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Depressive Symptoms and Serum Lipid Levels in Young Adult Women

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Abstract

Accumulating data suggest that depression is associated with risk factors for cardiovascular disease, but few studies have investigated potential behavioral mediators of such associations, particularly among women. In this study of healthy young adult women ($n = 225$), we examined associations among depressive symptoms, health behaviors, and serum lipid levels. Depressive symptoms were assessed with the 20-item Center for Epidemiologic Studies – Depression (CES-D) scale, and a fasting blood sample was obtained for serum lipid levels, including total cholesterol, high-density lipoprotein (HDL-C) and low-density lipoprotein (LDL-C). Diet was measured using 24-hour recalls, and other health behaviors (physical activity, smoking) were assessed via self-report questionnaire. Results indicated a modest negative association between depressive symptoms and LDL-C levels. Higher levels of depressive symptoms were also associated with lower total and insoluble dietary fiber intake, both of which were associated with HDL-C and LDL-C. Mediation analyses indicated a significant indirect effect of depressive symptoms on LDL-C via total and insoluble dietary fiber in unadjusted analyses, but not in adjusted analyses. The present findings suggest that depressive symptoms are inversely associated with serum LDL-C levels in young adult women, but that these associations are not likely mediated by adverse lifestyle behaviors.

Keywords

Depression; cholesterol; health behaviors; diet

Accumulating data suggest that depression may contribute to the onset and development of coronary artery disease (Lett et al., 2004; Wulsin & Singal, 2003) and metabolic syndrome (Gary, Crum, Cooper-Patrick, Ford, & Brancati, 2000; Kinder, Carnethon, Palaniappan, King, & Fortmann, 2004; McCaffery, Niaura, Todaro, Swan, & Carmelli, 2003). The association between depression and disease risk has been attributed, in part, to lifestyle factors. Considerable data support an association between depression and adverse health behaviors (Whooley et al., 2008). These behaviors, in turn, have well-established effects on serum lipid levels (Martinez-Gonzalez et al., 1998; Schubert et al., 2006; Yamamoto et al., 2003). Indeed, among middle-aged men, poor health habits (smoking, poor diet, inadequate physical activity levels) mediated the associations observed between depression and lower levels of high-density lipoprotein cholesterol (HDL-C) and higher levels of low-density lipoprotein cholesterol (LDL-C) (Igna, Julkunen, Vanhanen, Keskivaara, & Verkasalo, 2008).

However, it has been noted that a direct path from depression to serum cholesterol levels also exists, but that this path is indicative of depression being associated with a more favorable serum lipid profile (Igna, et al., 2008). Specifically, several studies have noted that higher levels of depressive symptoms are associated with lower levels of LDL-C (Igna, et al., 2008; Shin, Suls, & Martin, 2008) and higher HDL-C among men (Igna, et al., 2008; Shin, et al., 2008).

The interrelations among depressive symptoms, health behaviors, and serum lipid levels have not been well-studied among women, despite the higher prevalence of depression that exists among women (Leach, Christensen, Mackinnon, Windsor, & Butterworth, 2008). A few studies have noted that a higher prevalence of depressive symptoms is associated with lower levels of total cholesterol among middle-aged (Horsten, Wamala, Vingerhoets, & Orth-Gomer, 1997) and young adult women (Suarez, 1999), whereas others did not observe any such associations (Markovitz et al., 1997). And to date, none has examined whether potential associations between depressive symptoms and lipid levels in women are mediated by adverse lifestyle behaviors.

Therefore, guided by the framework proposed by Igna and colleagues (Igna, et al., 2008), we investigated the relation between depressive symptoms and serum lipid levels among young adult women and explored whether such associations would be mediated by health behaviors and body mass index (BMI). Based on prior studies (Horsten, et al., 1997; Igna, et al., 2008; Suarez, 1999), it was hypothesized that there would be a direct association between depressive symptoms and unfavorable lipid profiles (i.e. higher levels of total cholesterol, higher LDL-C, and lower HDL-C). In addition, it was hypothesized that there would be an indirect effect of lifestyle behaviors (i.e. smoking, diet, physical activity) on lipid levels such that greater depressive symptoms would be associated with greater smoking, poorer diet and lower levels of physical activity, which in turn, would be associated with unfavorable lipid profiles (i.e. higher levels of total cholesterol, higher LDL-C, and lower HDL-C) similar to the findings reported previously among men (Igna, et al., 2008).

Method

Participants

Study participants were subjects in the DISC06 Follow-Up Study, which was a follow-up of the multi-center Dietary Intervention Study in Children (DISC). The initial DISC clinical trial was designed to test the safety and efficacy of a dietary intervention to reduce serum LDL-C in male and female children aged 8–10 years old with elevated LDL-C levels. The trial's original design and results have been previously described (DISC Collaborative Research Group, 1993; Obarzanek et al., 1997). In 2006, the DISC06 Follow-Up Study was initiated to evaluate the long-term effects of the dietary intervention on various biomarkers in DISC female participants (Dorgan et al., 2010). All female DISC participants were invited to participate in the follow-up study. Of the 301 females originally enrolled in DISC, 260 (86.4%) participated in the follow-up study. Women who were pregnant or breastfeeding, or who had completed a pregnancy or breastfeeding within 12 weeks before their follow-up visit were excluded from the present analyses ($n = 30$). An additional five participants who were currently taking lipid-lowering medication and/or did not fast prior to the blood draw were also excluded, leaving a sample of 225 participants. Details concerning the design and methods of the DISC06 Follow-Up Study have been previously published (Dorgan, et al., 2010).

Procedure

Each participant attended a single data collection visit between 2006 and 2008. These follow-up visits were timed to occur in the luteal phase of the menstrual cycle, 1–14 days before the anticipated start of next menses. During the visit, blood samples were drawn and participants completed questionnaires concerning: demographic characteristics, medical history, and health behaviors. In addition, data from three nonconsecutive 24-hour dietary recalls were collected over 2 weeks and were averaged to estimate nutrient intakes. Greater detail concerning the measures is provided below.

Data were collected by staff who were masked to the participant's original study condition. A centralized data collection training session was held before initiation of data collection to train and certify data collection staff. Each clinical center¹ had at least one person centrally trained and certified to collect each type of data and who was responsible for training and certifying others at their local center.

Measures

Demographic and medical information—Demographic information, including age, race and ethnicity, marital status, and highest level of education was obtained. In addition, assessments of weight and height were obtained by trained staff using a standardized protocol. Body mass index (BMI) for each participant was calculated as weight (kg)/height (m^2). Potential covariates, including parental history of heart disease or diabetes and current medication and hormonal contraceptive use, were recorded.

Depressive symptoms—Depressive symptoms were assessed using the 20-item Center for Epidemiological Studies-Depression scale (CES-D)(Radloff, 1977). In this self-report index of depressive symptoms, responses to each item are rated from 0 to 3 and summed to create a total score (Radloff, 1977). The total score can range from 0 to 60, with higher

¹The six DISC clinical centers were located at Childrens' Hospital, New Orleans, LA; Johns Hopkins Hospital, Baltimore, MD; Kaiser Permanente Center for Health Research, Portland, OR; New Jersey Medical School, Newark, NJ; Northwestern University Feinberg School of Medicine, Chicago, IL; and University of Iowa, Iowa City, IA; and the DISC coordinating center was located at Maryland Medical Research Institute, Baltimore, MD.

scores indicating the presence of more depressive symptomatology. The CES-D has high reliability and internal validity and has been widely used across a variety of populations (Golomb, Criqui, White, & Dimsdale, 2004; Tsuboi et al., 2006; Vogelzangs et al., 2007).

Lifestyle factors and health behaviors—With respect to smoking status, participants were categorized as never smokers, current smokers, or former smokers based on their self-reported smoking behavior. Dietary intake was assessed using three 24-hour dietary recalls collected within 2 weeks of the clinic visit by certified nutritionists using Nutrition Data System for Research (NDS-R), developed by the Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN. The system calculates nutrient composition and has been used extensively in nutrition research (Schakel, 1997). Two recalls were conducted on weekdays and one on a weekend day. The first recall was conducted in-person with the nutritionist. The second and third recalls were conducted by telephone. Two dimensional food models were used to help participants estimate serving sizes. These procedures are similar to those used in the initial DISC study (DISC Collaborative Research Group, 1993). A subgroup of dietary variables were selected due to their relevance to serum lipid levels, including total energy (kcal), % kcal from fat (including saturated fat, monounsaturated fat, and polyunsaturated fat), dietary cholesterol, total dietary fiber intake, soluble fiber intake, insoluble fiber intake, and % kcal from alcohol.

Physical activity was assessed using the historical version of the Modifiable Activity Questionnaire (MAQ) (Kriska et al., 1990). Adapted for use in the DISC06 Follow-Up Study, the historical MAQ is an interviewer-administered, self-report instrument that estimates historical (ages 14–21 years) and past year leisure-time physical activity levels. The DISC06 version of the historical MAQ includes a list of 49 leisure-time physical activities that are common among girls and young women. For the present analyses, only the past year leisure-time physical activity estimate was used and reported. The past year leisure-time physical activity estimate was calculated as the product of the duration and frequency of each activity (in hours per week), weighted by an estimate of the metabolic equivalent (MET) of that activity (Ainsworth et al., 2000) and summed for all activities performed. The derived estimate of leisure-time physical activity was expressed as MET hours per week ($\text{MET} \cdot \text{h} \cdot \text{wk}^{-1}$) (Kriska et al., 1990). This questionnaire has been previously shown to be a reliable (Kriska et al., 1990) and valid (Kriska et al.; Schulz, et al., 1994) estimate of past year physical activity levels (Kriska, 1997).

Serum lipid fractions—Overnight fasting blood samples were collected by venipuncture. Total cholesterol, HDL-C and triglycerides were assayed at the University of Iowa Hospitals and Clinics Clinical Chemistry Laboratory on the Roche/Hitachi 917 instrument using enzymatic colorimetric assays (Kohlmeier, 1986; Matsuzaki, Kawaguchi, Morita, & al, 1996; Siedel, Hagele, Ziegenhorn, & Wahlefeld, 1983; Sugiuchi et al., 1995). Coefficients of variability for all assays were < 5%. LDL-C was calculated using Friedewald's formula (Friedewald, Levy, & Fredrickson, 1972).

Statistical Analysis

Depressive symptoms and lipid levels were treated as continuous variables. Multiple linear regression models were used to evaluate the association between depressive symptoms, lipids, and proposed mediators in both unadjusted and adjusted models. In adjusted models, we included the following as possible confounding variables: prior treatment condition, current participant age, race, education level, marital status, hormonal contraceptive use, household income, and history of heart disease or diabetes in mother or father. Linear structural equation models were used to assess whether lifestyle factors mediate any observed associations between depressive symptoms and lipid levels (Imai, Keele, &

Tingley, 2010). Mediation analyses were performed controlling for the aforementioned variables. In both unadjusted and adjusted regression and structural equation analyses, robust standard errors were used to account for correlation of responses within clinical center (Williams, 2000). Slope coefficients from the regressions represent the standardized coefficients; that is, the coefficients from models fit after variables have been standardized to have mean 0 and standard deviation 1. The standardized coefficients assist the reader in comparing the magnitude of associations across the variables, as the variables have different scales and ranges.

The bootstrap method (Shrout & Bolger, 2002) was used to estimate whether the attenuation of associations of depressive symptoms with serum lipid levels after the inclusion of the proposed mediator variables (e.g., physical activity, dietary variables) was statistically significant. We accounted for clustering within clinic in the bootstrap sampling algorithm. For models investigating the effects of dietary mediators, energy intake was included as a confounding variable. Energy and age were entered into all the models via restricted cubic splines with 3 knots at the empirical quantiles (Harrell, 2001). All analyses were conducted using STATA version 10 (StataCorp, College Station, Texas).

Results

Participants were predominantly non-Hispanic white (84.9%) and, on average, 27 years of age (Table 1). Over 55% were never married and the majority had obtained a college (51.1%) or post-graduate (16.0%) degree. Data on relevant health behaviors, including smoking status, physical activity, and dietary intake, are also presented in Table 1.

Participants who received the dietary intervention in their childhood reported currently lower intake of saturated fat and greater intake of soluble dietary fiber compared with participants in the control condition ($p < .05$). However, no differences between intervention and control group participants were observed with respect to current BMI, serum levels of total cholesterol, HDL-C or LDL-C, leisure physical activity, smoking status, alcohol consumption or depressive symptoms. In subsequent analyses, models were adjusted for treatment group.

Preliminary Analyses

Preliminary regression analyses accounting for clustering within clinics indicated several associations among demographic and medical variables with depressive symptoms and/or serum lipid levels. Women who were married or living as married had lower levels of HDL-C ($M = 58.38$, $SD = 16.54$) compared to women who were single, separated, or divorced ($M = 64.10$, $SD = 16.83$), $p < .02$. Similarly, current use of hormonal contraception was associated with higher total cholesterol ($M = 205.10$, $SD = 30.16$) and higher HDL-C ($M = 65.34$, $SD = 17.81$) compared to women who reported former use (total cholesterol: $M = 193.88$, $SD = 25.97$; HDL: $M = 58.96$, $SD = 14.68$) or never use of hormonal contraceptives (cholesterol: $M = 194.33$, $SD = 26.30$; HDL: $M = 48.27$, $SD = 10.53$), $p < .03$. As a result, use of hormonal contraceptives and marital status were included as covariates in subsequent analyses.

In adjusted regression analyses, depressive symptoms were not significantly associated with total cholesterol ($\beta = -.14$, $t = -1.63$, $p = .16$) or HDL-C ($\beta = .05$, $t = .50$, $p = .64$). A marginally significant association was observed with LDL-C levels ($\beta = -.16$, $t = -2.30$, $p = .07$) after controlling for age, treatment group, race, education, income, marital status, hormonal contraceptive use, family history of heart disease or diabetes. To examine whether the association between depressive symptoms and lipid levels varied by dietary intervention treatment group, we ran unadjusted models for each of the three lipid measures in which we

included depressive symptoms, dietary intervention assignment, and the interaction term of depressive symptoms and intervention assignment (i.e. CES-D score times intervention assignment category). None of the interaction terms was statistically significant ($p > .27$ for each interaction term in the three regression models).

Relationship between depressive symptoms, cholesterol, and proposed mediators

Smoking—As expected, current smokers reported higher depressive symptoms ($M = 10.39$, $SD = 8.93$) compared to former ($M = 6.74$, $SD = 4.77$) or never smokers ($M = 6.86$, $SD = 5.79$) $p < .05$) from a joint test of categorical variable coefficients in the unadjusted regressions. Number of years smoking was related to LDL-C levels ($\beta = 1.5$ average standardized increase in LDL-C for a one unit standardized increase in years smoked, $p = .04$). There were no statistically significant relationships between smoking and HDL-C or total cholesterol.

Physical activity—Depressive symptoms were not associated with physical activity ($p = .15$ in the unadjusted model). Physical activity was associated with LDL-C ($\beta = -.21$ average standardized decrease in LDL-C for a one unit standardized increase in physical activity, $t = -6.48$, $p = .001$) but not with HDL-C or total cholesterol.

Diet—Depressive symptoms were negatively associated with dietary fiber intake, including total dietary fiber ($\beta = -.10$, $t = -3.51$, $p = .02$) and insoluble dietary fiber ($\beta = -.09$, $t = -3.23$, $p = .02$). Depressive symptoms were not associated with any of the other dietary variables.

As expected, diet was associated with serum lipid levels. Total dietary fiber ($\beta = .16$, $t = 2.93$, $p = .03$) and soluble dietary fiber ($\beta = .19$, $t = 4.76$, $p = .005$) were each positively associated with HDL-C. Total dietary fiber ($\beta = -.15$, $t = -3.02$, $p = .03$), soluble dietary fiber ($\beta = -.14$, $t = -2.74$, $p = .04$), and insoluble dietary fiber ($\beta = -.14$, $t = -2.67$, $p = .04$) were each negatively associated with LDL-C in unadjusted analyses, but these pathways were attenuated in adjusted analyses ($ps = .11$, $.10$, and $.14$, respectively). Percent of calories from alcohol was positively associated with HDL-C ($\beta = .28$, $t = 4.50$, $p = .006$) and negatively associated with LDL-C ($\beta = -.23$, $t = -3.73$, $p = .014$).

BMI—BMI was not significantly associated with depressive symptoms ($\beta = -.04$, $t = -.53$, $p = .62$), but it was positively associated with total cholesterol ($\beta = .26$, $t = 3.15$, $p = .03$) and LDL-C ($\beta = .45$, $t = 7.31$, $p = .001$), and negatively associated with HDL-C ($\beta = -.39$, $t = -6.97$, $p = .001$).

Thus, of the proposed mediators, only smoking and selected dietary variables, including total and soluble dietary fiber, were associated with both depressive symptoms and serum lipid levels (specifically LDL-C), thereby meeting the conditions for testing mediation (Imai, et al., 2010).

Mediational Analysis

Mediational analyses of depressive symptoms with LDL-C were performed controlling for possible confounding variables. There was a significant indirect effect of depressive symptoms on LDL-C via total dietary fiber in the unadjusted model (Indirect Effect, $p = .01$), but this finding was considerably attenuated in the adjusted model (Indirect Effect, $p = .52$) (see Table 2). A similar pattern was observed for insoluble dietary fiber, in which the unadjusted results reflected a statistically significant indirect effect ($p = .03$) that was attenuated in the adjusted model ($p = .66$).

The outcomes from the mediational analyses of dietary fiber variables suggested a suppression effect because the Path C coefficient, which represents the direct path between depressive symptoms and LDL-C (see Figure 1), is larger than the total effect. Therefore, post hoc analyses were conducted to assist in the interpretation of these complex findings. For ease of interpretation, variables (depressive symptoms, fiber intake) were dichotomized using the variable's median cutpoint. Findings from these post hoc exploratory analyses suggest that women with high depressive symptoms (i.e. above the median) were more likely to have lower LDL-C levels (i.e. below the median) compared with women with fewer depressive symptoms. However, women with high depressive symptoms also reported consuming less fiber (i.e. lower intake of total dietary fiber and insoluble dietary fiber). As LDL-C levels are highly negatively associated with dietary fiber intake, this association (between fiber intake and LDL-C) may partially mask the relationship between depressive symptoms and LDL-C. Stated another way, women with fewer depressive symptoms tend to have higher intake of dietary fiber, which lowers their LDL-C levels due to the protective benefits of fiber. In contrast, women with high depressive symptoms tend to eat less fiber, which raises their LDL-C levels. The impact of fiber causes the mean LDL-C levels within each group (high vs. low depressive symptoms) to move closer together. As a result, when the pathways were examined separately, the relationship between depressive symptoms and LDL-C levels became more pronounced in unadjusted analyses. Adjusted analyses, however, did not support mediation of the association of depressive symptoms with LDL-C by the health behaviors examined.

Discussion

Our findings suggest that higher depressive symptoms are associated with lower levels of LDL-C. Indeed, this inverse association has been reported in several prior studies (Igna et al., 2008; Shin et al., 2008). It has been postulated that the association between depressive symptoms and cholesterol is driven, in part, by serotonergic pathways (Engelberg, 1992; Shrivastava, Pucadyil, Paila, Ganguly, & Chattopadhyay, 2010). Specifically, low cholesterol levels may be associated with deficiencies in serotonergic transmission (Shrivastava et al., 2010; Steegmans et al., 1996), with early animal studies reporting that dietary restriction of cholesterol among young adult monkeys resulted in lower serotonergic activity (Kaplan et al., 1994). In humans, serotonin transporter gene polymorphisms have been associated with cholesterol levels, such that individuals who carry the *T*-allele had higher levels of LDL-C (Fischer, Gruenblatt, Pietschmann, & Tragl, 2006; Tomson, Merenäkk, Loit, Mäestu, & Harro, 2011). Further, other human studies have reported evidence for shared genetic factors that may explain the co-occurrence of lipid levels and depressive symptoms (Lopez-Leon et al., 2008; Lopez-Leon et al., 2010).

Consistent with our hypotheses and prior literature regarding depression and adverse lifestyle behaviors (Gravely-Witte, Stewart, Suskin, & Grace, 2009), higher levels of depressive symptoms were associated with greater smoking and lower dietary fiber intake. Further, smoking was associated with higher levels of LDL-C, but this relationship was no longer statistically significant in the mediational model. Similarly, dietary fiber intake was associated with serum lipid levels in unadjusted models, but not in the adjusted models. Although total and insoluble dietary fiber intake mediated the association between depressive symptoms and LDL-C in unadjusted analyses, the indirect effects were considerably attenuated in the adjusted analyses. We speculate that the associations between the confounding variables (marital status, income, and education level) and the variables of interest (depressive symptoms, health behaviors, cholesterol) diminish the ability to detect mediational pathways. For example, considerable empirical data indicate that marital status and education levels are strongly associated with more positive health benefits and behaviors, including diet, physical activity and smoking cessation (Broms, Silventoinen,

Lahelma, Koskenvuo, & Kaprio, 2004; Lee et al., 2005; Schoenborn, 2004; Trost, Owen, Bauman, Sallis, & Brown, 2002). Further, data from the National Survey of Families and Households (NSFH) consistently indicate that getting married decreases depressive symptoms (Lamb, Lee, & DeMaris, 2003; Wood, Goesling, & Avellar, 2007).

With respect to educational attainment, prior studies have reported that female college students and graduate students eat more foods high in dietary fiber compared to female non-students (Georgiou et al., 1997). Community-based studies report similar findings, with lower education and occupation levels being associated with poorer diet (e.g., diets low in fish and vegetables, but high in fried foods, pasta, and sugar) (Galobardes, Morabia, & Bernstein, 2001). Studies in men have also reported that high educational level and presence of a permanent relationship act as protective factors against depressive feelings and poor health behaviors (e.g., smoking, diet) (Igna et al., 2008). In contrast, lower levels of education were significantly associated with increased risk for metabolic syndrome in a large-scale study of young adults, even after controlling for other relevant variables in multivariate analyses (Carnethon et al., 2004). As a result, the significant associations between marital status and education with health behaviors and health outcomes make it challenging to detect any meaningful associations that might exist between depressive symptoms and cholesterol.

Although preliminary analyses did not support evaluating the other variables in mediational models, we did observe the expected associations between these variables with serum cholesterol levels. BMI was positively associated with total cholesterol and LDL-C levels and negatively associated with HDL-C, similar to findings from a number of prior studies (Denke, Sempos, & Grundy, 1994; Gupta et al., 2007). On the other hand, higher levels of physical activity were associated with lower levels of LDL-C, and higher levels of soluble dietary fiber intake were positively associated with levels of HDL-C, reinforcing the protective benefits of such behaviors (Houston et al., 2009; Katcher, Hill, Lanford, Yoo, & Kris-Etherton, 2009). Higher percent of calories from alcohol was also positively associated with HDL-C, which is consistent with extensive published findings on alcohol-induced changes on lipoproteins in premenopausal women (Clevidence et al., 1995). Moderate alcohol consumption, defined as one drink per day for women, has been reported to confer health benefits, including a reduced risk of heart disease (Brien, Ronksley, Turner, Mukamal, & Ghali, 2011).

Limitations

The strengths of this study include a large sample with regional diversity and comprehensive measures of potential mediators (e.g., 24-hour dietary recalls) and cholesterol assessments. However, since the participant sample was composed of young women who had been enrolled in a dietary intervention study as children due to unfavorable serum lipid profiles, these findings may not be generalizable to young men or to women who did not have elevated cholesterol levels in childhood. Also, due to the cross-sectional nature of the data, causal pathways cannot be evaluated. Prospective studies and experimental designs involving multiple assessments of such variables over time are needed to address any causal nature of this association. The observation that depressive symptoms are associated with lower levels of total cholesterol and LDL-C, even in this relatively young cohort, suggests that unhealthy lifestyle behaviors are not mediating the association of depression with serum lipid levels, at least not in early adulthood.

Conclusions

In summary, the present findings suggest that depressive symptoms are inversely associated with serum total cholesterol and LDL-C levels, and that the associations between depressive

symptoms and serum lipid levels are not mediated by health behaviors or BMI. Although prior findings have been somewhat mixed, many studies have noted that higher levels of depression are generally associated with lower levels of LDL-C and higher HDL-C. However, adverse health behaviors may be masking or attenuating, to some degree, such relationships. As a result, the heterogeneous findings that have been reported to date in the literature likely reflect the complexity of studying such associations, due to the competing nature of the factors that are involved.

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Figure 1. Model depicting the mediation analyses of lifestyle behaviors on the relationship between depressive symptoms and LDL-C.

Table 1**Participant Demographic Characteristics (n=225)**

Measure	
Current age in years	M = 27.20 (SD = 1.07; Range=24–29 years)
Race/ethnicity	
Hispanic	7.6%
Non-Hispanic white	84.9%
Non-Hispanic black	5.8%
Other	1.8%
Education	
High school/vocational school	11.1%
Some college	21.8%
College degree	51.1%
Post-graduate degree	16.0%
Marital status	
Single (never married)	55.6%
Married/living as married	40.4%
Separated/divorced	4.0%
Total household income	
< \$9,000	1.8%
\$9,000–\$14,999	1.3%
\$15,000–\$24,999	6.2%
\$25,000–\$34,999	6.2%
\$35,000–\$49,999	12.0%
\$50,000–\$74,999	21.3%
\$75,000–\$99,999	17.3%
\$100,000+	19.6%
Unknown	14.2%
Family history	
Maternal hx of diabetes	4.4%
Maternal hx of heart disease	2.7%
Paternal hx of diabetes	10.7%
Paternal hx of heart disease	14.7%
Depressive symptoms (CES-D)	M = 7.79 (SD = 6.78; Range =0–38)
Body mass index (BMI)	M = 25.30 (SD = 5.34; Range =15.85–46.47)
Total cholesterol	M = 200.17 (SD = 28.83; Range= 132–280)
HDL	M = 61.80 (SD = 16.91; Range= 29–122)
LDL	M = 119.02 (SD = 26.14; Range= 41–193)
Triglycerides	M = 95.55 (SD = 54.50; Range= 25–375)
Smoking status	
Never	52.4%
Former	20.4%

Measure	
Current	27.1%
Leisure physical activity in past year	
Median (IQR)	20.65 MET·h·wk ⁻¹ (8.38–36.24)
Median nutrient intake* (IQR)	
Energy (kcal)	1641.68 (1357.66–2024.41)
Total fat (% kcal)	31.52 (27.11–35.52)
Saturated fat (% kcal)	10.49 (8.23–12.48)
Monounsaturated fat (% kcal)	11.32 (9.65–13.48)
Polyunsaturated fat (% kcal)	6.36 (5.38–7.94)
Alcohol (% kcal)	0.12 (0.00–4.57)
Cholesterol (mg/1000 kcal)	119.51 (81.99–162.05)
Total dietary fiber (g/1000 kcal)	7.91 (5.99–10.99)
Soluble dietary fiber (g/1000 kcal)	2.27 (1.77–2.88)
Insoluble dietary fiber (g/1000 kcal)	5.57 (4.05–7.95)

Note.

* indicates N=213 for nutrient intake variables due to missing 24-hour dietary recalls.

Abbreviations used: Mean (M); standard deviation (SD); interquartile range (IQR).

Analyses Testing Physical Activity and Dietary Variables as Mediators of the Association between Depressive Symptoms and LDL-C

Table 2

Mediator	Outcome	Total Effect [*]			Path A ^{**}			Path B [†]			Path C [†]			Indirect Effect		
		Coefficient (CI)	p	R ²	Coefficient (CI)	p	R ²	Coefficient (CI)	p	R ²	Coefficient (CI)	p	R ²	Coefficient (CI)	p	p
Smoking	Unadjusted	-.14 (-.29,.02)	.07	.018	.18 (.08,.34)	.04	.031	.02 (-.18,.22)	.80	.031	-.14 (-.32,.04)	.11	.019	.0002 (-.02,.02)	.98	
	Adjusted	-.16 (-.34,.02)	.07	.167	.13 (.02,.24)	.03	.256	-.05 (-.23,.14)	.55	.256	-.15 (-.34,.04)	.09	.169	-.004 (-.02,.02)	.70	
Total fiber	Unadjusted	-.17 (-.38,.03)	.08	.031	-.10 (-.18,-.03)	.02	.010	-.17 (-.31,-.04)	.02	.010	-.19 (-.41,.02)	.07	.061	.02 (.01,.03)	.01	
	Adjusted	-.18 (-.40,.03)	.08	.188	-.07 (-.26,.12)	.40	.193	-.11 (-.26,.03)	.10	.193	-.19 (-.41,.03)	.08	.198	.008 (-.014,.03)	.52	
Insoluble fiber	Unadjusted	-.17 (-.38,.03)	.08	.031	-.09 (-.17,-.02)	.02	.009	-.16 (-.31,-.01)	.04	.009	-.19 (-.41,.03)	.08	.058	.015 (.002,.03)	.03	
	Adjusted	-.18 (-.40,.03)	.08	.188	-.06 (-.23,.11)	.41	.187	-.10 (-.25,.04)	.13	.187	-.19 (-.41,.03)	.08	.197	.006 (-.01,.02)	.66	

Note. The Indirect Effect is the Total Effect coefficient minus the Path C coefficient, which is also equal to the Path A coefficient times the Path B coefficient. We used bootstrap standard errors to test whether the indirect effect was statistically significant. All nine adjusted regressions included age (via restricted cubic spline), treatment group, race, education, income, marital status, hormonal contraceptive use, and family history of heart disease and diabetes. In addition, the fiber models included total energy intake (kcal, via restricted cubic spline) in the adjusted models.

* Coefficients derived from regression of LDL-C with depressive symptoms as a covariate.

** Coefficients derived from regression of mediator variable with depressive symptoms as a covariate.

† Coefficients derived from regression of LDL-C with depressive symptoms and mediator covariates. The coefficients differ between the smoking and dietary fiber models due to missing data (n=224 in smoking model, n=212 in fiber models) and the additional covariate of energy intake.