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Direct and Mediated Effects of Two Theoretically Based Interventions to Increase Consumption of Fruits and Vegetables in the *Healthy Body Healthy Spirit* Trial

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Abstract

This study tested the effects of two theory-based interventions to increase fruit and vegetable intake. Hypothesized intervention mediators included self-efficacy (SE), social support (SS), autonomous motivation (AM), and controlled motivation (CM). At baseline, 1,021 African American adults were recruited from 16 churches randomized to one comparison and two intervention groups: Group 1 (standard educational materials), Group 2 (culturally targeted materials), and Group 3 (culturally targeted materials and telephone-based motivational interviewing). A well-fitted model based on structural equation modeling—$\chi^2(df = 541, N = 353, 325) = 864.28$, $p < .001$, normed fit index = .96, nonnormed fit index = .98, comparative fit index = .98, root mean square error of approximation = .042—demonstrated that AM was both a significant mediator and moderator. In the subgroup with low baseline AM, AM mediated 17% of the effect of the Group 3 intervention on fruit and vegetable intake. Conversely, SS, SE, and CM were not significant mediators. Implications related to theory and intervention development are discussed.

Keywords

African Americans, fruit and vegetable consumption, mediation analysis, interaction effects, latent variable structural equation modeling

Introduction

Adequate consumption of fruits and vegetables (FVs) has been found to promote health and reduce the risk of several chronic diseases (Hung et al., 2004). The revised Dietary Guidelines for Americans recommend 2.5 to 6.5 cups daily of FVs depending on age, gender, and caloric intake (U.S. Department of Health and Human Services, 2005). Despite the documented health benefits of FV intake (FVI), most Americans are not meeting even the previously recommended guidelines of 5 or more cups of FVs daily (Blanck, Kimmons, Seymour, & Serdula, 2008; Kimmons, Gillespie, Seymour, Serdula, & Blanck, 2009).

Behavioral interventions targeting FVI are a potentially effective way to address this public health concern. A relatively recent review of 44 behavioral intervention studies found consistent outcomes ranging from an increase of 0.1 to 1.4 servings of FVs per day (Pomerleau, Lock, Knai, & McKee, 2005). Similarly, another comprehensive review of interventions for nutrition behavior found an average daily increase of 0.6 servings of FVs across the reviewed studies, but the authors stated that "a serious deficit still exists" in our understanding of the efficacy of different intervention approaches for high-risk ethnic and lower income populations (Ammerman, Lindquist, Lohr, & Hersey, 2002). One reason for this deficit may be the relatively low explanatory power of health behavior theories; existing causal models account for less than 30% of the variance in dietary behaviors (Baranowski, Klesges, Cullen, & Himes, 2004; Shaikh, Yaroch, Nebeling, Yeh, & Resnicow, 2008).

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The limited ability of current theories to predict FVI behavior change underscores the need to increase our understanding of the relationships between psychosocial variables and FVI. Although many interventions have been conducted to increase FVI (Ammerman et al., 2002), theory testing has been limited by the preponderance of cross-sectional designs that do not allow for testing of causal effects; and intervention studies with weak or null treatment effects. More recent statistical techniques such as mediation analysis with latent variable structural equation modeling (SEM) allow for more sophisticated methods of theory testing and intervention building by focusing on potential mediators of behavior change (Baranowski et al., 2004).

The current study used SEM to investigate the mediating and moderating role of several psychosocial variables that were measured in the *Healthy Body Healthy Spirit* (HBHS) trial, a cluster-randomized church-based intervention for increasing FVI and physical activity in African American adults (Resnicow et al., 2002). At 1-year follow-up, groups who received a culturally targeted intervention alone (increase of 0.44 servings at follow-up) or in conjunction with a motivational interviewing (MI) intervention (increase of 1.13 servings at follow-up), had a greater increase in FVI than the comparison group did (Group 1; increase of 0.17 servings at follow-up), with a larger increase seen in the MI intervention group (Resnicow et al., 2005). Applying the mediating variable framework proposed by Baron and Kenny can help clarify the processes of behavior change in HBHS by exploring the association of psychosocial variables and change in FVI (Baron & Kenny, 1986).

HBHS was grounded in several theoretical models, most notably social cognitive theory (SCT) and self-determination theory (SDT). SCT describes human behavior as a dynamic reciprocal interaction among the behavior, environment, and personal factors such as self-efficacy and social support (Glanz, Rimer, & Lewis, 2002). SDT posits that behaviors such as FVI that are motivated by higher levels of autonomous self-regulation (e.g., possessing a strong value for eating healthy) will be more likely to occur and will last longer than behaviors motivated by lower levels of these motives. Conversely, FVI motivated by higher levels of controlled forms of self-regulation (e.g., being told by others to eat healthy, or feeling guilty if one did not eat healthy) may be less likely to occur and are not as likely to be maintained over time compared to lower levels of these motives (Deci & Ryan, 1985).

Other studies have found self-efficacy (Fuemmeler et al., 2006; Langenberg et al., 2000) and social support (Fuemmeler et al., 2006; Langenberg et al., 2000) to be significant mediators of adult FVI. Although the full SDT model has been tested and confirmed for several health behaviors (Williams et al., 2006), little empirical work has been done to assess whether autonomous motivation (AM) is a mediator or moderator of FVI. The only other mediation analysis of AM found that it was not a significant mediator of FVI, with the authors hypothesizing insufficient treatment effect as the limiting factor (Fuemmeler et al., 2006). Based on this backdrop, the following hypotheses regarding mediation and moderation were investigated in the current study: (1) Self-efficacy, social support, and AM for eating more FVs partially or fully mediate the effects of the HBHS intervention on FVI. In contrast, (2) controlled motivation (CM) for eating more FVs is not a significant mediator of FVI. And (3) with regard to moderation, subgroups with lower baseline levels of the measured psychosocial variables would be more responsive to the effects of the HBHS intervention. That is, since the intervention targeted self-efficacy, social support, and AM, it is more likely that respondents with deficits in these constructs will benefit more from the HBHS intervention.

Method

Participants and Study Design

Participants were recruited through a quota sampling process at health fairs conducted in 16 churches in the Atlanta Metropolitan area. Churches were randomly allocated to one of three intervention groups, and baseline questionnaires were completed at these health fairs. A second health fair was conducted 1 year later, during which participants completed the follow-up questionnaire. There were 1,021 African American adults enrolled at baseline (76.2% female). As shown in Table 1, there were no significant differences in baseline sociodemographic variables across the three intervention groups ($p < .05$). Relatively low intraclass correlations (.005 to .02) were observed for participant FVI nested within churches, with no significant variation between groups (Resnicow et al., 2005).

At 1-year follow-up, 965 participants who completed the postintervention survey were assessed (retention rate 94.5%). Analysis of dropouts indicated no differences in gender, marital status, or FVI compared to members retained in the cohort. Dropouts were significantly more likely to be younger and from lower income and educational demographics. There was no differential attrition across the three groups for the variables in Table 1 (using chi-square and analysis of variance $p < .05$; Resnicow et al., 2005).

Intervention Design

The culturally targeted component of the HBHS intervention was based on a multidimensional model of cultural sensitivity developed by Resnicow and colleagues (2001) that involved extensive formative evaluation including examination of existing literature, focus groups, and an ethnic mapping procedure to tap into the culture and values of the target population. The end goal was the creation of salient and acceptable health promotion materials targeted at an African American southern church-based population. A brief description of the interventions follows, but detailed reports have been published elsewhere (Resnicow et al., 2002; Resnicow et al., 2005).

Table 1. Characteristics of Eligible Study Participants at Baseline

Variable	Comparison (n = 293)	Self-Help (n = 361)	Self-Help + MI (n = 367)	Total (N = 1,021)
Age, years (M)	45.9 (13.4)	45.8 (12.8)	45.8 (13.5)	45.8 (13.2)
Education, %				
Less than eighth grade	0	0.9	1.1	0.7
Some high school	4.6	1.7	2.5	2.9
High school graduate	13.8	12.5	13.8	13.3
Vocational/technical	15.9	9.3	13.3	12.6
Some college	25.1	26.2	26.6	26.0
Graduated college	19.1	24.1	23.2	22.3
Some postgraduate	7.0	7.6	6.5	6.9
Finished postgraduate	14.8	17.7	13.0	15.2
Gender (%)				
Male	26.3	22.2	22.3	23.4
Income, $ (M)	47,409	48,919	49,463	48,671
Marital status, %				
Married	50.3	50.6	52.8	51.3
Single, never married	24.3	21.8	20.4	22.0
Widowed	10.6	8.4	6.6	8.4
Divorced/separated	14.4	18.3	19.9	17.8
Living with a partner	0.35	0.87	0.28	0.51

Note: MI = motivational interviewing.

In all three groups the intervention was launched at church-based health fairs, where participants received their intervention materials. Materials given to the comparison group (Group 1; n = 295) were drawn from government sources and commercial vendors, whereas Groups 2 (n = 363) and 3 (n = 367) received similar materials that were culturally targeted (Resnicow, Braithwaite, Ahluwalia, & Dilorio, 2001; Resnicow et al., 2002). Special effort was made by the investigators to develop materials that were comparable in format and dose to the comparison group (i.e., all materials targeted self-efficacy and social support for eating more FVs) in an effort to maximize the internal validity of comparison between groups.

In addition to the culturally targeted intervention materials, Group 3 also received four MI (Miller & Rollnick, 2002) telephone counseling calls, two on nutrition and two on physical activity behavior. Each call was made by a master's- or doctoral-level psychologist and lasted about 30 minutes. The protocol focused on eliciting change talk to increase autonomous motivation for eating more FVs using several strategies. A unique element of the counseling process involved the use of a values clarification strategy where clients were asked to select up to five values or goals they found most important, such as being a good parent, successful, and energetic, and then link these goals to their dietary behavior.

SDT has been proposed as a framework for explaining MI, which is a widely adopted technique of counseling for promoting behavior change (Markland, Ryan, Tobin, & Rollnick, 2005). Both MI and SDT are based on the assumption that humans have innate tendencies for personal growth toward psychological integration and better health. They also identify AM and perceived competence as psychological needs that energize behavior change and can be influenced by the individual's social environment. MI can thus help elicit the psychological impetus for change postulated by SDT through three universal needs: autonomy, competence, and relatedness. Support of these needs facilitates the internalization of autonomous self-regulation and perceived competence, thereby allowing clients to take the responsibility for deciding whether to change their behavior and what they need to best achieve the outcome (Miller & Rollnick, 2002). Thus, Group 3's MI intervention was designed to promote the internalization of AM for increasing FVI. Perceived competence and relatedness were not measured in this trial. The tone of the health education materials developed for Groups 2 and 3 also focused on supporting autonomous motivation.

Measures

Dependent variable: FVI. The HBHS trial used three different measures of FVI to maximize the convergent validity of the primary outcome: a 19-item FVI screener developed by the National Cancer Institute, a 2-item measure, and a 36-item food frequency questionnaire (FFQ; Resnicow et al., 2000). Baseline and follow-up FVI was operationalized as a latent construct for the SEM analyses with the three measures as indicators.

Computation of daily FVI excluded the measure of fried potatoes or french fries in the screener and FFQ. Serum carotenoids were obtained from 79% of the baseline sample to validate the FFQs (validity coefficients ranged from .17 to .37; Resnicow et al., 2000).

Autonomous and controlled self-regulation. HBHS used a revised 15-item version of the Treatment Self-Regulation Questionnaire (TSRQ) developed by Williams, Rodin, Ryan, Grolnick, and Deci (1998) to assess the degree to which an individual's motivation for eating more FVs is autonomous or self-determined. The TSRQ is composed of two primary subscales, a seven-item autonomous self-regulation measure and an eight-item controlled self-regulation measure. Each item began with the words "The reason I eat more fruit or vegetables is . . ." and was rated on a 7-point scale ranging from *not at all true* to *very true*. An example of an item measuring AM for eating FVs is "Because it is an important choice I really want to make . . . ." An example of an item measuring CM is "Because others would be upset with me if I didn't . . . ." Cronbach's alpha was .86 for the AM subscale and .89 for the CM subscale. Latent constructs were represented by two indicators based on mean scores of half the items in the subscales.

Self-efficacy for eating more FVs. This variable was assessed with a previously developed 10-item behavior-specific scale (Baranowski, Hearn, Baranowski, Smith, & Doyle, 1995). An example of one item is "How confident are you that you could order fruit and vegetables when eating at a restaurant?" Items were rated on a 4-point scale ranging from *not at all confident* to *very confident*, and Cronbach's alpha was .92. In the analyses, this construct was represented by two indicators, each based on mean scores of half the items in the scale.

Social support. A three-item scale was used to assess social support for eating more FVs (Resnicow et al., 2001). The items asked respondents to rate the encouragement they receive from family, friends/colleagues, and people at their church on a 4-point scale ranging from *none* to *a lot*. Cronbach's alpha was .71 and the latent construct was represented by three indicators.

Statistical Analysis Plan

Structural equation modeling (with EQS version 6.1) was used as the primary method of analysis. SEM allows for testing of relatively complex a priori models (including models with mediational effects between variables), and it provides less biased estimates by controlling for both random and correlated measurement error (Kenny, 2006). In most cases, the constructs were represented by parceled indicators (means of sets of items) as this procedure reduces nonnormal distribution of individual items and results in better fit (Bandalos, 2002).

Although both SEM and ordinary least squares regression methods can be used to test for mediation, SEM is generally superior because regression does not explicitly delineate the link between intervention and mediating variables, and it does not take measurement error into account, leading to potential decreased accuracy in the resultant coefficients.

The method of parameter estimation was maximum likelihood, which is relatively robust to departures from normality. Model fit was assessed using the recommendation of Raykov, Tomer, and Nesselroade (1991) for reporting the following goodness-of-fit measures: normed fit index (NFI), nonnormed fit index (NNFI, also known as Tucker-Lewis Index), and comparative fit index (CFI). As recommended by Boomsma (2000), the misfit index known as root mean square error of approximation (RMSEA) was also reported. "Rules of thumb" indications for minimum acceptable fit are provided by fit indices that exceed .90 and RMSEA less than .10. Work by Hu and Bentler (1999) suggests that models with CFI and NNFI indices closer to .95 and RMSEA less than or equal to .06 provide reliable evidence of acceptable fit. Lastly, the Sobel method was used to assess the significance of mediational pathways (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002).

Proposed theoretical model. Mediation analysis requires testing of the causal pathways between the independent variable, the mediating variable, and the behavioral outcome (MacKinnon & Dwyer, 1993; MacKinnon, Warsi, & Dwyer, 1995). Thus, in the HBHS study, mediation can be established if the intervention had a significant impact on the mediator, and the mediator on the outcome, independent of the intervention's effect on the outcome, with a significant Sobel test result being the fourth criterion (Baron & Kenny, 1986).

Based on our theoretical and analytic framework, Figure 1 depicts the structural model that specifies the direct and indirect (including mediated) effects of the HBHS intervention through self-efficacy, social support, AM, and CM on FVI. The model is designed to assess whether change in the potential mediators influences change in FVI. Two dummy variables were created to provide estimates for the effects of membership in either Group 2 or Group 3 versus Group 1 (the comparison group) on the mediators and the behavioral outcome (i.e., FVI). Significant paths between these dummy variables and posttest variables indicate that the treatment generated change in the follow-up variable. The structural model also includes (a) paths linking latent variables at baseline and 1-year follow-up (i.e., providing stability coefficients to help establish that significant change in follow-up variables is due to the interventions); (b) correlations among baseline AM, CM, self-efficacy, social support, and the intervention groups to confirm random assignment of participants to groups; (c) correlations between error terms of corresponding indicators across time; and (d) diagonal paths from baseline mediating constructs to posttest FVI, which according to Kessler and Greenberg (1981) indicate the extent that change in the mediators (baseline to follow-up) correlated with change in FVI.

Finally, to investigate Research Question 2 regarding moderation, the model depicted in Figure 1 was used in a series of analyses to assess whether baseline levels of self-efficacy, social support, AM, and CM moderated the relationships between the HBHS interventions, these psychosocial variables, and FVI. To conduct simultaneous two-group SEM analyses (Kline, 2005), the sample was divided using a median split into low and high subgroups on baseline values of each psychosocial variable. The fit and parameters of a two-group model were then estimated, while constraining the factor loadings, paths,

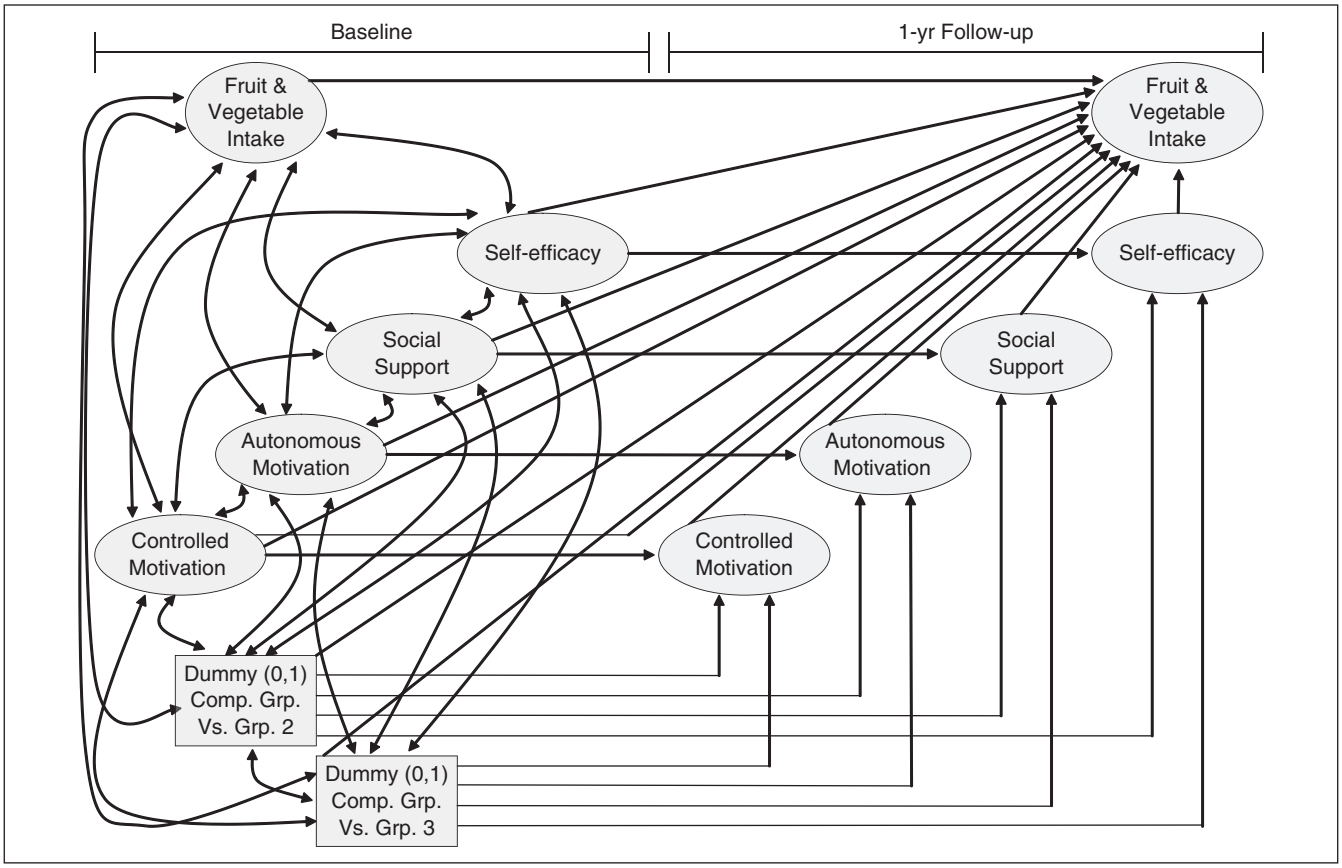

Figure 1. Theoretical model of the effects of two interventions on key mediators and the consumption of fruit and vegetables in the *Healthy Body Healthy Spirit* trial

and covariances to be equal. After fitting a two-group model, those constraints that would improve model fit were then released. If releasing the constraints between specific hypothesized paths results in a statistically significant improvement in model fit (i.e., significant reduction in chi-square), then baseline level of the variable is demonstrated to be moderating the relationship between the intervention and outcome in the path of interest.

Results

Table 2 presents the means, standard deviations, and correlations among study variables.

Measurement Model

Based on our theoretical model as depicted in Figure 1, a measurement model was used to assess the relationships among the latent variables and their effects on the observed indicators. The overall fit of the measurement model was good: $\chi^2(df = 230, n = 678) = 426.09$, $p < .001$, NFI = .95, NNFI = .97, CFI = .98, RMSEA = .035. Except for social support ($r = -.08$, $p < .05$), baseline correlations between the intervention groups and psychosocial variables were nonsignificant, demonstrating the suitability of the model for estimation of structural coefficients (see Table 2).

Model Fit

The model depicted in Figure 1 was used to test for mediation. The results indicate a good fit of the model to the data, $\chi^2(df = 251, n = 678) = 520.64$, $p < .001$, and with NFI = .94, NNFI = .96, CFI = .97, RMSEA = .040. Listwise deletion resulted in 343 cases being dropped from analysis. Additional analysis using the EM imputation procedure in EQS (which derives maximum likelihood estimates) provided results that did not significantly differ from the nonimputed data; thus, all results are presented from the nonimputed data set.

The results of estimating all the parameters of the model in Figure 1 are presented in Figure 2; but Figure 2 includes only the correlations and paths that were statistically significant at $p < .05$ using two-tailed (solid lines) or one-tailed (dotted lines) tests. The Lagrange multiplier test indicated that adding a correlation between the disturbance terms for posttest AM and self-efficacy would result in a significant improvement with a reduction of 102.71 chi-square units. Thus, Figure 2 also

Table 2. Means, Standard Deviations, and Intercorrelations for Study Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. Dummy 1	1											
2. Dummy 2	–.55**	1										
3. Baseline autonomous motivation	–.06	.02	1									
4. Baseline controlled motivation	–.03	.00	.26**	1								
5. Baseline self-efficacy	–.03	.02	.30**	.02	1							
6. Baseline social support	–.04	–.08*	.21**	.28**	.09**	1						
7. Baseline FVI	–.01	–.02	.33**	.13**	.29**	.20**	1					
8. Follow-up autonomous motivation	.00	.00	.42**	.06	.19**	.06	.17**	1				
9. Follow-up controlled motivation	–.05	.14**	.11**	.43**	.03	.17**	.12**	.14**	1			
10. Follow-up self-efficacy	.06	–.03	.24**	–.01	.48**	.02	.24**	.39**	–.02	1		
11. Follow-up social support	–.03	.000	.13**	.14**	.10**	.41**	.16**	.19**	.21**	.13**	1	
12. Follow-up FVI	–.00	.11**	.19**	.03	.22**	.06	.55**	.23**	.09**	.29**	.21**	1
M	.35	.36	5.99	2.62	3.05	2.39	4.47	6.19	2.86	3.14	2.65	5.16
SD	.48	.48	1.13	1.53	.68	.85	2.43	.99	1.52	.61	.82	2.83

Note: Dummy 1 and Dummy 2 refer to variables comparing Group 1 versus Group 2 and Group 1 versus Group 3 interventions; intercorrelations for all 26 model variables are available upon request. FVI = fruit and vegetable intake.
*$p < .05$. **$p < .01$.

includes one post hoc modification based on potentially overlapping construct validity, the correlation between the disturbance terms of self-efficacy and AM.

As can be seen in Figure 2, the Group 2 intervention significantly increased posttest self-efficacy ($\beta = .08$, $p < .05$), whereas the Group 3 intervention significantly increased posttest FVI ($\beta = .15$, $p < .05$), CM ($\beta = .18$, $p < .05$), and social support ($\beta = .10$, $p < .05$). In addition, posttest self-efficacy and social support had a significant effect on posttest FVI (respectively, $\beta = .12, .18$; both $p < .05$). Both Group 2 and Group 3 interventions also increased AM when a one-tailed test is applied (both βs = .08, $p < .05$, one tailed).

It should be noted that the path coefficients from baseline AM and social support to posttest FVI have negative signs ($\beta = -.15$ and $-.17$, respectively, $p < .05$). According to Kessler and Greenberg (1981), reversing the sign in such diagonal paths provide values that are interpreted as changes in the independent variables from baseline to follow-up that are hypothesized to produce the changes in the outcome variable from baseline to follow-up. Consequently, these paths can be interpreted as evidence that the Group 3 intervention produced the change in social support that contributed to the increase in FVI. Similarly, there is evidence that both the Group 2 and Group 3 interventions produced the change in AM that contributed to the increase in FVI.

Mediation Analysis: Self-Efficacy, Social Support, AM, and CM

Using the Sobel test, mediating effects were tested in those instances where an intervention had a significant effect on a mediator, and the mediator also had a significant relationship with the FVI outcome at follow-up. Group 2 had a significant effect on self-efficacy, which in turn had a significant effect on FVI, but the results from the Sobel test was not statistically significant. Similarly, Group 3 had a significant effect on social support, which in turn had a significant effect on FVI. Here the Sobel test provides borderline evidence for the notion of social support as a potential mediator of FVI using a one-tailed test ($t = 1.73$, $p = .08$).

Analysis of Moderating Effects of the Baseline Psychosocial Variables

The model depicted in Figure 1 was used to assess whether baseline levels of the psychosocial variables moderated the relationships between the HBHS interventions, change in the psychosocial variables, and change in FVI. These analyses revealed statistically significant moderating effects for two of the psychosocial variables: AM and CM.

The results of the two-group structural model with participants who were low versus high on baseline AM (based on median split) indicated excellent fit of the model to the data, $\chi^2(df = 542, N = 353, 325) = 871.05$, $p < .001$, and with NFI = .96, NNFI = .98, CFI = .98, RMSEA = .042. When the constraint between low and high groups for the path from intervention Group 3 to posttest AM was released, the model chi-square was significantly reduced by 6.79 chi-squares. The results were virtually the same as those presented in Figure 2 except for the path between Group 3 and AM. As hypothesized, for those participants with low baseline AM, there was a significant effect for the Group 3 intervention on posttest AM.

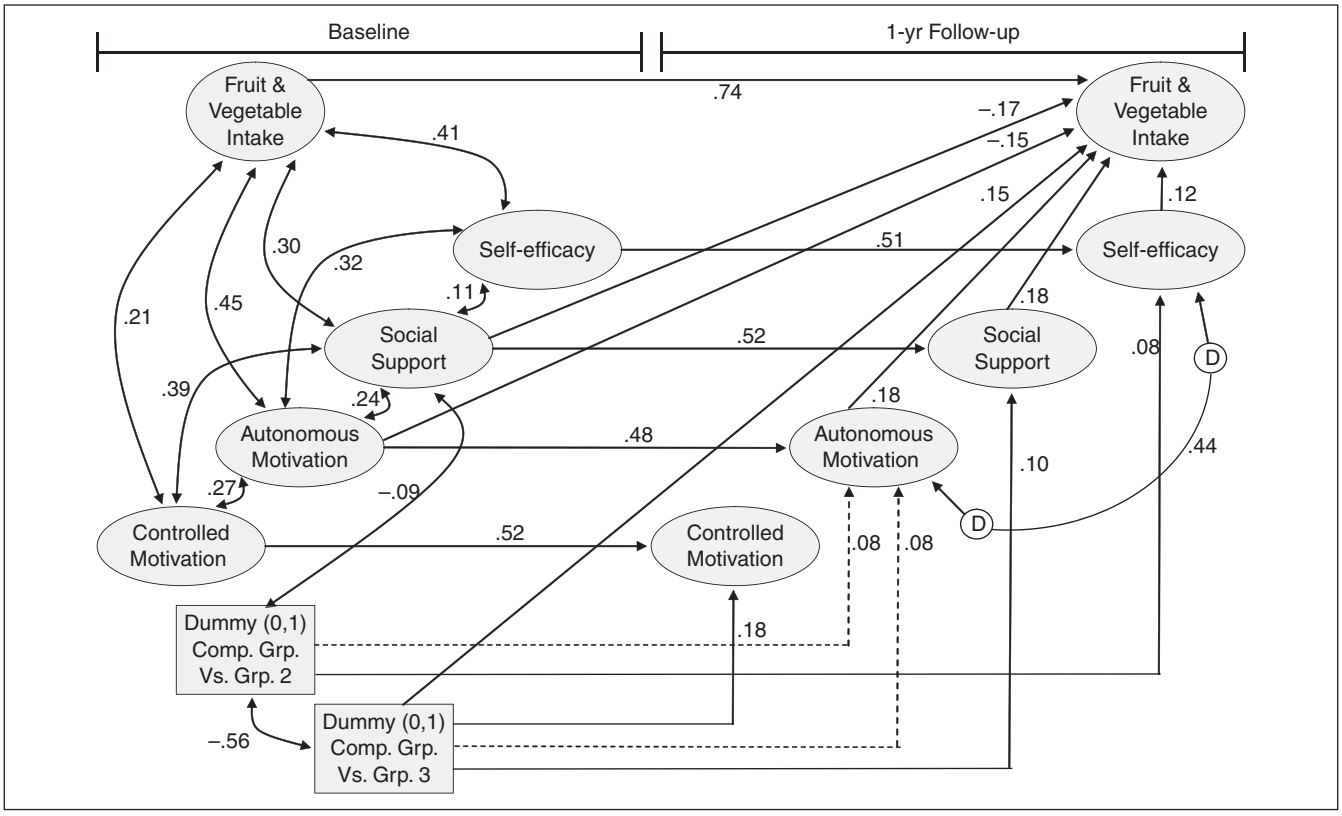

Figure 2. Effects of two interventions on key mediators and fruit and vegetable intake (FVI) in the *Healthy Body Healthy Spirit* trial
Note: $\chi^2(df = 251, n = 678) = 520.64$, normed fit index = .94, nonnormed fit index = .96, comparative fit index = .97, root mean square error of approximation = .040. Continuous curves and lines represent statistically significant correlations and standardized paths ($p < .05$). Dotted lines represent paths statistically significant for one-tailed tests ($p < .05$). Not presented in this figure are the correlations and paths included in Figure 1 that did not attain statistical significance at $p < .05$.

Participants in Group 3 with low baseline AM underwent a significant increase in posttest AM ($\beta = .14, p < .05$), whereas those with high baseline AM did not ($\beta = -.02, p > .05$). That is, compared to those with high baseline AM, the Group 3 intervention had a significantly stronger effect on AM in those participants with low baseline AM.

Regarding the moderating effect of CM, the two-group model with low and high subgroups of this variable showed acceptable fit, $\chi^2(df = 542, N = 340, 338) = 969.01, p < .001$, and with NFI = .90, NNFI = .95, CFI = .95, RMSEA= .048. When the constraint between low and high groups for the path from intervention Group 3 to posttest FVI was released, the model chi square was significantly reduced by 5.76 chi-squares. As before, except for the path between Group 3 and FVI, the results were virtually the same as those presented in Figure 2. The Group 3 intervention had a significant effect on increasing FVI in those participants with high baseline CM ($\beta = .24, p < .05$). Conversely, the Group 3 intervention did not have a significant effect on FVI in participants with low baseline CM ($\beta = .06, p > .05$). In other words, compared to those with low baseline CM, the Group 3 intervention had a significantly stronger effect on FVI in those individuals with high baseline CM.

The results of the two-group analyses for a median split on self-efficacy and social support did not demonstrate any significant differences in paths of interest between the HBHS interventions, psychosocial variables, or FVI. Participants with high or low baseline levels of self-efficacy and social support did not exhibit substantially different paths in the model.

Consequently, the significant paths between the Group 3 intervention and posttest AM, and from AM to FVI for individuals with low baseline AM enabled testing of the significance of AM as a mediator. The Sobel test results indicated that AM was a significant mediator of the effects of the Group 3 intervention on FVI for individuals with low baseline AM ($t = 2.13, p = .02$). The standardized path coefficients were then used to calculate the amount of indirect effect, or the reduction in the direct effect of the intervention on FVI due to the mediating pathway (Kenny, 2006). The product of the standardized path coefficient from the intervention to AM ($\beta = .14$) and the path coefficient from AM to FVI ($\beta = .21$) gives the magnitude of the mediated effect ($\beta = .03$). Dividing the indirect effect ($\beta = .03$) by the total effect of the intervention on FVI ($\beta = .03 + .15$) gives the proportion of the effect of the intervention mediated by AM. Therefore, the proportion of the intervention effect mediated by AM for individuals in Group 3 with low baseline AM was .17 or 17%.

Discussion

This study assessed the mediating and moderating effects of four psychosocial variables: self-efficacy, social support, AM, and CM in the HBHS intervention. The results demonstrate that only the intervention containing the additional MI component (i.e., Group 3) had a statistically significant effect on FVI. They also demonstrate that AM for eating more FVs partially mediated the effects of the Group 3 intervention on FVI in individuals with relatively low baseline levels of AM. Thus, individuals with low AM for eating more FVs may be more receptive to MI counseling that targets AM for this health behavior. Although similar relationships have been suggested by two other studies (one with a cross-sectional design and the other with a prospective design) that found AM to be significantly associated with FVI (Fuemmeler et al., 2006; Trudeau, Kristal, Li, & Patterson, 1998), this is the first study to find AM to be a significant mediator of an intervention to increase FVI.

The relative absence of intervention effect in Group 1 in comparison to Groups 2 and 3 is not surprising as this was the comparison condition. The findings also show that even though Group 2 received culturally targeted program materials, its intervention was not as effective as Group 3 at facilitating change in the hypothesized mediators and FVI compared to Group 1. This indicates that the Group 3 MI intervention had sufficient fidelity (or dosage) to effectively facilitate the internalization of AM for eating more FVs.

Both SDT's organismic-dialectical meta-theory (i.e., the notion that people are active agents with tendencies toward psychological growth) and SCT's concept of reciprocal determinism suggest synergistic effects between individuals and their social environment that could lead to greater perceived social support in the intervention groups. Three other studies found that social support for eating more FVs was a significant mediator of treatment effects on FVI behavior (Fuemmeler et al., 2006; Langenberg et al., 2000; Steptoe, Perkins-Porras, Rink, Hilton, & Cappuccio, 2004). In contrast, this study did not find social support to be a significant mediator even though the Group 3 intervention had a significant effect on social support. This may be because the church-based health promotion activities did not sufficiently target participant social support for eating more FV.

Even though self-efficacy was not found to be a significant mediator or moderator of FVI, there was a significant association between the disturbance terms of AM and self-efficacy at follow-up ($\beta = .44$, $p < .05$). Such association indicates that either overlapping construct validity or common measurement error (or both) may be taking place. SCT's construct of self-efficacy has been hypothesized as being related to SDT's perceived competence in both concept and measurement, but their relationship has not been quantified. Nonetheless, findings from other studies lend support to the notion of overlapping construct validity, because greater AM led to greater perceived competence in a number of different behaviors, including physical activity, student learning, and diabetes self-care behaviors (McNeill, Wyrwich, Brownson, Clark, & Kreuter, 2006; Williams & Deci, 1996; Williams, Freedman, & Deci, 1998). Further research is needed to determine the interrelationships between self-efficacy and AM, and more broadly, for comparative theoretical approaches such as SCT and SDT for behavioral modeling.

As predicted by SDT, CM was not found to be a significant mediator of the effects of the intervention on FVI. However, the results demonstrate that CM was a significant moderating variable, in that the Group 3 intervention with the MI component increased FVI in participants with high baseline CM. Although CM was not explicitly targeted, the MI technique may have been sufficiently autonomy supportive to reduce resistance in these more highly controlled individuals. It may also be possible that elements within the HBHS setting, such as being church-based, use of MI, culture, and ethnicity of participants helped make the social context of HBHS for those higher in CM more supportive of external motivators for eating more FVs such as devotion to God and strengthening the community. Both SDT and SCT provide a possible theoretical explanation to support this finding because they posit behavior is influenced by interaction between the active individual and their social context (Bandura, 2001; Deci & Ryan, 1985). As a result, even though CM was not a significant mediator, it may still warrant further study as a potential mediator as well as moderator of FVI in specific populations such as African Americans where the intervention may be targeting CM.

It should also be noted that the moderate *R*-squared explained reflect the limits of linear models of behavior change. Current models may only be able to account for a modest degree of variance given quantum and nonlinear influences on human thought and action, but this does not abrogate the potential of psychosocial mediators and models to help inform development of more effective behavioral interventions.

Strengths and Limitations

The results of this study are based on a cluster-randomized longitudinal experimental design using a large community sample of more than 1,000 participants with excellent follow-up retention (94.5%). The HBHS intervention's 1-year prospective design provides robust evidence for causal pathways. Formal mediation analysis of interventions on nutritional behavior has rarely been done; using SEM as the method of analysis had the advantage of correcting for measurement errors while formally testing complete mediational models, which were guided by the evidence-based intervention framework used in HBHS. These strengths lend support to the validity of the results. At the same time, certain limitations of the study should be noted.

First, the generalizability of the findings is limited to adult, predominantly female church-going members of the African American population living in the Southeastern region of the

United States. HBHS provided access to a relatively hard to reach population, but the quota-based sampling used to recruit participants may have achieved a study sample that was nonrepresentative of the total church-going population. Unfortunately, data to assess sampling bias or representativeness were not available. However, the findings may yet apply to other demographic groups because mediation analysis of FVI interventions targeting children have also found significant effects for psychosocial predictors such as positive outcome expectations and knowledge of FV recommendations (Reynolds et al., 2004). It would also be important to test the effects of interventions similar to HBHS in other populations to investigate mediation and moderation of variables such as self-efficacy, social support, AM, and CM in these groups.

A second potential limitation relates to the validity of self-report measures. Regarding the FVI outcome measure in particular, validity coefficients compared to serum total carotenoids, as well as multiple 24-hour recalls, demonstrated an acceptable range of validity correlations (Resnicow et al., 2000).

Finally, the dosage or fidelity of the MI counseling sessions for Group 3 were not assessed; however, the HBHS intervention utilized trained psychologists when delivering the MI intervention to minimize potential bias. Future research using MI should consider using postintervention coding of a random sample of audiotaped MI counseling sessions to assess intervention fidelity.

Implications for Practitioners

Overall, the findings provide support for the effectiveness of AM as a potential mediator of adult FVI. Study findings also demonstrate the potential for MI interventions to increase FVI by facilitating the internalization of AM and self-regulation, particularly among those low in autonomy, and possibly by reducing resistance in those that are high in CM and self-regulation. More recent studies have continued to explore the use of lay health advisors for MI interventions for greater potential dissemination and diffusion (English, Merzel, & Moon-Howard, 2010). Additional research should assess the effectiveness of MI for facilitating internalization of autonomous self-regulation of behavior across multiple populations. With CM also warranting further study as a potential mediator and moderator of FVI, the findings as a whole support the potential importance of SDT constructs in explaining changes in health behavior. By adding FVI to the list of other health behaviors such as tobacco dependence treatment (Williams et al., 2006), physical activity (Fortier, 2007), and physical activity and weight loss (Silva et al., 2010) that have been shown to be malleable to interventions based on SDT, this study has important implications in helping researchers adopt "new" strategies for developing behavior change interventions for increasing FVI.

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