Examining the Psychological Pathways to Behavior Change in a Group-Based Lifestyle Program to Prevent Type 2 Diabetes

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OBJECTIVE—To examine the psychological process of lifestyle change among adults at risk for type 2 diabetes.

RESEARCH DESIGN AND METHODS—A randomized control trial in which 307 volunteers (intervention, $n = 208$; wait control, $n = 99$) diagnosed with prediabetes completed a six-session group-based intervention to promote healthier living. Participants' motivation to change, diet and exercise self-efficacy, mood, knowledge about diabetes, activity levels, healthy eating, waist circumference, and weight were assessed before and after the program.

RESULTS—Participation in the program was associated with significant increases in healthy eating and physical activity, reductions in waist and weight, and improvements in motivation, positive mood, self-efficacy, and knowledge. Examination of the pathways to lifestyle change showed that the educational aspect of the program increased activity levels because it increased diabetes knowledge and improved mood. Eating behavior was not mediated by any of the psychological variables. Improvements in diet and physical activity were, in turn, directly associated with changes in weight and waist circumference.

CONCLUSIONS—Although the program significantly improved motivation, self-efficacy, and mood, its impact on knowledge uniquely explained the increase in physical activity. Group-based programs that are tailored to lifestyle behaviors may provide a cost-effective method of diabetes prevention, but more research is needed to explain why they improve healthy eating.

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Type 2 diabetes is one of the fastest growing chronic health conditions (1); therefore, cost-effective ways to reduce the burden of this disease and its associated long-term health complications (2) are essential. Prediabetes is widely recognized as providing early warning of the development of type 2 diabetes (3). Reducing modifiable lifestyle risk factors among those with prediabetes is an important pathway to prevention. Research shows that lifestyle programs are relatively successful in improving behavioral outcomes such as diet and exercise (3–6), but little research has examined the actual process of lifestyle change. It is unclear why certain lifestyle intervention programs are (or are not) successful. This is particularly the case with group-based interventions, in which participants complete a healthy living course in the presence of others rather than receiving individual care from a health professional. Elucidating the process of change that may be triggered by an intervention program and, in turn, the relative success of its specific elements, will better equip diabetes practitioners to design successful, cost-efficient lifestyle programs to prevent or slow this debilitating and costly disease. The current research moves from examining program outcomes to examining the psychological process of change in a group-based lifestyle program designed to prevent type 2 diabetes.

There is ample evidence that resource-intensive, individually based lifestyle programs can improve diet and exercise behaviors, which, in turn, can successfully reduce obesity, a physiological risk factor for type 2 diabetes (3–6). Individual programs have also been associated with changes in psychological variables such as mood and cognition. In particular, negative mood has been reduced (7,8), whereas cognitive factors such as knowledge (9,10), motivation to change (11,12), and self-efficacy beliefs about the ability to adopt and maintain healthy lifestyles (13,14) have been enhanced. What has not been adequately assessed is how changes in mood and cognition are implicated in the uptake of healthier behaviors as a result of completing a group-based lifestyle program. It is not clear if behavioral improvement is dependent on psychological changes in motivation, knowledge, mood, and self-efficacy uniquely or in combination. Likewise, it is unclear if some psychological factors are more important than others in the process of behavior change. Finally, it is not known if changes in both diet and exercise behaviors are driven by the same psychological process.

We recently conducted a randomized control trial to evaluate the outcomes of the Healthy Living Course (HLC), a group-based lifestyle intervention program for adults with prediabetes (15,16). Outcomes of the program were consistent with results of individually based programs (3–14), suggesting that a group intervention could effectively reduce the risk of developing type 2 diabetes. Our comparison of HLC participants with a wait list control group showed that those who completed the program demonstrated greater mean decreases in weight (−2.6 kg), waist circumference (−2.5 cm), diastolic blood

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pressure (−3.1), and fasting glucose levels (−0.21 mmol/L) and showed greater improvements in diabetes knowledge (+13.0%), motivation to change (13.2%), mood (2.5%), self-efficacy (2.0%), healthy eating (4.8%), and activity levels (86.9 min/week) (16). Further, those completing the HLC improved their diagnosis, moving from prediabetes to no diabetes, at almost twice the rate of the controls who received standard care from their general practitioners (GP) (43 vs. 26%). In the current paper, we take analysis of the HLC one step further by examining the psychological process that prompted changes in eating and exercise behavior among those at risk for type 2 diabetes.

The specific aim of the research reported here was to identify, via multiple mediation models, the psychological variables that mediate, or drive, behavior changes associated with a group lifestyle intervention. Our aim was to test the relationships between behavior change and the psychological variables of diabetes knowledge, motivation to change, mood, diet self-efficacy, and exercise self-efficacy, following participation in a group lifestyle intervention (or wait-list control group). Given that this was the first attempt to empirically compare a number of psychological mediators, no specific hypotheses were formulated regarding which variables relative to others would be the most important reasons for successful lifestyle improvements.

RESEARCH DESIGN AND METHODS

Participants and procedure

A sample of 307 Australian adults (aged 28–86, mean 62.5, SD 10.1) diagnosed with prediabetes volunteered for a randomized control trial of the HLC diabetes prevention program (Australian New Zealand Clinical Trial Registry number ACTRN12609000817246). Volunteers were randomly allocated to either the HLC (N = 208; 85 males, 123 females) or wait control group (N = 99; 41 males, 58 females) at a ratio of approximately 2:1. The unequal ratio was a practical compromise to accommodate referring GPs who wanted participants to begin the intervention without delay. Time 1 measures for both groups were completed prior to the program beginning. Six months later, after completing the program, HLC participants completed time 2 posttest measures. At that time, the wait control group completed identical time 2 postwait measures and was offered the HLC program. There were no differences between the control and HLC groups on all study variables taken at time 1, including demographic, psychological, and biological measures. Details of ethics approvals, sample recruitment, retention rates, demographic characteristics, diagnosis, screening, and study procedures are fully described elsewhere (16,17).

The HLC program comprised six small group sessions (6–12 participants plus trained facilitator; 150-min sessions) in weeks 1, 2, 3, 4, 12, and 26. The program content was psychosocial-educational, providing motivational support and information about diabetes, diet, exercise, and behavior change. Participants were encouraged to marshal social support for their change efforts, both from within and outside the group. The wait control group received standard care from their GPs, which typically involved health monitoring and dietary and lifestyle advice. Overall retention rate for the study was 89%, with 12% of the HLC participation and 8% of the control group failing to complete all time 2 measures. For those in the HLC group, 90% attended at least five of the six sessions. Full details of the program can be obtained elsewhere (17).

Measures

GPs recorded participants' weight (kilograms) and waist circumference (centimeters) at time 1 and again at time 2 (6 months later). Behavioral, cognitive, and mood variables described below were assessed at times 1 and 2 by self-report questionnaires. More detail on their psychometric properties can be obtained elsewhere (17).

A cognitive measure of motivation to change was used based on the transtheoretical model of Prochaska et al. (18). It consisted of a five-option forced-choice question, with response options reflecting: *1*) precontemplation, *2*) contemplation, *3*) preparation, *4*) action, or *5*) maintenance stages of change. Each response choice referred to a person's readiness for lifestyle changes involving more exercise and healthier eating.

Positive and negative aspects of mood were measured with two widely used, psychometrically sound standard scales: the Positive Affect subscale of the Positive and Negative Affect Schedule (19) and the Depression, Anxiety, and Stress subscales of the 21-item Depression Anxiety Stress Scale (20). Cronbach α coefficients for the Mood subscales in this study ranged from 0.78 to 0.92, indicating good reliability.

Diabetes self-efficacy in regard to diet and exercise was assessed using 18 items derived from the Stanford University Patient Education Research Centre Self efficacy for Diabetes Scale (http://patienteducation.stanford.edu/research/sediabetes.pdf) and the Diabetes Empowerment Scale (21). Items were summed and averaged to obtain total exercise and diet self-efficacy scores (α = 0.89 and 0.91, respectively).

Physical activity was measured with a short version of the International Physical Activity Scale (22). Participants estimated how many minutes they engaged in five types of activity in the previous week (walking, household chores/gardening, sports, moderate exercise, vigorous exercise), and times were summed to produce a total activity score. The International Physical Activity Scale is reportedly suitable for measuring physical activity levels among 18- to 65-year-old adults in diverse settings (22), but the scale demonstrated poor reliability in the current study (α = 0.38).

Healthy eating was assessed with the Food Choices Questionnaire, a 16-item measure devised for this study in accordance with the Dietary Guidelines for Australian Adults (23). Food Choices Questionnaire items reflected general principles of healthy eating (e.g., limiting fats, salt, and alcohol, consuming fruits and vegetables) rather than specific dietary guidelines for patients with diabetes. Participants rated the frequency with which they made particular food choices, and ratings were summed to give an overall healthy eating score (α = 0.67).

A 13-item true/false Diabetes Knowledge Scale was devised for this study based on information sourced from Diabetes Australia (http://diabetesaustralia.com.au/). Items assessed general knowledge about the nature of type 2 diabetes, its management and prevention (through diet and exercise), and associated medical risks. The total number of correct answers was summed to yield a diabetes knowledge score (α = 0.76).

Statistical analysis

Pearson's correlation coefficients and missing value analyses were conducted using Prediction and Analysis Software version 18 (IBM, Somers, NY). Cases with >30% missing values were removed (i.e., 38 cases). A missing value analysis for the remaining 269 cases suggested that missing values on all variables were distributed at random: χ^2 (783) = 833.35;

P = 0.103. Thus, they were estimated using the expectation-maximization estimation method.

To identify the presence of mediation, the distribution of the product approach (DOPA) (24) was used via a series of multiple mediation models. Time 2 measures were used for all psychological mediator variables, as it was assumed that the paths connecting the program to these variables represent its potential to change the participants' psychology and that this effect is carried through to changes in lifestyle behaviors and body. In support of this assumption, there were no significant differences (at $P < 0.05$) between the randomly assigned program participant and control groups on any study variables at time 1. Weight loss, waist reduction, increase in healthy eating, and activity were represented by change scores and created by subtracting time 2 from time 1 scores (weight and waist decreased and healthy eating and activity increased significantly at $P < 0.001$ across time 1 and time 2 for the intervention group, but not for the control group). Time 1 and time 2 mean scores for all variables are described in full elsewhere (17).

Mplus version 5 was used to test the models and generate standardized total and specific indirect effects. The models were estimated with maximum likelihood parameter estimates, with bootstrapping used to adjust for nonnormality (Mardia's normalized estimate = 5.64). Six multivariate outliers were found and deleted prior to model testing. A power analysis using a Monte Carlo simulation with all paths estimated at 0.25 and the two factor loadings at 0.80 revealed acceptable power (i.e., all power estimates were >0.79) for all parameter estimates in the largest model at n = 263 (25).

RESULTS

Descriptive statistics

Table 1 shows Pearson's correlation coefficients between all study variables. Being in the program group rather than the control group was correlated with significant increases in healthy eating and activity, significantly greater weight loss and reduction in waist circumference, significantly greater readiness to change, exercise self-efficacy, diet self-efficacy, diabetes knowledge, and positive mood.

Model testing

A series of path models were computed to assess whether the psychological variables mediated the effects of program participation on change in diet, activity, waist, and weight. Potential psychological mediator variables that significantly correlated with program participation and at least one of the four change variables were included in the analyses (knowledge, positive mood, motivation, exercise self-efficacy, and diet self-efficacy). Because reductions in weight and waist circumference were strongly correlated (Table 1), they were treated as a single latent body change variable in all models. A baseline model was computed first to establish the pattern of relationships between program participation and changes in diet, activity, and body (Fig. 1). The results suggested that the model was not an acceptable fit with the data and could be improved with the addition of a direct path from program participation to body change (modification index = 9.78). The modified model, with a nonsignificant correlation between change in activity and diet removed, was subsequently shown to be an acceptable fit with the data: χ^2 (3) = 5.62; $P > 0.05$; Tucker-Lewis index = 0.93, Comparative Fit Index = 0.98, root mean square error of approximation = 0.06, standardized root mean square residual = 0.03 (Fig. 1).

To assess each mediator variable's ability to transmit the effects of the program to the change variables, five separate models were computed, each inserting the mediator variable into the modified baseline model. The mediator variable was regressed onto program participation, and changes in diet and activity were regressed onto the mediator variable. All models were an acceptable fit with the data, apart from the knowledge model in which modification indices suggested adding a path from knowledge directly to body change (modification index = 8.68). The path was added, resulting in acceptable fit indices. The standardized indirect effects showed that only knowledge (0.05; $P < 0.05$) and positive mood (0.03; $P < 0.05$) significantly mediated the effect of program participation on change in activity. There was also a significant indirect effect for the program participation → knowledge → body change path (−0.06; $P < 0.01$). None of the other indirect effects were significant, suggesting that self-efficacy and motivation did not explain the program's ability to increase activity, and none of the psychological variables accounted for why the program improved the participants' diet. In addition, none of the mediators explained why the program was able to reduce participants' body weight and waist circumference.

The final model was designed to compare the indirect effects of knowledge and positive mood on their unique ability to transmit the effects of the program to the change variables. Both variables were inserted into the baseline model and regressed on program participation. Changes in diet and activity were regressed on knowledge and positive mood. Because knowledge and positive mood were both assessed at time 2, this model assumed that the influence of the program on both was contemporaneous. After removing nonsignificant paths, the results showed that the final model was a good fit with the data: χ^2 (9) = 13.15; $P > 0.05$; Tucker-Lewis index = 0.95, Comparative Fit Index = 0.98, root mean square error of approximation = 0.04, and standardized root mean square residual = 0.04 (Fig. 1).

Overall, Fig. 1 suggests that the program was successful in increasing participants' positive mood, knowledge about diabetes, healthy eating, and physical activity levels and reducing their weight and waist circumference. In total, the results from the final model revealed that roughly half of the impact of the program on change in body was due to the mediator variables (total indirect effect = −0.12; $P < 0.005$), with the other half being directly due to the program (direct effect = −0.14; $P < 0.05$). The only variable to significantly and uniquely mediate the effects of the program on body change was knowledge (specific indirect effect = −0.06; $P < 0.05$). No other specific indirect effects were significant, suggesting that increased mood, activity, and healthy eating did not uniquely explain why the program led to body change. Body change was also a direct result of completing the program, despite concomitant changes in knowledge, mood, activity, and diet.

Figure 1 also reveals that none of the psychological variables significantly mediate change in healthy eating. Although the program did result in improved healthy eating, it did so independently of any increase in participants' mood, knowledge, or activity levels. The psychological variables did, however, significantly explain the impact of the program on increased activity levels. The effect of the program on change in activity was entirely indirect (0.08; $P < 0.005$), suggesting that the combination of knowledge and positive mood significantly mediated the effects of the program on activity.

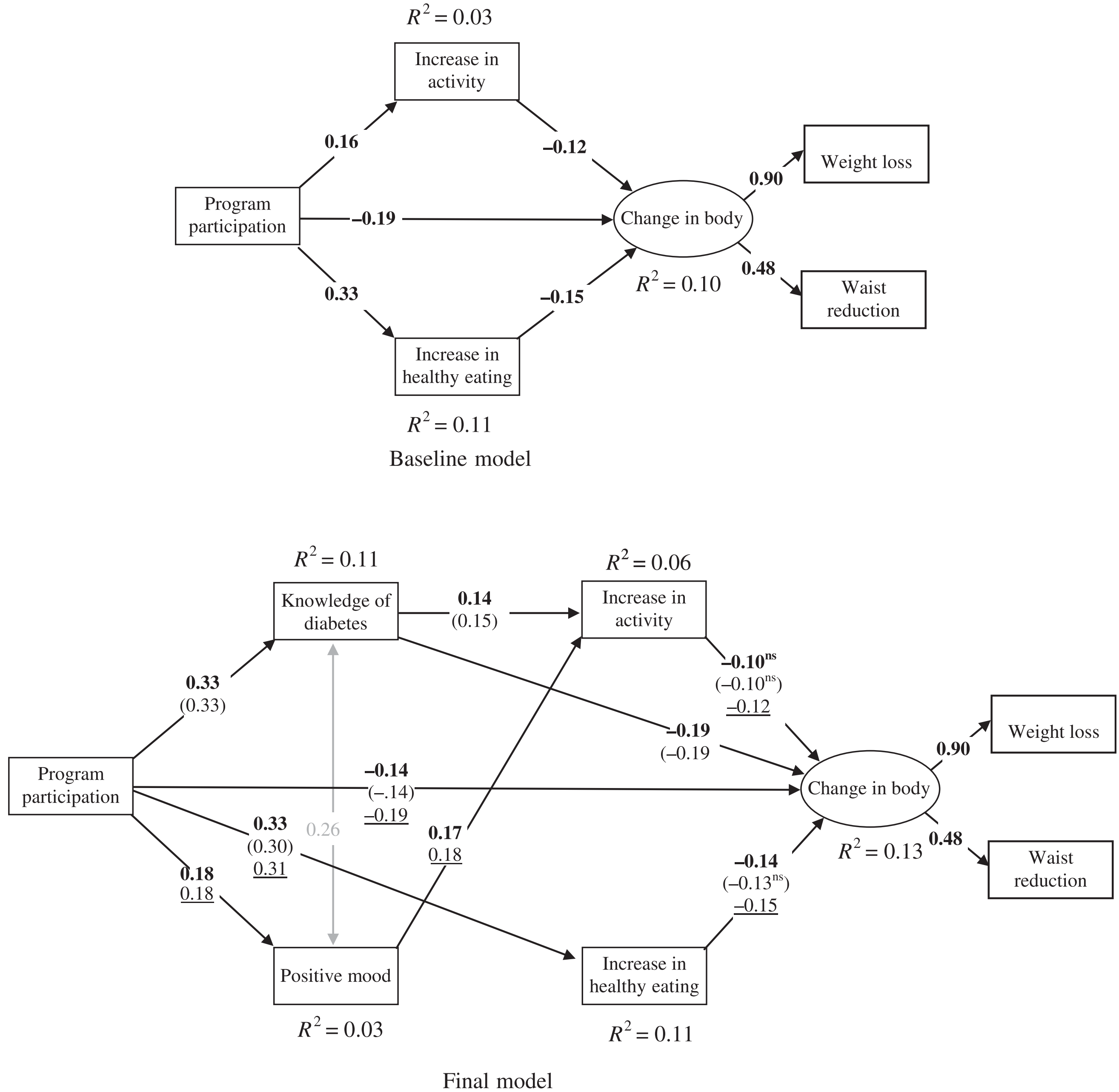

Figure 1—*Standardized parameter estimates for baseline and final multiple mediation models explaining predictors of lifestyle and body change among adults diagnosed with prediabetes. All parameter estimates were significant at* $P < 0.05$ *unless specified. Numbers in parentheses in the final model represent parameter estimates for the model containing only knowledge as a mediator, and underlined estimates represent those for the model containing only affect as a mediator.* R^2*, the proportion of variance explained in the dependent variable by all independent variables.*

However, examination of the specific indirect effects revealed that only knowledge significantly accounted for the ability of the program to increase activity levels (0.05; $P < 0.05$). When controlling for the mediating effects of knowledge, the specific indirect effect for positive mood was not significant (0.03; $P > 0.05$). This suggests that the initial ability of positive mood to transmit the effect of the program to activity change was due to its relationship with knowledge.

CONCLUSIONS—These results showed that a group-based HLC intervention was successful in facilitating improvements in lifestyle behaviors, with concomitant reductions in weight and waist circumference. This is consistent with previous research showing that individually based interventions can successfully reduce the risk factors associated with type 2 diabetes (3–6); but in this case, the intervention was a more cost-effective group program. The current results are consistent with previous research linking lifestyle programs to increased readiness to change (11,12), knowledge of diabetes (9,10), and perceived efficacy to change diet and exercise (13,14). However, a key finding reported in this paper was that HLC success was primarily due to increasing participants' knowledge of diabetes and positive mood. Although the HLC strongly emphasized the importance of both healthy eating and physical exercise, improvements in knowledge and mood gained from the program were only able to explain increased activity. Increases in healthy eating and, in turn, enhanced weight and waist reduction were a direct result of participation in a group program with peers who were also at risk for type 2 diabetes.

Predicting increased physical activity

The results suggest that the HLC increased activity levels primarily by increasing participants' knowledge about diabetes. Mood also played a role, but its ability to transmit the effects of the program to increased activity was explained by knowledge. This supports past research emphasizing the importance of knowledge (9,10) and, to a certain extent, mood (13,14) in reducing the risk of diabetes (9,10), yet is contrary to research highlighting the importance of improving motivation (11,12) and self-efficacy (13,14). On the surface, this implies that practitioners designing prevention programs should focus on strategies to increase participants' ability to understand and retain knowledge, particularly in relation to the role of physical activity in diabetes prevention. However, techniques designed to increase positive mood, self-efficacy, and motivation should not be ignored without further inquiry, as they all were associated with greater knowledge in this research.

The ability of knowledge to transmit the effects of an intervention program to lifestyle change may therefore occur if participants also experience additional psychological improvement and, particularly, increased mood. Indeed, previous research has shown that negative mood (26,27) and poor motivation (28) impede knowledge retention. It is possible that the knowledge gained by attending the program was enhanced by the group's ability to support participants' motivation and increase their mood. Those who feel more positive and motivated may be more inclined to act on their knowledge when deciding to increase physical activities. The use of the DOPA revealed that the mediating effects of positive mood and knowledge were associated, hinting at the possibility that knowledge may be enacted in terms of increasing one's activity, if mood is also enhanced. Future research should thus focus on how the elements of group programs may enhance mood and knowledge acquisition, which is then acted upon to increase activity levels.

Predicting increased healthy eating

The current research revealed that the process by which a group lifestyle program

Table 1—Pearson correlation coefficients for all variables

	Program completion	Readiness to change	Exercise self-efficacy	Diet self-efficacy	Knowledge	Depression	Stress	Anxiety	Positive affect	Change in healthy eating	Change in activity	Change in weight	Change in waist
2	0.38***												
3	0.13*	0.27***											
4	0.12*	0.24***	0.58***										
5	0.36***	0.32***	0.12	0.16*									
6	0.04	-0.10	−0.27***	−0.37***	−0.16**								
7	0.08	−0.16**	−0.23***	−0.33***	−0.11	0.69***							
8	0.06	−0.12	−0.21***	−0.26***	−0.17**	0.66***	0.63***						
9	0.16**	0.33***	0.54***	0.59***	0.27***	−0.38***	−0.19**	−0.24***					
10	0.34***	0.22***	0.12	0.10	0.20**	0.02	−0.03	0.05	0.19**				
11	0.17**	0.10	0.09	0.14*	0.18**	−0.08	−0.06	−0.13*	0.19**	0.14*			
12	−0.18**	−0.14*	−0.11	−0.09	−0.17**	0.01	0.00	0.04	−0.10	−0.19**	−0.19**		
13	−0.15*	−0.11	−0.20**	−0.15*	−0.12*	−0.01	0.03	0.10	−0.10	−0.17**	−0.02	0.51***	—

For program completion: intervention group = 1, control group = 0. Means and SDs for the intervention and control groups are available in Moore et al. (16). The possibility that the relationships between readiness to change and the four change variables may be quadratic (i.e., lower change for those low and high in readiness to change) was tested via four separate multiple regression equations. Each included a linear and a centered quadratic term predicting change in health eating, activity, weight, and waist. All quadratic terms and *F* change statistics were not significant, suggesting the relationships were primarily linear. $^{*}P < 0.05$. $^{**}P < 0.01$. $^{***}P < 0.001$.

increased healthy eating was different from that which led to increases in physical activity. Knowledge or mood did not explain why the program participants' diets improved. Indeed, it seemed that program participation alone improved the eating habits of participants, despite their psychological improvement and increased knowledge. This suggests that other variables not measured in this research (e.g., peer support, group dynamics) may have accounted for the program's success in changing participants' diet.

The finding that knowledge about diabetes was not a significant factor in the program's ability to increase healthy eating, but was a key driver for increased activity, may have been due to the nature of the disease and the participants' prediabetic status. Diabetes is a disease that is associated with food choices and obesity in the popular media. Thus, the lay public and particularly those who know that they are at risk for diabetes may already strongly associate diet with the disease. Indeed, all participants were diagnosed with prediabetes due to glucose impairment, and all demonstrated a relatively high level of knowledge before the program (16).

Knowledge was assessed by measuring participants' awareness of the nature of diabetes, including risk factors and potential long-term health consequences. If participants already knew about the role of diet in controlling blood glucose levels, the additional knowledge obtained through the program may have been in areas other than diet (e.g., risks and consequences). Increasing knowledge about healthy eating among those already at risk, and who are already relatively knowledgeable about the diabetes-diet link, may therefore not be as important in facilitating healthy eating as other factors not measured in this research, such as the perceived risk and consequences of developing diabetes.

Limitations and future research

Although perceived risk and aspects specific to a group-based program, such as peer support, may have accounted for the program's ability to increase healthy eating, this remains speculative until measures of these variables are obtained directly. Future research should also consider other variables not assessed in this paper that may explain or hinder lifestyle change, such as alcohol and tobacco use, and also compare the effects of individual and group-based programs on lifestyle change.

The measures used in this research also need further examination, particularly the IPAQ measure of physical activity, which showed very poor internal consistency for this sample. Despite showing good reliability over time and validity in previous research (22), the poor reliability of this measure in this research calls for further investigation into the IPAQ's psychometric properties. Another potential problem measure was motivation to change. This single item assessed a person's readiness to increase three actions: exercise, healthy eating, and weight loss. The prospect of simultaneously changing all three lifestyle elements may have reduced the connection between motivation and actual change.

The current research makes a contribution to the evaluation of healthy lifestyle programs by examining the process of change, as opposed to simply focusing on program outcomes, in a diabetes prevention program. Past studies have generally examined the psychological precursors of diet and exercise change separately, thus the relative and unique contributions of specific factors to different lifestyle behaviors had not been clearly delineated. The use of the DOPA in this paper suggests that the cognitive educational component of an intervention program, within a context of improved psychological functioning, is important for changing activity levels. In contrast, these factors were not important reasons for why the group-based program influenced healthier eating. Overall, these results show that a group intervention program can improve lifestyle and reduce risk in those diagnosed with prediabetes. Given that limited resources are available for diabetes prevention and that group-based programs such as the HLC can be more cost-effective than individually based interventions, their availability could help increasing numbers of people who are at risk for diabetes.

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C.R.C. wrote the manuscript, conducted the statistical analysis, and contributed to the design of the research. E.A.H. reviewed and edited the manuscript and contributed to the design of the research. S.M.M. edited and reviewed the manuscript and contributed to the design and management of the research. C.R.C. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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