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RESEARCH ARTICLE

Lifestyle changes are related to reductions in depression in persons with elevated coronary risk factors

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This observational study investigates whether persons with elevated coronary risk factors (CRFs >3 and/or diabetes) and depression [i.e., ≥16 on the Center for Epidemiological Scale – Depression (CES-D)] can make changes in health behaviours over 3 months and improve depressive symptoms and other CRFs. Analyses were based on data from 310 men and 687 women enrolled in the high-risk arm of the Multisite Cardiac Lifestyle Intervention Program, targeting diet (10% fat), exercise (3 h per week) and stress management (7 h per week). As expected, at study entry, depressed persons had a more adverse medical status, consumed more dietary fat and practiced less stress management than non-depressed persons. To examine 3-month changes, participants were grouped into (1) depressed persons who became non-depressed (CES-D ≤ 16, $n = 248$; 73%), (2) persons who remained or became depressed (CES-D >16, $n = 76$) and (3) non-depressed persons who remained non-depressed ($n = 597$). All persons, regardless of group, met program goals. The greatest improvements (i.e., diet, exercise, perceived stress, hostility and mental health) were observed in Group 1 relative to Groups 2 and 3, which did not differ from each other. Comprehensive lifestyle changes appear to be feasible and beneficial for initially depressed persons with elevated CRFs.

Keywords: elevated coronary risk factors; depressive symptoms; lifestyle changes

Introduction

Over the past two decades the number of persons at high risk for coronary heart disease (CHD) has dramatically increased (Eckel, Grundy, & Zimmet, 2005). This worldwide development is driven by the global epidemic of obesity and diabetes (Eckel et al., 2005). In the US, approximately 35–40% of the population meets the criteria for the metabolic syndrome (Ford, 2005), a constellation of metabolic risk factors including glucose abnormalities (e.g., elevated plasma glucose), central obesity, dyslipidemia and hypertension (Bianchi, Penno, Romero, Del Prato, & Miccoli, 2007; Grundy et al., 2005). No consensus has yet been reached regarding

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the inclusion of type 2 diabetes as an additional criterion for the metabolic syndrome. For example, the World Health Organization and the International Diabetes Federation include type 2 diabetes as a criterion for metabolic syndrome whereas the National Cholesterol Education Program (NCEP)-ATP III Guidelines do not. Regardless of the exact definition of the syndrome, the risk for major cardiac events in patients with this syndrome is at least twice as high as for those without the syndrome (Eckel et al., 2005). For patients with type 2 diabetes, the added diagnosis of metabolic syndrome confers an approximate five-fold greater risk for cardiac events (Eckel et al., 2005).

Lifestyle modification is currently the primary treatment recommended to prevent progression of the metabolic syndrome to CHD (Bianchi et al., 2007) and may represent an effective and safe alternative to intensive medical treatment for patients with type 2 diabetes (The Action to Control Cardiovascular Risk in Type 2 Diabetes Study Group, 2008). In particular, bodyweight reduction, regular physical activity and dietary changes are recommended to reduce the underlying behavioural risk factors of the metabolic syndrome (Bianchi et al., 2007; Grundy et al., 2005; Yusuf et al., 2004). Lifestyle interventions addressing these behavioural risk factors have been tested in numerous studies and have demonstrated improvements in cardiovascular risk factors (Boulé, Haddad, Kenny, Wells, & Sigal, 2001; Boulé, Kenny, Haddad, Wells, & Sigal, 2003; Costacou & Mayer-Davis, 2003; Elmer et al., 2006; Hu & Willett, 2002; Kronenerg et al., 2000; Orchard et al., 2005; Stampfer, Hu, Manson, Rimm, & Willett, 2000; The Look AHEAD Research Group, 2007; Toobert, Stryker, Glasgow, Barrera, & Angell, 2005; Tuomilehto et al., 2001; Wister et al., 2007) and a delay in the onset of type 2 diabetes (Lindström et al., 2006; Pan et al., 1997; The Diabetes Prevention Program Research Group, 2002). In addition to behavioural risk factors, psychological factors have been linked to the etiology and prognosis of the metabolic syndrome.

A recent prospective cohort study found that high levels of depressive symptoms at baseline predicted an increased risk of developing metabolic syndrome in initially healthy women 15 years later (Räikkönen, Matthews, & Kuller, 2007). Similarly, depression was associated with approximately 60% increased odds for the metabolic syndrome in 652 women with suspected coronary artery disease (i.e., women who received coronary angiography; Vaccarino et al., 2008). These results were independent of demographic factors, behavioural risk factors and functional status. In this study, women with both elevated depressive symptoms and a previous diagnosis of depression (Vaccarino et al., 2008) were compared to women with either one of these two conditions. The number of metabolic syndrome risk factors increased gradually by severity of depression across these three depression groups. Women with both elevated depressive symptoms and a previous diagnosis of depression had a 2.6 times higher risk for cardiovascular disease over a median follow-up of 5.9 years. Thus, it would be advisable to target depression in lifestyle interventions that modify behavioural risk factors of the metabolic syndrome.

It is known that depression is an obstacle to lifestyle changes that are necessary to reduce cardiovascular risk factors and to prevent heart disease. Depressed patients may find it difficult to follow lifestyle changes (Vickers, Nies, Patten, Dierkhising, & Smith, 2006). Depression is associated with a more sedentary lifestyle, smoking, obesity, lack of exercise and poor glycemic control (Gonzalez et al. 2007; Goodman & Whitaker, 2002; Katon et al., 2004; Patton et al., 1998; Rajala, Uusimäki, Keinänen-Kiukaanniemi, & Kivelä, 1994; Steptoe et al., 1997). Engaging in exercise

or improving one's lifestyle, on the other hand, has been shown to have a strong antidepressant effect in patients with CHD and in healthy non-depressed patients (Farmer et al., 1988; Lett, Davidson, & Blumenthal, 2005).

While there is growing literature on depression in cardiac populations (e.g., Blumenthal, 2008; Lichtman et al., 2008), only a few studies have investigated changes in depression in persons with metabolic syndrome participating in lifestyle interventions. Two studies have assessed changes in depression in patients with type 2 diabetes participating in lifestyle interventions. Toobert et al. (2007) evaluated changes in depression in postmenopausal women with diabetes who participated in a comprehensive lifestyle intervention (Mediterranean diet, exercise, stress management and smoking cessation) compared to a usual care group but did not find significant changes in depression over 2 years. Georgiades et al. (2007) found that cognitive-behavioural therapy significantly reduced depression in patients with diabetes (71% female) over 1 year. However, these reductions were not associated with changes in HbA1c or fasting glucose levels and gender differences were not tested. It is conceivable that the interventions employed in the above studies were not sufficiently intensive to affect depression and CRFs in this population.

The purpose of this study was to evaluate whether persons with elevated coronary risk factors (CRF >3 and/or diabetes) and depression (i.e. ≥ 16 on the Center for Epidemiological Scale – Depression (CES-D)) can reduce dietary fat intake to 10%, exercise 3 h per week, practice stress management for 7 h per week and reduce depressive symptoms. In addition, we examined whether improvements in depressive symptoms are associated with reductions in CRFs.

Method

Participants

The present investigation was based on 997 persons with metabolic syndrome (i.e., >3 CRFs and/or diabetes) (310 men, 687 women) who enrolled in the Multisite Cardiac Lifestyle Intervention program (MCLIP) from September 1998 to December 2006. The MCLIP is an on-going comprehensive lifestyle change program for the prevention of CHD administered by insurance companies and proven to be effective in prior clinical trials (Ornish et al., 1983; Ornish et al., 1990). The MLCIP included two groups: one arm included patients with CHD (Daubenmier et al., 2007; Frattaroli, Weidner, Merritt-Worden, Frenda, & Ornish, 2008; Govil, Weidner, Merritt-Worden, & Ornish, 2008), the second arm included persons at high risk for CHD, which is the focus of this study. The protocol was approved by the Committee on the Protection of Rights of Human Subjects and written informed consent was obtained from all participants. The study was performed in accordance with the ethical standards of the 1964 Declaration of Helsinki.

Participants were referred to the program by physicians or self-referred through multiple recruitment strategies that included advertising, media publicity and letters from their health insurance company. All participants were members of health insurance plans (e.g. Highmark, Inc., West Virginia Public Employees Insurance Agency, Mountain State BlueCross/BlueShield). The company's claims databases were used to identify members who were at high risk for CHD. Persons were eligible for the program's high CHD risk arm if they had either a family history of premature CHD (i.e., 1st-degree relative with myocardial infarction or sudden cardiac

death; male relative: <age 55 years, female relative: <age 65 years) or were a male aged >45 years or female aged >55 years. In addition, eligible persons must have presented with at least two other of the following documented cardiovascular risk factors: current cigarette smoking (within past 5 years), hypertension (blood pressure >140/90 mmHg or on antihypertensive medication), low high-density lipoprotein cholesterol (HDL-C) (<40 mg/dL or on medications for lipid therapy), elevated apolipoprotein (a) (>30 mg/dL or on medications for elevated lipids), total cholesterol >240 (or on medications for elevated lipids), low-density lipoprotein cholesterol (LDL-C) >160 (or on medications for elevated lipids), high sensitivity c-reactive protein >3 mg/dL and <10 mg/dL, obesity (BMI >30), insulin resistant state as per American Heart Association/National Heart, Lung and Blood Institute diagnosis guidelines [including any three of the following criteria: abdominal obesity (men: waist >40 in.; women: waist >35 in.), triglycerides >150 mg/dL and HDL (men: <40 mg/dL, women: <50 mg/dL), blood pressure ≥130/85 mmHg, either fasting glucose ≥110 mg/dL], type 2 diabetes. The diagnosis of type 2 diabetes was defined as a 'coronary risk equivalent' (Third Report of the NCEP Expert Panel, 2002) indicating that a diagnosis of type 2 diabetes only sufficed to be eligible for the program.

Exclusion criteria included (1) current tobacco user not concurrently enrolled in a smoking cessation program, or with at least a 2-month history of smoking cessation, (2) primary residence more than a 1 h commute from the program site, unless approved, (3) history of substance abuse disorder without documentation of a minimum 1-year abstinence, (4) history of a significant psychiatric disorder without documentation of a minimum 1-year stability, (5) impaired cognitive function, such as dementia or delirium, (6) English language illiteracy unless program site could accommodate, (7) non-ambulatory, (8) uncooperative spouse or partner, defined as obstructive in attitude or behaviour and (9) likely to be disruptive to group setting.

Two different methods were employed to examine the third question addressed in this study, that is whether reductions in depression are associated with reductions in cardiovascular risk factors and improvements in health behaviours, glycemic control and psychological outcomes over 3 months in persons at high risk for CHD. First, we compared cardiac and psychological outcomes of three groups of persons with metabolic syndrome based on their depression scores: (1) depressed persons who became non-depressed (CES-D ≤ 16 at 3 months, $n = 248$; 73%), (2) persons who remained or became depressed (CES-D > 16 at 3 months, $n = 76$), (3) non-depressed persons who remained non-depressed (CES-D ≤ 16 at 3 months; $n = 597$). Second, we analysed associations of changes in depression as a continuous variable with changes in cardiovascular risk factors, health behaviours and psychological outcomes.

Measures

At baseline, demographic information and medical history were documented.

Depression

At baseline and at 12 weeks, depression was assessed by the CES-D (Radloff, 1977). Participants were asked to indicate how often they experienced specific

depressive symptoms during the past week. Total scores range from 0 to 60 with higher scores indicating more symptoms. To determine the presence of a clinically significant number of depressive symptoms, a CES-D cut-off score of 16 was used. A CES-D score $\geq$16 is widely used to diagnose minor depression in healthy and CVD populations (Anstey & Luszcz, 2002; Penninx et al., 1999; Shinar et al., 1986; Weissman, Sholomskas, Pottenger, Prusoff, & Locke, 1977) and has high predictive validity for acute coronary syndrome events and for mortality in initially healthy patients (Anstey & Luszcz, 2002; Lesperance, Frasure-Smith, Juneau, & Theroux, 2000; Rowan, Haas, Campbell, MacLean, & Davidson, 2005; Rugulies, 2002). Similarly, a CES-D score $\geq$16 has been frequently used in patients with type 2 diabetes to assess depressive symptoms (Saydah, Brancati, Golden, Fradkin, & Harris, 2003; Vickers et al., 2006). Patients with diabetes exceeding 15 points on the CES-D scale had a 54% increased mortality, after controlling for sociodemographic, lifestyle and health-status variables (Zhang et al., 2005).

Medical variables

Height, weight and blood pressure were measured by trained health professionals. Fasting blood samples were collected and analysed for total cholesterol, HDL-C, LDL-C, triglycerides and glycated haemoglobin (for patients with diabetes) (HbA1c). Exercise tolerance was assessed by a symptom-limited treadmill test according to the Bruce protocol and the guidelines of the American College of Sports Medicine (Whaley, Brubaker, & Otto, 2006). Metabolic equivalents (METs), a measure of energy expenditure, were automatically calculated by the testing device during the exercise testing (1 MET equals $\sim$3.5 mL of oxygen consumed per minute per kilogram of body weight, for further detail see Frattaroli et al., 2008). Medications (i.e. anti-depressants, beta-blockers, angiotensin-converting enzyme inhibitors, calcium antagonists, diuretics, lipid-lowering agents, oral antiglycemics and insulin) were assessed at baseline and 3-month follow-up by medical staff at the sites.

Other psychosocial variables

In addition, hostility was evaluated using the modified version of the Cook–Medley Hostility scale, a 27-item measure containing three subscales: cynicism, hostile affect and aggressive responding (Barefoot, Dodge, Peterson, Dahlstrom, & Williams, 1989). Total scores range from 0 to 27 with higher scores reflecting greater hostility. Psychological stress was assessed by the 10-item Perceived Stress Scale, which measures the degree to which situations during the past month are appraised as stressful (Cohen, Kamarck, & Mermelstein, 1983). Individual responses range from 0 (never) to 4 (very often) and total scores range from 0 to 40, with higher scores indicating greater perceived stress. Quality of life was measured by the Medical Outcomes Study 36-item Short Form Health Survey (MOS SF-36) (Ware, Snow, Kosinski, & Gandek, 1993) and summarised as physical and mental health aggregate scores (Ware & Kosinski, 2001).

Lifestyle Change Program

Participants attended an onsite program in groups (supervised by site personnel) twice a week for 3 months for a total of 104 h (Billings, 2000; Daubenmier et al., 2007). All participants were encouraged to eat a very low-fat, plant-based diet (10% daily calories from fat, 15% from protein and 75% from complex carbohydrates), engage in moderate aerobic exercise for a minimum of 3 h per week (with a minimum of 30 min per session exercising within their target heart rates) and strength training activities at least twice per week, practice stress management for 1 h per day, and attend group support sessions for 2 h each week for 12 weeks. Participants were individually prescribed exercise levels (typically walking) according to their baseline treadmill test results. This study was approved by each site's institutional review board and all subjects gave informed consent.

Adherence to the Lifestyle Change Program

Diet: Percent of calories from fat (goal: 10%). A registered dietitian instructed participants on how to complete 3-day food diaries and verified dietary data entry, as a measure of quality assurance. Data were analysed using nutrition data system for research software (NDS-R) (versions 4.01_29, 1999 and 4.02_30, 2000, Nutrition Coordinating Center, University of Minnesota, Minneapolis). *Exercise:* Hours per week (goal: 3 h per week). *Stress Management:* hours per week of yoga/meditation (goal: 1 h per day). *Attendance of Intervention Groups:* Number of sessions attended divided by the number of sessions offered. All adherence, risk factor, quality of life and psychological status measurements were made at baseline and 12 weeks. In addition, a lifestyle index, based on a formula validated in previous research (Daubenmier et al., 2007; Ornish et al., 1998; Pischke, Scherwitz, Weidner, & Ornish, 2008), measured overall adherence to intervention guidelines and was calculated as the mean percentage of adherence to each lifestyle behaviour. Zero equalled no compliance and one equalled 100% compliance.

Statistical analyses

For baseline comparisons, patients were categorised into one of the two groups according to their levels of depression: no depression (CES-D score <16) *versus* depression (CES-D score ≥ 16). Baseline group differences were tested using chi-squared (χ^2) analyses and multi-way frequency analyses (for group by gender interactions of categorical variables) and independent samples *t*-tests and ANOVAs (for continuous variables). Changes in depression grouping (i.e., percentage of participants moving from one depression group to another over the follow-up) were assessed using the McNemar test. Group effects, gender effects, time effects and their interactions for CRFs, quality of life, psychosocial outcomes, and adherence to lifestyle changes were tested with repeated measures for ANOVAs and Bonferroni adjustments. In addition, separate analysis was performed for the 11 participants who became depressed at 3 months. Bivariate Pearson's correlations were used to analyse associations between 3-month changes in depression and 3-month changes in CRFs, psychosocial outcomes, quality of life and adherence [using the lifestyle index] as continuous variables in participants who became non-depressed. Statistical analyses were performed using SPSS 14.0 (SPSS Inc, Chicago).

Results

Baseline characteristics

Baseline characteristics are listed in Table 1. Nine-hundred and ninety-seven persons with ≥3 CRFs and/or diabetes and complete CES-D baseline data were included in our analyses. Three-hundred and forty-one persons (82 men, 259 women) had a CES-D score ≥16 and 656 persons (228 men, 428 women) had a CES-D score <16. Depressed persons were more likely to be Caucasian, to be medicated with anti-depressants (especially women) and gastrointestinal medication, to have higher body mass, to have higher diastolic blood pressure, higher levels of hostility and perceived stress and to consume more dietary fat, while non-depressed persons were older, had higher SF-36 physical and mental component scores and practiced more stress management.

Main effects for gender can be seen in Table 1. Briefly, men were more likely to be married, to be employed, to have a college degree, to have a history of smoking and to have systemic hypertension (except for men with diabetes, who were less likely to be hypertensive), but were less likely to have diabetes than women. Compared to women, men also had higher diastolic blood pressure, total cholesterol/HDL ratios and higher levels of hostility. However, women had higher body mass and body fat, total cholesterol, LDL-C, perceived stress and more physical inactivity than men. Significant gender by depression group interactions for levels of education, HbA1c-levels and SF-36 physical component scores indicated that depressed men had higher levels of education than non-depressed men, while depressed women had lower HbA1c-levels and SF-36 physical component scores than non-depressed women.

Changes in depression

Baseline and 3-month depression data were available for 921 of the 997 persons (92%). As can be seen in Table 2, of the 341 persons (76% female) reporting depression (CES-D ≥16) at baseline, 73% became non-depressed (83% of the men and 69% of the women), 19% remained depressed (12% of the men and 21% of the women) and 8% (5% of the men and 9% of the women) had missing 12-week data. Of the 656 persons (61% female) not reporting depression (CES-D <16) at baseline, 91% remained non-depressed (92% of the men and 91% of the women), 2% became depressed (0.4% of the men and 2% of the women) and 7% had missing 12-week data (8% of the men and 7% of the women). Overall, there was significantly more improvement than worsening in depression ($p < 0.001$). There was no significant relationship between gender and change in depression, with all sub-groups showing significant improvements over time.

Lifestyle behaviours, CRFs and psychosocial outcomes

Table 3 shows all outcomes by depression status and time points. Significant time effects were noted for all variables, regardless of depression status: Persons who became non-depressed, who remained non-depressed and those who remained or became depressed improved on all lifestyle behaviours, CRFs and psychosocial outcomes from baseline to 3 months [except HDL cholesterol, which was significantly reduced, as expected in the context of a low-fat diet (Brinton, Eisenberg, & Breslo, 1990); all $p < 0.01$, except for triglyceride levels ($p < 0.05$)].

Table 1. Patient characteristics by depression (CES-D < 16 *vs.* ≥ 16) and gender at baseline.

	No depression (CES-D < 16) at baseline		Depression (CES-D ≥ 16) at baseline				
	Men $N = 228$	Women $N = 428$	Men $N = 82$	Women $N = 259$	Gender p	Group p	Gender-by-Group p
Demographics							
Age, Mean (SD)	56 (10)	56 (9)	54 (10)	53 (9)	0.99	<0.001**	0.28
Ethnicity, *N* (% Caucasian)	213 (93%)	388 (91%)	79 (96%)	247 (95%)	0.23	<0.05**	0.45
Education, *N* (% college degree)	139 (61%)	203 (47%)	59 (72%)	107 (41%)	<0.001*	0.40	<0.05***
Married or cohabitating, *N* (%)	185 (81%)	289 (68%)	64 (78%)	170 (66%)	<0.001*	0.20	0.86
Employed outside the home, *N* (%)	159 (70%)	247 (58%)	60 (73%)	160 (62%)	<0.01*	0.46	0.71
Medical history, *N* (%)							
Previous cigarette smoker	94 (41%)	134 (31%)	33 (40%)	70 (27%)	<0.01*	0.15	0.69
Systemic hypertension[a]	112 (49%)	183 (43%)	49 (60%)	126 (49%)	<0.05*	0.06	0.54
Systemic hypertension in patients with DM[a]	61 (27%)	132 (31%)	29 (35%)	86 (33%)	<0.01*	0.45	0.47
Hyperlipidemia[b]	206 (90%)	368 (86%)	77 (94%)	231 (89%)	0.06	0.19	0.80
Diabetes mellitus	70 (31%)	175 (41%)	30 (37%)	107 (41%)	<0.05*	0.40	0.45
Type 2 DM	69 (30%)	158 (37%)	29 (35%)	100 (39%)	<0.05*	0.87	0.40
Medication, *N* (%)							
Beta blockers	54 (24%)	95 (22%)	23 (28%)	48 (19%)	0.19	0.48	0.26
Angiotensin-converting enzyme inhibitors	67 (29%)	131 (31%)	30 (37%)	83 (32%)	0.86	0.33	0.55
Calcium antagonists	32 (14%)	32 (7%)	13 (16%)	30 (12%)	<0.01*	0.09	0.39
Diuretics	25 (11%)	92 (21%)	15 (18%)	51 (20%)	<0.01*	0.34	0.10
Anticoagulants	118 (52%)	206 (48%)	43 (52%)	134 (52%)	0.46	0.40	0.53
Lipid lowering	107 (47%)	157 (37%)	30 (37%)	98 (38%)	<0.05*	0.28	0.09
Oral antiglycemics	37 (16%)	97 (23%)	17 (21%)	48 (19%)	0.64	0.37	0.53
Insulin	5 (2%)	24 (6%)	3 (4%)	16 (6%)	0.09	0.36	0.90
Antidepressant	19 (8%)	58 (14%)	13 (16%)	59 (23%)	<0.01*	<0.001**	0.97

(*Continued*)

Table 1. Continued.

	No depression (CES-D < 16) at baseline		Depression (CES-D ≥ 16) at baseline				
	Men $N = 228$	Women $N = 428$	Men $N = 82$	Women $N = 259$	Gender p	Group p	Gender-by-Group p
Arthritis medication	12 (5%)	32 (7%)	5 (6%)	27 (10%)	0.09	0.09	0.70
Gastrointestinal medication	21 (9%)	39 (9%)	6 (7%)	42 (16%)	0.15	<0.01**	0.07
Hormone replacement	–	67 (16%)	–	40 (15%)	–	–	–
CRFs, Mean (SD)							
Body mass index (kg/m^2)	33.8 (7.3)	34.8 (8.3)	34.5 (7.2)	37.2 (8.4)	<0.01*	<0.05**	0.16
Body weight (lbs)	235.1 (54.5)	203.2 (51.1)	243.2 (54.8)	217.8 (51.7)	<0.001*	<0.01**	0.42
Body fat (%)	30.2 (9.0)	39.6 (8.0)	31.1 (7.8)	40.8 (8.0)	<0.001*	0.11	0.84
Functional capacity (METs)	9.9 (2.9)	8.1 (2.5)	9.8 (3.1)	7.8 (2.5)	<0.001*	0.32	0.83
Systolic blood pressure (mmHg)	135.6 (15.9)	134.1 (17.1)	135.0 (17.2)	135.5 (16.7)	0.71	0.74	0.45
Diastolic blood pressure (mmHg)	81.8 (9.8)	80.2 (9.8)	84.8 (10.7)	82.2 (9.7)	<0.01*	<0.01**	0.49
Total cholesterol (mg/dL^1)	193.8 (45.2)	209.1 (44.6)	197.6 (37.3)	211.0 (45.6)	<0.001*	0.40	0.77
HDL cholesterol (mg/dL^1)	41.5 (10.4)	50.5 (12.6)	39.7 (9.0)	50.5 (13.5)	<0.001*	0.30	0.32
LDL cholesterol (mg/dL^1)	116.8 (36.8)	122.6 (37.5)	116.8 (31.8)	122.5 (37.9)	<0.05*	0.99	0.99
Triglycerides ($mg\,dL^{-1}$)	195.5 (157.0)	188.9 (134.5)	204.0 (81.9)	195.6 (135.6)	0.47	0.46	0.93
Total cholesterol/HDL-C Ratio	4.9 (1.5)	4.4 (1.3)	5.1 (1.2)	4.4 (1.4)	<0.001*	0.13	0.38
HbA1c (%)	7.5 (1.7)	7.8 (1.7)	8.2 (2.2)	7.3 (1.4)	0.20	0.49	<0.01***
Depression (CES-D)	7.0 (4.4)	7.3 (4.6)	23.5 (7.3)	24.4 (7.3)	0.16	<0.001**	0.48
Hostility (Cook–Medley)	7.7 (4.5)	6.3 (4.1)	12.2 (5.1)	9.3 (7.1)	<0.001*	<0.001**	0.07
Perceived Stress Scale	11.8 (6.3)	13.1 (6.4)	21.3 (7.3)	22.9 (7.0)	<0.01*	<0.001**	0.76
Quality of Life, Mean (SD)							
Physical Component Score (MOS SF-36)[c]	46.2 (9.2)	44.3 (10.4)	45.5 (10.8)	40.4 (10.6)	<0.001*	<0.01**	<0.05***
Mental Component score (MOS SF-36)[c]	49.8 (10.4)	50.3 (9.9)	35.2 (11.6)	37.0 (11.7)	0.15	<0.001**	0.42

(*Continued*)

Table 1. Continued.

	No depression (CES-D < 16) at baseline		Depression (CES-D ≥ 16) at baseline				
	Men $N = 228$	Women $N = 428$	Men $N = 82$	Women $N = 259$	Gender p	Group p	Gender-by-Group p
Lifestyle Behaviours							
Dietary Fat Intake (% of total calories)	30.6 (10.8)	30.4 (10.3)	34.0 (9.7)	32.2 (10.2)	0.23	<0.01**	0.33
Exercise (hrs per week)	1.2 (1.9)	1.1 (1.6)	1.2 (1.7)	0.7 (1.1)	<0.01*	0.14	0.21
Stress management (hrs per week)	0.5 (1.3)	0.5 (1.4)	0.3 (1.0)	0.2 (.9)	0.52	<0.05**	0.76

Notes: Some sites failed to collect complete baseline information on education, employment status, history of cigarette smoking and medication; therefore, data are shown for 64–96% of men with no depression at baseline ($n = 147$–218), 66–94% of women with no depression at baseline ($n = 284$–402), 63–98% of men with depression at baseline ($n = 52$–80) and 63–94% of women with depression at baseline ($n = 164$–243), depending on the variable. One woman who was non-depressed at baseline had a silent myocardial infarction. Diabetes type: among non-depressed patients at baseline 1 man (1.5%) and 16 women (9.4%) had type 1 diabetes and among depressed patients at baseline one man (3.3%) and eight women (7.5%) had type 1 diabetes.

[a]Systemic hypertension was defined as <140/90 mmHg or <130/80 mmHg for patients with diabetes.

[b]Hyperlipidemia was defined as LDL cholesterol ≥ 100 mg/dL^1 or HDL cholesterol ≤ 40 mg/dL^1, or triglycerides ≥ 150 mg/dL^1.

[c]Scores were standardized to have a mean of 50 and a SD of 10 based on a 1998 representative sample of the general US population.

*Significant gender effect, ** Significant group effect, *** Significant gender-by-group interaction.

Table 2. Number of patients by depression (CES-D < 16 *vs.* ≥16) at baseline and 12 weeks.

			Depression at 12 weeks	
		Total	No depression (CES-D < 16) at 12 weeks	Depression (CES-D ≥ 16) at 12 weeks
Depression at baseline	No depression (CES-D < 16) at baseline	210 Men, 398 Women	209 Men, 388 Women	1 Man, 10 Women
	Depression (CES-D ≥ 16) at baseline	78 Men, 235 Women	68 Men, 180 Women	10 Men, 55 Women
	Total	288 Men, 633 Women	277 Men, 568 Women	11 Men, 65 Women

Notes: McNemar test, $p < 0.001$, with significant reductions in depression over 12 weeks. 12-Week data for depression were missing for 22 men and 54 women (18 men and 30 women with CES-D < 16 at baseline, 4 men and 24 women with CES-D ≥ 16 at baseline).

These time effects were modified by group for exercise and dietary fat intake, perceived stress, hostility and SF-36 Mental Component scores (all $p < 0.05$). Depressed persons who became non-depressed at follow-up reduced dietary fat intake, perceived stress and hostility more and increased exercise and SF-36 mental component scores more than persons in the other two groups.

Time effects were modified by gender for exercise capacity, SF-36 physical component scores, weight, total cholesterol, LDL-C, triglyceride levels, total cholesterol/HDL ratios and HbA1c levels (all $p < 0.05$), suggesting that men improved their exercise capacity and SF-36 physical component scores more and reduced their weight, total cholesterol, LDL-C, triglyceride levels, total cholesterol/HDL ratios and HbA1c levels more than women.

Time effects were modified by gender and group for stress management, triglyceride levels and depression (all $p < 0.05$). Follow-up analyses indicated gender differences in stress management and depression, but only in persons who remained or became depressed. Compared to women, men increased stress management and reduced depression more in this group. In persons who became non-depressed and in those who remained non-depressed, men reduced triglyceride levels more than women.

Group-by-gender interactions were noted for exercise, group support attendance, HbA1c levels, hostility and depression (all $p < 0.05$). In the group of persons who became non-depressed, men exercised more and had higher HbA1c-levels than women across time points. Follow-up analyses for the significant group-by-gender interactions for group support attendance ($p < 0.001$) and depression ($p < 0.05$) rendered gender differences in the individual depression groups non-significant. Follow-up analyses for the significant group-by-gender interaction for hostility revealed that men had higher hostility scores than women across time points in all three depression groups.

All participants met program requirements regarding exercise (3 h per week) and practiced stress management more than 6 h per week at 3 months. Except for women who remained or became depressed, all patients reduced their dietary fat intakes

Table 3. Means (SD) of risk factors, psychosocial outcomes, quality of life and lifestyle behaviours at baseline and 12 weeks (among patients with complete CES-D data).

	Became non-depressed		Remained non-depressed		Remained or became depressed	
	Men $N=68$	Women $N=180$	Men $N=209$	Women $N=388$	Men $N=11$	Women $N=65$
CHD risk factors						
Weight (lbs)[a,b,c,d]						
Baseline	244.1 (53.2)	218.9 (52.2)	234.8 (55.0)	201.4 (50.6)	226.6 (57.6)	216.2 (55.0)
12 Weeks	224.8 (47.4)	204.2 (47.4)	217.4 (48.6)	189.9 (48.3)	212.8 (56.8)	205.0 (51.8)
Change	−8%	−7%	−7%	−6%	−6%	−5%
Body fat[a,b]						
Baseline	31.1 (7.2)	40.9 (7.7)	30.2 (8.8)	39.4 (7.9)	26.5 (6.9)	40.3 (8.5)
12 Weeks	26.6 (7.8)	37.4 (6.9)	26.2 (7.8)	35.9 (7.7)	23.2 (7.3)	36.3 (8.9)
Change	−15%	−9%	−13%	−9%	−13%	−9%
Exercise capacity (METs)[a,b,d]						
Baseline	9.8 (3.2)	7.9 (2.4)	10.0 (3.0)	8.1 (2.5)	9.5 (3.3)	7.7 (2.5)
12 Weeks	12.2 (3.1)	9.6 (2.5)	12.5 (3.1)	10.0 (2.6)	12.1 (4.3)	9.3 (2.4)
Change	25%	22%	25%	24%	27%	21%
Systolic BP (mmHg)[b]						
Baseline	134.4 (16.0)	135.2 (16.2)	135.9 (16.1)	134.3 (17.1)	139.1 (22.1)	135.8 (18.9)
12 Weeks	119.7 (15.0)	123.5 (13.5)	123.2 (13.1)	122.7 (14.3)	129.3 (21.9)	124.0 (14.3)
Change	−11%	−9%	−9%	−9%	−7%	−9%
Diastolic BP (mmHg)[a,b]						
Baseline	85.0 (10.6)	81.6 (9.0)	82.0 (9.9)	80.2 (9.7)	83.5 (11.9)	83.6 (11.0)
12 Weeks	75.3 (9.2)	75.5 (8.2)	75.2 (8.5)	74.3 (8.3)	77.1 (7.1)	75.7 (8.4)
Change	−11%	−7%	−8%	−7%	−8%	−9%
Total cholesterol (mg/dL)[a,b,d]						
Baseline	199.4 (35.8)	209.5 (46.2)	193.2 (45.1)	209.2 (44.3)	201.8 (41.3)	212.4 (41.8)
12 Weeks	158.8 (32.9)	182.3 (42.9)	156.4 (34.9)	182.6 (40.3)	154.8 (24.2)	191.6 (41.1)
Change	−20%	−13%	−19%	−13%	−23%	−10%

(*Continued*)

Table 3. Continued.

	Became non-depressed		Remained non-depressed		Remained or became depressed	
	Men $N=68$	Women $N=180$	Men $N=209$	Women $N=388$	Men $N=11$	Women $N=65$
HDL cholesterol (mg/dL)[a,b]						
Baseline	39.6 (9.0)	50.4 (14.1)	42.0 (10.4)	50.7 (12.8)	40.5 (10.3)	49.4 (12.2)
12 Weeks	35.2 (7.5)	43.2 (12.6)	36.3 (8.7)	43.4 (10.9)	32.8 (9.2)	44.2 (13.9)
Change	−11%	−14%	−14%	−14%	−19%	−11%
LDL cholesterol (mg/dL)[a,b,d]						
Baseline	121.4 (31.6)	119.6 (38.0)	116.6 (36.9)	122.4 (36.9)	112.3 (30.4)	130.0 (36.9)
12 weeks	92.3 (27.3)	101.5 (38.3)	91.8 (28.7)	104.1 (32.3)	87.1 (25.3)	113.0 (36.2)
Change	−24%	−15%	−21%	−15%	−22%	−13%
Triglycerides (mg/dL)[‡b,d,g]						
Baseline	200.6 (75.8)	195.7 (129.4)	190.8 (147.0)	189.3 (135.2)	222.9 (115.7)	192.3 (158.9)
12 Weeks	167.1 (75.7)	195.5 (118.3)	150.6 (77.8)	179.6 (96.7)	169.7 (80.5)	189.6 (107.0)
Change	−17%	−0%	−21%	−5%	−24%	−1%
Total cholesterol/HDL ratio[b,d]						
Baseline	5.2 (1.2)	4.4 (1.4)	4.8 (1.5)	4.4 (1.3)	5.2 (1.2)	4.6 (1.5)
12 Weeks	4.6 (1.1)	4.4 (1.4)	4.5 (1.2)	4.4 (1.4)	5.0 (1.4)	4.6 (1.3)
Change	−12%	–	−6%	–	−4%	–
Haemoglobin A1c (%)[†b,d,f]						
Baseline	8.5 (2.3)	7.3 (1.4)	7.3 (1.6)	7.7 (1.6)	6.2 (.2)	7.3 (1.5)
12 Weeks	7.2 (1.7)	6.7 (1.1)	6.4 (.9)	6.9 (1.1)	5.5 (.1)	7.3 (1.3)
Change	−15%	−8%	−14%	−12%	−11%	–
Depression (CES−D)[a,b,c,e,f,g]						
Baseline	22.1 (6.1)	23.1 (6.4)	6.8 (4.3)	7.2 (4.6)	28.1 (9.6)	24.2 (9.6)
12 Weeks	7.6 (4.6)	6.8 (4.3)	4.3 (3.9)	4.3 (4.0)	19.6 (3.3)	22.3 (6.2)
Change	−66%	−71%	−37%	−40%	−30%	−8%
Hostility (Cook–Medley)[a,b,c,e,f]						
Baseline	12.0 (5.2)	8.9 (4.4)	7.7 (4.4)	6.2 (4.2)	13.3 (3.3)	8.9 (4.2)
12 Weeks	8.9 (5.0)	6.0 (3.9)	6.5 (4.1)	5.2 (3.7)	10.4 (3.5)	7.6 (3.9)
Change	−26%	−33%	−16%	−16%	−22%	−15%

(*Continued*)

Table 3. Continued.

	Became non-depressed		Remained non-depressed		Remained or became depressed	
	Men $N=68$	Women $N=180$	Men $N=209$	Women $N=388$	Men $N=11$	Women $N=65$
Perceived Stress Scale[b,c,e]						
Baseline	20.5 (6.8)	22.2 (6.2)	11.8 (6.3)	13.1 (6.5)	24.4 (6.9)	22.5 (7.2)
12 Weeks	11.0 (4.8)	11.4 (4.7)	7.6 (4.7)	9.0 (5.0)	19.8 (4.9)	19.5 (6.9)
Change	−46%	−49%	−36%	−31%	−19%	−13%
Quality of Life						
Physical Component Score (SF-36)[b,c,d,e]						
Baseline	45.7 (10.7)	40.5 (10.3)	46.2 (9.1)	44.7 (10.4)	43.4 (11.4)	40.9 (10.6)
12 Weeks	50.1 (8.5)	47.7 (9.3)	51.2 (8.7)	50.0 (8.6)	45.0 (10.2)	46.2 (10.4)
Change	10%	18%	11%	12%	4%	13%
Mental Component Score (SF-36)[b,c,e]						
Baseline	35.7 (11.5)	37.5 (11.0)	50.3 (10.0)	50.1 (10.0)	34.5 (13.5)	36.8 (12.7)
12 Weeks	50.2 (10.3)	53.0 (9.2)	54.8 (9.0)	56.2 (7.5)	40.7 (10.4)	41.4 (11.1)
Change	41%	41%	9%	12%	18%	13%
Lifestyle Behaviours						
Dietary Fat (% of total calories)[b,c,e]						
Baseline	34.2 (9.8)	32.7 (10.1)	30.9 (10.6)	30.2 (10.1)	31.7 (12.8)	30.8 (10.6)
12 Weeks	9.6 (2.9)	9.7 (3.0)	9.4 (2.6)	9.8 (3.2)	9.2 (3.1)	10.8 (7.2)
Change	−72%	−70%	−70%	−68%	−71%	−65%
Exercise (hrs per week)[a,b,e,f]						
Baseline	1.3 (1.7)	.8 (1.1)	1.3 (1.9)	1.1 (1.6)	1.0 (1.4)	0.7 (1.1)
12 Weeks	4.3 (1.9)	3.7 (1.6)	3.8 (1.7)	3.7 (1.4)	4.4 (1.5)	3.3 (1.9)
Change	231%	363%	192%	236%	340%	371%
Stress Management (hrs per week)[b,d,g]						
Baseline	0.4 (1.0)	0.2 (0.8)	0.5 (1.4)	0.5 (1.4)	0.3 (0.5)	0.3 (1.0)
12 Weeks	6.1 (1.8)	6.2 (1.7)	6.3 (2.2)	6.3 (2.3)	7.6 (2.3)	6.0 (2.9)
Change	1425%	3000%	1160%	1160%	2433%	1900%

(*Continued*)

Table 3. Continued.

	Became non-depressed		Remained non-depressed		Remained or became depressed	
	Men $N=68$	Women $N=180$	Men $N=209$	Women $N=388$	Men $N=11$	Women $N=65$
Group Support Attendance[a,c,f]						
Baseline	–	–	–	–	–	–
12 Weeks	95.6 (5.9)	94.6 (6.5)	94.5 (9.5)	94.9 (7.0)	92.0 (6.2)	91.5 (8.2)
Change	–	–	–	–	–	–
Lifestyle Index[a,b]						
Baseline	0.33 (0.22)	0.30 (0.16)	0.35 (0.21)	0.35 (0.20)	0.32 (0.17)	0.28 (0.16)
12 Weeks	0.92 (0.14)	0.89 (0.13)	0.90 (0.13)	0.91 (0.12)	0.96 (0.10)	0.84 (0.17)
Change	178%	197%	157%	160%	200%	200%

Notes: [†]For patients with diabetes only.
[‡]Winsorizing statistical outliers (i.e. replacing values ± 3 SDs of the mean with 'most extreme acceptable values' in the distribution of this variable) did not yield significantly different results.
N ranged from 62 to 68 for men who became non-depressed, from 157 to 180 for women who became non-depressed, from 182 to 209 for men who remained non-depressed and from 342 to 388 for women who became non-depressed, from 10 to 11 for men who remained or became depressed and from 55 to 65 for women who remained or became depressed, depending on the outcome.
[a]Significant gender effect. Overall, men exercised more, attended more group support sessions, weighed more, had higher diastolic blood pressure, higher exercise capacity and higher hostility levels (all $p<0.05$), while women had higher body fat, higher total cholesterol, higher LDL cholesterol and higher HDL cholesterol (all $p<0.01$).
[b]Significant time effect.
[c]Significant group effect. Persons who became non-depressed consumed more dietary fat and weighed more than persons who remained non-depressed (all $p<0.01$). Persons who remained non-depressed had the highest SF-36 Mental Component Scores and the lowest levels of perceived stress and depression, followed by those who became non-depressed, followed by those who remained or became depressed (all $p<0.001$). Also, persons who remained non-depressed had higher SF-36 Physical Component Scores and lower levels of hostility than persons in the other 2 groups (all $p<0.01$). Persons who remained non-depressed and those who became non-depressed attended more group sessions than those who remained or became depressed ($p<0.001$).
[d]Significant time-by-gender interaction.
[e]Significant time-by-group interaction.
[f]Significant gender-by-group interaction.
[g]Significant gender-by-time-by-group interaction.

to <10%. Analysis of the data from the 11 persons who became depressed indicated that these participants experienced similar risk factor reductions as the rest of the sample (not shown), except for diastolic blood pressure which was not significantly reduced (baseline: 81.6 ± 10.6, 3 months: 76.0 ± 8.6), and triglyceride levels and total cholesterol/HDL ratios which increased over the follow-up (baseline: 133.3 ± 58.7, 3 months: 150.9 ± 68.4; baseline: 4.4 ± 1.4, 3 months: 4.5 ± 1.8, respectively).

In order to examine whether changes in depression as a continuous variable are associated with changes in cardiovascular risk factors, health behaviours and psychological outcomes in persons who became non-depressed, bivariate correlations were performed. Associations were noted as follows: In both, men and women who became non-depressed over the course of 3 months, reductions in depression were associated with decreases in weight ($r = 0.33$, $p < 0.01$, $r = 0.17$, $p < 0.05$, respectively). These associations became marginally significant when controlling for baseline depression and age ($r = 0.22$, $p < 0.10$, $r = 0.14$, $p < 0.10$, respectively). Reductions in depression were also associated with reductions in systolic blood pressure in women ($r = 0.13$, $p < 0.10$) and with reduced triglyceride levels in men, but only after controlling for baseline depression and age ($r = 0.32$, $p < 0.01$).

Regarding psychosocial outcomes, reductions in depression were associated with reductions in hostility ($r = 0.50$, $p < 0.01$, $r = 0.17$, $p < 0.05$, respectively) and perceived stress ($r = 0.54$, $p < 0.01$, $r = 0.51$, $p < 0.001$, respectively), and with improvements in SF-36 mental component scores ($r = 0.70$, $r = 0.41$, both $p < 0.001$) in both sexes, and with improved SF-36 physical component scores ($r = 0.16$, $p < 0.05$) in women. Associations between reductions in depression and improvements in hostility rendered marginally significant when controlling for baseline depression and age. Similarly, associations with mental health (SF-36) became non-significant after controlling for baseline depression and age. The relationships between reductions in depression and physical health (SF-36) and triglyceride levels in men were significant after controlling for baseline depression and age ($r = 0.28$, $p < 0.05$; $r = -0.32$, $p < 0.01$). In regard to changes in lifestyle, reductions in depression were associated with increases in stress management in men with and without controlling for baseline depression and age ($r = 0.26$, $p < 0.05$, $r = 0.31$, $p < 0.05$, respectively) and were marginally related to improvements in the lifestyle index in men ($r = 0.24$, $p < 0.10$) without controlling for baseline depression and age.

In sum, in both, men and women who became non-depressed over the course of 3 months, reductions in depression were associated with weight reductions. In women, reductions in depression were also related to reductions in systolic blood pressure; in men, an association of reductions in depression with increases in stress management and in the lifestyle index was noted.

Changes in medications

Follow-up medication data were only collected at 17 sites ($n = 783$, 76.5% complete data). We, therefore, only report changes in medications over 3 months for these 17 sites. Medication use, including anti-depressant medication, beta-blockers, angiotensin-converting enzyme inhibitors, calcium antagonists, diuretics, lipid lowering medication, oral antiglycemics and insulin (for patients with diabetes), remained unchanged for over 90% of persons who became or remained non-depressed.

This was also true for persons who remained or became depressed, except for oral antiglycemic use in patients with diabetes. In this group, 84% remained on medication or were not medicated, 8% started medication and 8% had stopped medication by the end of follow-up.

Participants lost during follow-up

A total of 22 men (7%) and 54 women (8%) did not complete the 12-week follow-up. Participants completing the follow-up ($n = 921$) were more likely to have a college degree ($p < 0.001$), to be medicated with anticoagulants ($p < 0.05$), insulin ($p < 0.05$) and hormone replacement ($p < 0.05$) than those not completing the follow-up. They also had higher body mass ($p < 0.05$), higher CES-D scores ($p < 0.05$), higher levels of hostility ($p < 0.01$), were older ($p < 0.05$) and exercised less ($p < 0.05$) than those not completing the follow-up. No other statistically significant differences were noted.

Discussion

Consistent with other studies (Farmer et al., 1988; Katon et al., 2004), our findings indicated that depressed participants engaged in fewer health behaviours (i.e. diet and stress management) and had worse CRF profiles and psychological status than non-depressed participants at baseline. Our major question was whether depressed persons with metabolic syndrome could make intensive lifestyle changes over 3 months. All participants, regardless of depression group, met program requirements regarding exercise (3 h per week) and practiced stress management more than 6 h per week at 3 months. All participants reduced their dietary fat intake to 10% (except for women who remained or became depressed who reduced dietary fat intake to 11%). Some of these improvements in health behaviours were more pronounced in persons who became non-depressed during follow-up. These persons reduced dietary fat intake and increased exercise more than persons who remained or became depressed and more than those who remained non-depressed over 3 months. No time-by-group-by-gender interactions were noted for health behaviour change. Thus, improvements in health behaviours were associated with reductions in depression regardless of gender.

The second question addressed in this study was whether participating in an intensive lifestyle intervention would be beneficial in terms of reducing depression in persons with metabolic syndrome. Seventy-three percent of persons whose symptoms suggested the presence of clinical depression at baseline became non-depressed by 3 months. It is unlikely these improvements in depression were due to changes in anti-depressant medication use throughout follow-up, as anti-depressant medication use remained constant in 98% of persons who became non-depressed during follow-up. Furthermore, in our study, both men and women showed similar improvements in depression. Thus, our results indicate that addressing depression in behavioural interventions may be beneficial for both women and men with metabolic syndrome, including patients with diabetes.

The American Diabetes Association (2006) recommends screening for psychosocial problems such as depression in patients with type 2 diabetes and an incorporation of psychological treatment into routine care to address these psychosocial problems. However, according to the American Diabetes Association, psychological

treatment is only indicated when adherence to the medical regimen is poor. One could also argue that targeting depression in persons participating in lifestyle interventions may potentially facilitate the modification of behavioural and CRFs of the metabolic syndrome.

To examine this question, we compared cardiac and psychosocial outcomes of depressed persons who became non-depressed (Group 1) to persons who remained or became depressed (Group 2) and to those who remained non-depressed (Group 3) over 3 months. Our results show that, all participants, regardless of depression group, significantly improved CRF profiles, glycemic control (in patients with diabetes) and psychological outcomes over 3 months. Improvements in CRFs in our entire sample were similar to those noted in other lifestyle interventions (e.g., Costacou & Mayer-Davis, 2003; Elmer et al., 2006; Hu & Willett, 2002). However, it is noteworthy that, despite their worse clinical profiles at baseline (e.g., bodymass and diastolic blood pressure), depressed persons who became non-depressed improved clinical profiles to a similar degree as non-depressed persons. In contrast, persons who became or remained depressed did not reduce diastolic blood pressure, triglyceride levels and total cholesterol/HDL ratios.

We had also hypothesised that persons who became non-depressed would experience greater improvements in CRFs compared to persons in the other two groups. However, no significant time-by-depression group interactions were found. Only two marginally significant time-by-group interactions emerged for weight and diastolic blood pressure. The trend for weight suggested that persons who became non-depressed reduced weight more (-16.0 ± 9.7 lbs) than persons who remained non-depressed (-13.6 ± 5.5 lbs) and persons who remained or became depressed (-11.6 ± 7.1 lbs). Regarding diastolic blood pressure, reductions were similar in persons who became non-depressed (-7.2 mmHg) and in those who remained or became depressed (-7.7 mmHg), but lower in those who remained non-depressed (-6.2 mmHg). In addition, one significant time-by-group-by-gender interaction for triglyceride levels suggested that men who became non-depressed reduced triglyceride levels more than women in this group. In sum, our results suggest that reductions in depression were generally not closely linked to changes in CRFs. Similarly, Georgiades et al. (2007) did not find direct associations between reductions in depression and improvements in glycemic control in patients with type 2 diabetes.

In regard to psychosocial outcomes, depressed persons in our study who became non-depressed also improved psychological well-being more than persons in the other two groups. Specifically, they reported less hostility and perceived stress and improved quality of life (i.e., SF-36 mental component score: vitality, social functioning, role-emotional functioning and mental health) more than persons in the other two groups. Depressive symptoms have been previously linked to all domains of quality of life in primary care patients (Brenes, 2007). It is therefore plausible that reductions in depression may have been accompanied by improvements in hostility, perceived stress and mental health. However, we can only speculate which program component affected psychological well-being in patients who became non-depressed. Findings of another study, using the same intervention as the MCLIP, indicated that the intervention's social support group attendance was associated with improvements in mental health (even after controlling for diet, exercise and stress management; Schulz et al., 2008). Some have even suggested that psychological treatment similar to the social support group intervention in the MCLIP may have a

stronger effect on patients' well-being than pharmacotherapy (Pampallona, Bollini, Tibaldi, Kupelnick, & Munizza, 2002).

For exploratory purposes, we also analysed associations of changes in depression as a continuous variable with changes in CRFs, health behaviours and psychological outcomes in the group of participants that became non-depressed (Group 1). Contrary to findings of another study (Hainer et al., 2008), in both men and women who became non-depressed over the course of 3 months, reductions in depression were associated with weight reductions. In women, reduced depression scores were also related to reductions in systolic blood pressure; in men, an association of reduced depression scores with increases in stress management and in the lifestyle index was noted.

In regard to attrition, participants completing the follow-up were more likely to have a college degree and were more medicated than those not completing the follow-up. However, those who completed the follow-up were also older, exercised less, had higher bodymass and worse psychological status compared to those not completing the follow-up. This suggests that participants with worse medical and psychological status at baseline may have been more motivated to make lifestyle changes.

Several limitations of our study should be noted. First, the use of a clinical diagnostic interview for depression would have improved the validity of the assessment of depression in our study. However, the employment of self-report questionnaires such as the CES-D is common when it is not feasible to conduct psychiatric diagnostic interviews (Davidson, Rieckmann, & Rapp, 2005). Furthermore, the CES-D has shown high predictive validity for CHD events and mortality in initially healthy persons (Anstey & Luszcz, 2002). Second, this study did not include a control group. The MCLIP was a multi-site phase IV clinical trial evaluation covered by health insurance companies. Phase IV research typically consists of long-term surveillance of an intervention shown to be effective in previous stage III trials. Therefore, no assumptions about cause–effect relationships between changes in lifestyle and changes in outcomes can be made in this study. Also, spontaneous remission of depressive symptoms during follow-up may have occurred and associations between changes in lifestyle and changes in outcomes may have been affected by unmeasured third factors. In addition, the number and characteristics of ineligible persons or the number of eligible persons who declined participation were not available due to the wide range of recruitment strategies employed, limiting generalisability of our findings. Another limitation is the use of self-report measures for behavioural outcomes. However, the reported improvements in lifestyle were validated by changes in CRFs (e.g., reported reductions in dietary fat intake by total and LDL-C reductions; reported improvements in exercise by improved exercise capacity). Our sample was also predominantly white, limiting generalisability of our findings to an ethnically more diverse population. In sum, targeting multiple health behaviours appears to be feasible and beneficial for depressed persons with elevated CRFs. Depressed persons were able to make intensive lifestyle changes and improve their CRFs. Seventy-three percent of participants who were clinically depressed at baseline fell below the cut-off for depression on the CES-D 3 months later. Thus, depressed persons with elevated CRFs can benefit from participation in intensive lifestyle interventions, both in terms of improved CRF profiles and mental health.

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