering. First, although our study was prospective in design, it was not possible to determine whether physical activity levels were antecedent to, or consequences of, depression. Our CES-D measure was self-administered in 1999 only. Because it was not administered in 1995, we could not use the CES-D scale to identify and exclude women reporting depressive symptoms at baseline. However, by excluding women who reported physi-

TABLE 3

Multivariate Odds Ratios (ORs) for Depressive Symptoms in 1999 (CES–D 16+) in Relation to Leisure Time Physical Activity, Stratified by Age and Body Mass Index (BMI) at Baseline

	Younger Than Age 40			*Age 40 or Older*		
Type of Physical Activity	*No.*	*CES–D ≥ 16 (%)*	*Multivariate OR (95% CI)*[a]	*No.*	*CES–D ≥ 16 (%)*	*Multivariate OR (95% CI)*[a]
Adult vigorous activity, hr/week						
None	3,522	37.3	1.00[b]	4,915	23.8	1.00[b]
< 2	8,902	31.3	0.84 (0.77–0.91)	5,850	21.9	0.89 (0.81–0.98)
2–4	5,799	26.1	0.70 (0.63–0.77)	2,668	18.2	0.75 (0.66–0.85)
5+	2,458	28.5	0.77 (0.68–0.88)	1,110	19.6	0.78 (0.65–0.93)
Test for continuous trend[c]			$p = .017$			$p = .004$
Adult walking for exercise, hr/week						
None	2,120	32.4	1.00[b]	1,272	25.6	1.00[b]
< 2	10,282	31.4	1.08 (0.97–1.20)	6,832	23.1	0.99 (0.86–1.14)
2–4	6,187	28.5	1.01 (0.90–1.14)	4,652	18.8	0.85 (0.73–1.00)
5+	2,092	30.5	1.05 (0.91–1.21)	1,787	21.0	0.98 (0.82–1.18)
Test for continuous trend[c]			$p = .41$			$p = .20$
Lifetime vigorous activity, hr/week						
Never active	8,455	33.2	1.00[b]	7,082	23.3	1.00[b]
Active in high school, inactive in adulthood	5,037	31.1	0.93 (0.87–1.01)	3,725	21.0	0.86 (0.78–0.95)
Inactive in high school, active in adulthood	2,569	27.4	0.85 (0.77–0.94)	1,271	19.0	0.79 (0.67–0.92)
Always active	4,138	26.0	0.77 (0.71–0.84)	1,659	18.6	0.75 (0.65–0.86)
	BMI < 30			*BMI 30+*		
	No.	*CES–D ≥ 16 (%)*	*Multivariate OR (95% CI)*[a]	*No.*	*CES–D ≥ 16 (%)*	*Multivariate OR (95% CI)*[a]
Adult vigorous activity, hr/week						
None	5,077	27.0	1.00[b]	3,360	33.1	1.00[b]
< 2	10,292	25.8	0.88 (0.81–0.96)	4,460	31.6	0.85 (0.76–0.94)
2–4	6,743	22.8	0.75 (0.68–0.82)	1,724	26.7	0.68 (0.59–0.78)
5+	2,971	24.5	0.78 (0.69–0.87)	597	31.8	0.86 (0.70–1.06)
Test for continuous trend[c]			$p < .001$			$p = .19$
Adult walking for exercise, hr/week						
None	2,364	27.8	1.00[b]	1,028	34.4	1.00[b]
< 2	11,843	25.9	1.01 (0.91–1.12)	5,271	32.9	1.10 (0.94–1.27)
2–4	7,981	23.1	0.95 (0.85–1.06)	2,858	27.9	0.94 (0.79–1.10)
5+	2,895	25.1	1.05 (0.92–1.20)	984	29.2	0.93 (0.76–1.15)
Test for continuous trend[c]			$p = .94$			$p = .007$
Lifetime vigorous activity, hr/week[d]						
Never active	10,394	26.3	1.00[b]	5,143	33.6	1.00[b]
Active in high school, inactive in adulthood	5,959	25.6	0.95 (0.88–1.02)	2,803	29.3	0.83 (0.75–0.92)
Inactive in high school, active in adulthood	3,125	24.0	0.88 (0.80–0.97)	715	27.3	0.71 (0.59–0.85)
Always active	4,716	22.8	0.78 (0.72–0.85)	1,081	28.6	0.73 (0.63–0.85)

Note. CES–D = Center for Epidemiologic Studies–Depression Scale; CI = confidence interval.
[a]Adjusted for age, education, occupation, marital status, preexisting health conditions, energy intake, smoking, current alcohol consumption, and child care responsibilities. Mutually adjusted for each form of physical activity. [b]Reference group. [c]Excludes zero-level exposure category. [d]Active = 5+ hr in high school or 2+ hr in adulthood.

cian-diagnosed depression before 1999, we attempted to minimize the possibility that depression influenced levels of physical activity.

Second, as with any observational study in which the exposure is not randomly allocated, the association between physical activity and depressive symptoms may have been confounded by other unmeasured factors. We were able to measure and control for several potential confounding variables (e.g., preexisting health conditions, smoking) and results were similar whether or not we included these variables in the model.

Third, our study focused on leisure time physical activity and did not include other forms of physical activity that may be related to depression, such as occupational and utilitarian activity. In addition, we did not have extensive detail on the actual type of physical activity (e.g., basketball vs. aerobics) or its intensity (e.g., brisk vs. slow walking), which may have led to some misclassification of activity levels. The lack of a monotonic dose-response relation may suggest a threshold effect for vigorous physical activity or may indicate that women reporting levels of vigorous physical activity in excess of 5 hr per week represent a distinct group of individuals with a greater risk of depression (e.g., women with low self-image). The curvilinear pattern may also be the result of reporting error if, for example, women with underlying depression were more likely to overreport their activity levels relative to nondepressed women.

Fourth, although the CES-D scale has been widely used in community-based samples to screen for depression, it is not a definitive clinical measure of depression. In one study, a cutoff of "16 or more" identified 65% of women with clinical depression (40). Despite its inability to capture all women with depression, the CES-D scale is practical for large epidemiologic studies in which the administration of a more structured clinical interview is not feasible. Furthermore, results were similar when we used a cutoff of 25 or greater, which was more likely to identify women with clinical depression.

Finally, it is possible that women who developed depression after baseline were more likely to withdraw from the study. When we compared those included in this analysis to those not included with respect to baseline physical activity measures, in addition to demographic, social, and lifestyle characteristics, we did not observe any important differences. Prevalence estimates for vigorous physical activity and walking for exercise in the BWHS are consistent with estimates from nationally representative studies of Black women (26,48). The proportion of women who reported depressive symptoms (CES-D 16+) in our sample (27%) is higher than that found in the general population normative sample (21%) (30), but is compatible with estimates found for Black women in other studies (4,8).

Although study participants reside in more than 14 U.S. states, the BWHS is a convenience sample and was not designed to be representative of the general population of U.S. Black women. In particular, the study cohort underrepresents women with less than a high school education. However, the observed associations persisted within strata of education—as well as age and geographic region—suggesting that they might extend to the general population of U.S. Black women ages 21 to 69 years.

Several mechanisms could explain a protective effect of physical activity on depressive symptoms. Physical exercise influences the central dopaminergic, noradrenergic, and serotonergic systems (28). The increased biosynthesis of neurotransmitters, including monoamines (28), catecholamines (49), and endorphins (50,51), may improve mood. Social–psychological mechanisms include enhanced self-efficacy and self-esteem, improved self-image and self-worth, and decreased social isolation (10). Physical activity may also boost immune function (52,53), and prevent chronic conditions (e.g., hypertension and diabetes) associated with depression.

In summary, our results suggest that vigorous physical activity reduces depressive symptoms in U.S. Black women, and that despite a history of inactivity, the initiation of a current physical activity program could have mental health benefits. In the context of primary prevention research, additional studies are needed to clarify the optimal frequency and intensity of exercise needed to have an effect. According to data from the NHANES study, the prevalence of leisure time activity among Black women in the United States is about half that of White women (26,27). Interventions aimed at increasing physical activity among Black women will need to target groups with lower exercise levels, such as women with low educational attainment and obese women.

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