

Mediating Variables in a Transtheoretical Model Dietary Intervention Program

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This study identified mediators of a Transtheoretical Model (TTM) intervention to increase fruit and vegetable consumption among economically disadvantaged African American adolescents ($N = 549$). Single- and multiple-mediator models were used to determine whether pros, cons, self-efficacy, and stages of change satisfied four conclusions necessary for establishing mediation of intervention effects on youths' dietary behavior. All four conclusions were satisfied for stages of change and pros in the single-mediator models and for stages in the multiple-mediator model. Stages mediated 31% of the intervention effect, and pros mediated 7% of the intervention effect in the single-mediator models. In the multiple-mediator model, stages accounted for 72% of the intervention effect. Findings add to the limited data on mediating variables in TTM dietary intervention programs. Replication studies are needed before it can be concluded that stages of change and pros are consistent mediators of TTM intervention program effects.

Keywords: *mediating variables; Transtheoretical Model; dietary intervention; fruit and vegetable consumption; African Americans; adolescents*

The Transtheoretical Model (TTM) has been extensively used to guide behavior change for health promotion (Plummer et al., 2001). The model comprises four constructs: (1) *stages of change*, the temporal and motivational readiness to modify health behavior; (2) *decisional balance*, the relative importance of the perceived pros (advantages) and cons (costs) of change; (3) *situational self-efficacy*, confidence in the ability to modify behavior under certain circumstances; and (4) *processes of change*, intervention strategies and techniques that change agents (therapists, counselors) use to facilitate health behavior change (Prochaska & Velicer, 1997). According to the TTM, different processes of change need to be used at each stage of change (Redding et al., 1999). The delivery of stage-relevant processes promotes movement through the stages and effects improvements in health behavior, decisional balance, and self-efficacy.

Dietary applications of the TTM include fat reduction, weight control, consumption of dairy products, and fruit, vegetable, and grain intake (Greene et al., 1999). Cross-sectional studies support the utility of the model for understanding and predicting fruit and vegetable consumption (Di Noia, Schinke, Prochaska, & Contento, 2006; Greene et al., 2004; Henry, Reimer, Smith, & Reicks, 2006). TTM dietary intervention programs have

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been successful in increasing fruit and vegetable consumption in diverse populations (Di Noia, Contento, & Prochaska, 2008; Greene et al., 2008; Nitzke et al., 2007).

A focus of TTM dietary intervention program evaluations has been the assessment of change in targeted dietary behaviors. Less attention has been devoted to the investigation of mediating mechanisms by which program effects are obtained. Researchers have advocated the use of the mediating variable framework to identify which components of interventions are effective and how (Baranowski, Anderson, & Carmack, 1998). According to this framework, mediating mechanisms are the influences on a behavior derived from theoretical models of behavior (Baranowski, Cullen, Nicklas, Thompson, & Baranowski, 2003). Intervention programs are targeted at changing variables from these models and result in behavior change due to changes in mediating mechanisms (Baranowski et al., 2003). Mediation analyses are the statistical methods used to test whether an intervention program changed the mediators, which in turn changed the behavior (MacKinnon et al., 2001).

Mediation analyses provide valuable information for further refining an intervention program. For example, mediators unaffected by an intervention can be identified and intervention content revised to strengthen impact on these mediators (Reynolds, Yaroch, Franklin, & Maloy, 2002). Intervention effects that are unexplained by mediating mechanisms implicate the need for additional research to replicate the results and to identify possible mechanisms through which program effects were obtained (Baranowski et al., 2003). Strategies designed to change mediators found to be unrelated to a behavior may require elimination from a program, thereby resulting in a more parsimonious intervention (Reynolds et al., 2002). Despite these advantages, mediating variables in dietary intervention programs are rarely tested (Fuemmeler et al., 2006; Haerens, Cerin, Deforche, Maes, & De Bourdeaudhuij, 2007; Kristal, Glanz, Tilley, & Li, 2000; Langenberg et al., 2000; Reynolds et al., 2002, 2004).

This study examined mediating mechanisms in a TTM intervention to promote consumption of five or more daily servings of fruits and vegetables among economically disadvantaged African American adolescents. Mediation analyses were used to determine whether pros, cons, self-efficacy, and stages of change mediated program effects on youths' dietary behavior. Findings will extend the literature on mediating mechanisms in dietary intervention programs, aiding researchers and program developers in designing more efficient and effective interventions.

METHOD

Description of the TTM Intervention Program

The TTM intervention program is described in detail elsewhere (Di Noia et al., 2008). To facilitate change in potential mediators and fruit and vegetable consumption, the program delivered processes of change identified as most useful at the different stages of change (Redding et al., 1999). In earlier research with economically disadvantaged African American adolescents, we found that youths were unequally distributed across the five stages of change (Di Noia et al., 2006). Based on prior applications of the TTM to fruit and vegetable consumption, contemplation was combined with preparation and action with maintenance (Campbell et al., 1999). The program was designed for youths in these three stages. Youths in action/maintenance were consuming five or more daily servings of fruits and vegetables, whereas those in precontemplation and contemplation/preparation were not. The difference between youths in these two preaction

stages was that those in precontemplation were not intending to change their behavior. In contrast, those in contemplation/preparation were considering it.

Delivered via CD-ROM, the program provided youths with four 30-minute sessions of interactive intervention content. All youths completed an introductory session, which oriented them to the program and addressed the health benefits of a diet rich in fruits and vegetables. A staging measure and algorithm built into the session determined youths' stage of change and identified which three sessions they would additionally complete.

Three groups of three sessions were developed (one set each for youths in the different stages). The sessions for youths in precontemplation incorporated consciousness raising, dramatic relief, and environmental reevaluation processes for enhancing awareness of lower-than-recommended intakes and promoting acceptance of the need for dietary change. The sessions for youths in contemplation/preparation used self-reevaluation and self-liberation strategies to increase confidence in the ability to increase intake, resolve ambivalence regarding commitment to act, and facilitate the development of specific plans for modifying behavior. The sessions for youths in action/maintenance employed reinforcement management, helping relationships, counterconditioning, and stimulus control processes for promoting problem solving in situations that challenge efforts to sustain recommended intake levels.

Evaluation of the TTM Intervention Program

The program was evaluated in 27 youth services agencies located in New York, New Jersey, and Pennsylvania. The agencies served economically disadvantaged youths, defined as youths who resided in communities in which 20% or more of families had annual household incomes below federal poverty thresholds. Nine pairs of agencies matched on the size of their youth population were randomized to one of two study arms: computer intervention (CI) and control. One of the remaining agencies served a disproportionately large youth population compared to the others and was assigned to the control arm to guard against the potential loss of participants in this arm. The 8 other agencies were assigned to the CI arm.

Selection criteria for study participation were African American racial-ethnic heritage and aged 11 to 14 years. Following institutional review board approval, eligible youths enrolled in after school programs at participating sites were offered the opportunity to participate in the study when they presented for services. Youths who provided written assent and obtained informed written consent from a parent or guardian were enrolled.

Informed and assenting youths completed a pretest measurement battery under the direction of trained research staff ($N = 549$). Two weeks after pretesting, youths in the CI arm completed the intervention in four 30-minute weekly sessions. The completion rate for the four-session intervention was .93. Youths in the control arm participated in regular programs offered at collaborating sites. Two weeks after intervention, youths in CI and control arms completed posttests. The retention rate at posttest was .92 ($n = 507$).

The outcome measurement battery included items for assessing youths' age, gender, and Hispanic origin; scales for assessing the pros ($\alpha = .91$) and cons ($\alpha = .85$) of consuming five or more daily servings of fruits and vegetables and self-efficacy for fruit and vegetable consumption ($\alpha = .86$; Di Noia et al., 2006); and the staging measure developed by the Cancer Prevention Research Center (1995). Fruit and vegetable consumption was measured using the first item in the staging measure. Response options ranged from zero to six or more daily servings.

Table 1 presents the intercorrelations among the proposed mediators at pretest and posttest. Significant correlations were found among the variables, ranging from a

Table 1. Pretest and Posttest Correlations Among the Potential Mediators

Variable	1	2	3	4
Pretest correlations				
1. Pros	—			
2. Cons	.39**	—		
3. Self-efficacy	.36**	.37**	—	
4. Stages	.26**	.22**	.33**	—
Posttest correlations				
1. Pros	—			
2. Cons	.32**	—		
3. Self-efficacy	.34**	.42**	—	
4. Stages	.28**	.15**	.25**	—

** $p < .01$.

magnitude of .22 to .39 at pretest and from a magnitude of .15 to .42 at posttest. This suggests some correlation among the variables but not a high degree of multicollinearity.

Sample Characteristics

The sample of 507 youths had a mean age of 12.44 ($SD = .98$) years and was 61% female. A small proportion (15%) of youths was of African American Hispanic racial-ethnic heritage. At pretest, most youths (55%) were in the contemplation/preparation stage, followed by precontemplation (33%) and action/maintenance (12%) stages. Youths' mean intake was 2.54 ($SD = 1.48$) servings. Youths in CI and control arms did not differ on baseline measures of TTM variables and fruit and vegetable consumption.

Criteria for Establishing Mediation

We used the method of MacKinnon (1994) to determine evidence for mediation by TTM variables of the relationship between the intervention and changes in youths' fruit and vegetable consumption. To establish mediation, four conclusions must be satisfied. First, the intervention must produce change in the outcome variable. Second, the intervention must produce change in the mediator. Third, the mediator must be associated with the outcome variable when the effects of the intervention are controlled. Fourth, the mediated effect must be statistically significant.

Statistical Analysis

Analysis of covariance (ANCOVA) models were used to establish support for Conclusions 1 through 3. Both single- and multiple-mediator models were evaluated, controlling for youths' demographic characteristics, baseline intake, and baseline measures of the mediators. The significance of mediated effects (Conclusion 4) was evaluated using Sobel tests (MacKinnon & Dwyer, 1993). The proportion of the intervention effect accounted for by the mediators was also calculated as the ratio of the indirect effect to the total effect (MacKinnon, 1994).

RESULTS

Conclusion 1 was satisfied. Relative to controls, youths in the CI arm increased their fruit and vegetable consumption from pretest to posttest, $F(1, 501) = 26.62, p < .001$.

Table 2. Analyses of Conclusion 2 (Relationship of Program to Mediators), Conclusion 3 (Relationship of Change in Mediators to Change in Outcome), and Conclusion 4 (Significance of Mediated Effects)

TTM Variable	Relationship of Program to Mediator	Relationship of Mediator Change to Outcome Change					
		Single-Mediator Models			Multiple-Mediator Model		
		Estimate	SE	Sobel Statistic	Estimate	SE	Sobel Statistic
Pros	2.35*	0.03***	0.01	1.99*	0.01	0.01	1.21
Cons	0.70	0.02	0.01	0.66	0.01	0.01	0.60
Self-efficacy	1.09	0.02	0.01	1.01	0.01	0.01	0.94
Stages	0.33***	0.76***	0.08	4.33***	0.68***	0.08	4.23***

NOTE: TTM = Transtheoretical Model.

* $p < .05$. *** $p < .001$.

Conclusion 2 was satisfied for two of the four potential mediators (Table 2). The intervention increased pros, $F(1, 501) = 5.08$, $p < .05$, and promoted forward stage movement, $F(1, 501) = 23.19$, $p < .001$. Effect sizes were calculated for changes in intake, pros, and stages. Observed effect sizes were .60, .11, and .42, respectively.

Conclusion 3 was examined for variables that satisfied the first two conclusions for mediation. The single-mediator models found that increases in pros, $F(1, 500) = 22.18$, $p < .001$, and forward stage movement, $F(1, 500) = 98.83$, $p < .001$, were associated with increases in fruit and vegetable consumption. Forward stage movement, $F(1, 497) = 79.17$, $p < .001$, was also related to increases in intake in the multiple-mediator model. Pros were unrelated to changes in intake in this model.

Conclusion 4 was satisfied for pros (Sobel test statistic = 1.99, $p < .05$) and stages (Sobel test statistic = 4.33, $p < .001$) in the single-mediator models and for stages (Sobel test statistic = 4.23, $p < .001$) in the multiple-mediator model. Pros mediated 7% of the intervention effect, and stages mediated 31% of the effect in the single-mediator models. In the multiple-mediator model, stages accounted for 72% of the intervention effect.

DISCUSSION

Findings suggest evidence for mediation by stages of change of the relationship between the intervention and changes in youths' fruit and vegetable consumption. Stages satisfied all four conclusions for establishing mediation in both single- and multiple-mediator models, accounting for 31% of the total intervention effect in the single-mediator model and 72% of the total effect in the multiple-mediator model. The TTM intervention increased youths' temporal and motivational readiness to modify their fruit and vegetable consumption as evidenced by their progression to later stages of change. Youths' forward stage movement, in turn, resulted in increased intake. Pros also satisfied the criteria for establishing mediation in the single-mediator model, accounting for 7% of the total intervention effect. Exposure to the TTM intervention increased youths' endorsements of the benefits of consuming five or more daily servings of fruits and vegetables, which led to increased intake. Despite evidence for mediation by pros, in the multiple-mediator model, improvements in this outcome were unrelated to changes in intake. The lack of an effect for pros in the multiple-mediator

model suggests that its effect was accounted for by other mediators in the model (Reynolds et al., 2002).

The TTM intervention failed to effect change in two potential mediators, cons, and self-efficacy. Program strategies for decreasing cons included raising awareness of personally relevant barriers to increasing intake and providing feedback and suggestions for overcoming these barriers. Strategies for increasing self-efficacy included providing information on simple, actionable strategies for increasing intake, teaching youths a positive self-talk strategy, and guiding youths through the process of setting a daily fruit and vegetable goal and developing and implementing a plan for accomplishing the goal. In other TTM research with low-income adults, the use of similar strategies was found effective in decreasing cons and increasing self-efficacy (Langenberg et al., 2000). Langenberg et al. (2000) used peer educators to actively engage participants in the change process. The personal responsiveness and warmth of these individuals may have contributed to the success of these strategies in their program. Regardless of the interactivity our program provided, it could only respond in ways it was programmed, a feature of multimedia interventions that has been noted as both a strength and a weakness (Redding et al., 1999). A strength is that all users receive the same program delivered in the same way. A weakness is the inability to respond to potentially important cues other than those that have been input. Thus, differences between the intervention program delivery modalities used in the Langenberg et al. study and our study may account for the differential program effects on cons and self-efficacy. Alternatively, the strategies used to modify cons and self-efficacy may be more effective with adults than with adolescents. Additional research is needed to determine whether the effectiveness of these strategies differs based on program delivery modality (i.e., computer delivered vs. leader delivered). In addition, there is a need to identify alternative approaches that are effective in decreasing cons and increasing self-efficacy among economically disadvantaged African American adolescents.

Differences between Langenberg et al.'s (2000) findings and our findings may be an artifact of dissimilarities between the TTM interventions and outcome measures used in each study. The TTM interventions differed in intensity and duration. The Langenberg et al. program consisted of three components delivered over a 6-month interval: (1) peer-led nutrition education sessions, (2) dissemination of print (clue cards, tip sheets, recipe and activity booklets) and videotaped materials, and (3) direct mail of stage-tailored letters. Our program consisted of a single intervention component, interactive multimedia sessions, that were delivered over a 4-week interval. Possibly, effectively changing cons and self-efficacy requires program exposures of greater duration and intensity than were provided in our program.

The measures of cons and self-efficacy used in the Langenberg et al. (2000) study contained fewer items than did the measures used in our study. In addition, Langenberg et al. used a global measure of self-efficacy, which differed from our situational self-efficacy measure. Our measure was designed to assess self-efficacy as defined by the TTM. According to the TTM, self-efficacy refers to confidence in the ability to modify behavior in positive social, negative affect, and challenging situations (Greene et al., 1999). Positive social situations are social interactions that elicit positive feelings (e.g., while having a good time with friends at a party, while enjoying the company of others at a picnic). Negative affect situations are those that involve negative situations accompanied by feeling bad (e.g., while having an argument with someone close and feeling upset). Difficult situations are those in which it is inconvenient to engage in the behavior (e.g., when only junk food is readily available). The global measure used in the

Langenberg et al. study may have been more sensitive to detecting change in self-efficacy than the situation-specific measure used in our study, a factor that may account for differences between Langenberg et al.'s findings and our findings regarding intervention program effects on self-efficacy.

The absence of intervention effects on cons and self-efficacy implicates the need to redesign our program to strengthen impact on these potential mediators. One approach for strengthening program effects is to provide youths with opportunities to apply their learning by changing the intervention delivery schedule (i.e., from weekly to monthly or quarterly). Youths may also benefit from exposure to materials similar to those used in the Langenberg et al. (2000) study (i.e., print materials and stage-tailored letters). The utility of using alternative strategies to modify cons and self-efficacy (versus strengthening existing approaches) also requires examination. One promising strategy is the provision of personalized feedback on endorsements of the pros and cons of increasing intake and on self-efficacy for consumption both before and after intervention, an approach that has been successfully used in other TTM interventions to modify adolescent health behaviors (Redding et al., 1999).

Redesigning the program and replicating mediation analyses can provide insight regarding whether the lack of effects on cons and self-efficacy was due to intervention deficits. If the absence of mediated effects persists in an evaluation of the revised intervention, the possibility that cons and self-efficacy are unrelated to intake should be considered. Possibly, successfully increasing fruit and vegetable consumption among economically disadvantaged African American adolescents requires modifying a subset of TTM constructs hypothesized to influence intake (i.e., stages of change and pros). Conclusions regarding whether this is in fact the case must await further research.

Stages of change and pros varied directly with intake, a finding that is consistent with cross-sectional research on the TTM (Campbell et al., 1998, 1999; Di Noia et al., 2006; Greene et al., 2004; Henry et al., 2006; Ma et al., 2002). Stages of change and pros were amenable to change through intervention, and positive changes in these variables were associated with increases in fruit and vegetable consumption. Together, these findings support the utility of the TTM for guiding the development of our program.

Study Limitations and Strengths

The use of a self-selected sample limits the generalizability of study findings. Youths electing to participate in the study may have differed from economically disadvantaged African American adolescents in similar youth services agency settings. The quasi-experimental study design limits the internal validity of study findings. Youths in CI and control arms did not differ on baseline measures of TTM variables and fruit and vegetable consumption, a finding that increases our confidence that outcome changes among CI-arm participants were due to intervention and not some other factor. Data for the study were based on self-report and may therefore be susceptible to reporting bias. Although we minimized this potential by using previously validated instruments that were administered according to standardized protocols, this concern cannot be dismissed entirely. The design of our intervention and the measures used to evaluate the program were based exclusively on the TTM, precluding assessment of other potentially important mediators of intervention program effects.

Despite these limitations, this study had several strengths. One was the high participant retention and intervention completion rates. Another was the magnitude of intervention effects on fruit and vegetable consumption. The observed effect (.60 servings)

was moderate by Cohen's (1988) conventions and was larger than reported effects in a meta-analytic review of interactive multimedia dietary interventions (Norman et al., 2007). Findings add to the limited data on mediating variables in dietary intervention programs generally and in TTM interventions specifically. Although replication studies are needed to determine whether stages of change and pros are consistent mediators of intervention program effects, our findings suggest that these variables are important to target in programs designed to increase fruit and vegetable consumption among economically disadvantaged African American adolescents.

Implications for Practice

Study findings have implications for both health education practice and research. Clinicians working with economically disadvantaged African American adolescents are encouraged to emphasize the benefits of a diet rich in fruits and vegetables and to enhance youths' motivational readiness to modify their dietary behavior. Essential to the success of such efforts is the delivery of processes of change relevant to youths' stage of change. Thus, a necessary first step in the change process is to determine youths' stage of change for fruit and vegetable consumption, information that can be used to educate youths about where they are in the change process and to identify the relevant strategies for promoting change. When working with youths who are not intending to change their intake (i.e., those in precontemplation) the use of supportive and nondirective intervention processes (i.e., consciousness raising, dramatic relief, and environmental reevaluation) to increase information, awareness, and acceptance of the need for dietary change is suggested. Responding to the needs of youths who are considering making dietary changes but have not yet moved to action (i.e., those in contemplation/preparation) requires the use of self-reevaluation and self-liberation processes to increase their intention and motivation to proceed with the changes. The use of action-oriented processes (i.e., reinforcement management, helping relationships, counterconditioning, and stimulus control) is suggested when working with youths who have succeeded in increasing their intake to recommended levels (i.e., those in action/maintenance) to build skills for overcoming obstacles to sustaining intake. As shown in this study, delivering stage-relevant processes of change is effective in bringing about positive changes in stages of change and pros. This approach may be more effective in changing these mediators than using the same intervention strategies with all youths regardless of their stage of change.

Health education researchers can use our findings to inform the design of future mediation models. As has been suggested elsewhere, there is a need to specify, measure, and test additional mediators in these models (Reynolds et al., 2002). Targeting constructs found to mediate intervention program effects on fruit and vegetable consumption in this and other studies (i.e., pros, stages of change, positive outcome expectancies, social support, self-efficacy, cons, knowledge of recommended guidelines for fruit and vegetable consumption, attitudes toward fruit and vegetables, and predisposing [skills, knowledge, and beliefs] and enabling [social support and norms] factors for change) is recommended (Fuemmeler et al., 2006; Kristal et al., 2000; Langenberg et al., 2000; Reynolds et al., 2002, 2004). Because environmental factors are related to eating, the utility of combining changes in both individual and environmental influences on consumption also requires examination (Baranowski et al., 2003). Promising strategies for creating environments that are supportive of healthful eating include changing fruit and vegetable availability (physical access or environmental opportunity), price

(economic access, incentives), and promotional, advertising, and point-of-purchase information (French & Stables, 2003).

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