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ORIGINAL RESEARCH

Physical activity and healthy eating behavior changes among rural women: an exploratory mediation analysis of a randomized multilevel intervention trial

Brian K. Lo,[1] Meredith L. Graham,[2] Sara C. Folta,[3], David Strogatz,[4] Stephen A. Parry,[5] Rebecca A. Seguin-Fowler[2,]

[1]School of Social Work, Boston College, Chestnut Hill, MA
[2]Texas A&M AgriLife Research, Texas A&M University System, College Station, TX
[3]Friedman School of Nutrition Science and Policy, Tufts University, Boston, MA
[4]Center for Rural Community Health, Bassett Healthcare Network, Cooperstown, NY
[5]Cornell Statistical Consulting Unit, Cornell University, Ithaca, NY

Correspondence to: Rebecca A. Seguin-Fowler, r.seguin-fowler@ag.tamu.edu

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Abstract

Rural women experience disproportionately higher levels of obesity in comparison to their non-rural counterparts. The present exploratory mediation analysis sought to identify mechanisms that might have contributed to rural women's physical activity and diet changes after participating in a 6-month multilevel community-randomized trial: Strong Hearts, Healthy Communities (SHHC). SHHC was conducted in 16 rural towns in Montana and New York, between 2015 and 2016; 194 overweight, sedentary midlife, and older women (mean age 59; 26.8% overweight; 73.2% obese) participated. Participants in eight towns received the SHHC intervention ($n = 101$), which focused on healthy behavior change at the individual level as well as creating supportive social and built environments for physical activity and healthy eating. Participants in the other eight towns received an education-only control intervention ($n = 93$). We investigated the direct and indirect effects of the SHHC intervention through changes to self-efficacy, social support, and built environment perception, on changes in participants' physical activity and diet. Compared to the controls, SHHC intervention participants increased their social support from friends for physical activity ($p = 0.009$) and healthy eating ($p = 0.032$). Participants' improved social support from friends marginally mediated the intervention effects for walking metabolic equivalent minutes per week, explaining 40.5% of the total effect (indirect effect = +45.24, 95% CI: −1.51, +91.99; $p = 0.059$). Increasing social support from friends appears to be helpful in encouraging rural women to become more active. Further investigations are needed to better understand how multilevel interventions work in rural communities.

Keywords

Mediation analysis, Rural, Nutrition, Physical activity, Social support

Implications

Practice: Increased social supports were associated with positive change in physical activity, and modifications of the intervention strategies are suggested to better influence these mediators of behavior.

Policy: Policy, system, and environment (PSE) interventions are being widely implemented to improve population health but little is known about those interventions when paired with targeted individual and social level strategies; future work should include natural experiments and pragmatic trials that aim to quantify and elucidate mediators of change.

Research: Additional studies—in a variety of contexts—that are specifically designed and powered to examine the pathways through which multilevel healthy behavior interventions work, and to what degree, are needed.

INTRODUCTION

Over recent decades, substantial efforts have encouraged active living and healthy eating; however, over half of Americans still do not meet current physical activity and healthy eating recommendations [1, 2]. Rural women in particular are less likely to perform adequate physical activity and meet fruit and vegetables intake recommendations compared to their non-rural counterparts [3–6]. Such geographic disparities could be due to the unique barriers to healthy living that rural women face at different socioecological levels, including high prevalence of caregiving duties [7, 8], limited social support [7, 8], and lack of access to active living facilities and healthy food sources [9, 10]. Therefore, it is imperative to develop interventions that simultaneously target behavior change at multiple socioecological levels.

Up-to-date, behavior change interventions are uncommon in rural communities and the majority of them only target behavioral change factors at the individual level. Dixon and colleagues [11] recently reviewed 18 rural-based weight loss interventions in the USA and found that only two of the studies intervened both at the individual and interpersonal levels [12, 13], only two intervened at both the individual and physical environment levels [14, 15], and only one intervened at the individual, interpersonal, and physical environment levels simultaneously [16]. The findings of these multilevel interventions are mixed and did not appear

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to be more effective than individual level only interventions [11]. This could be due to the lack of sufficient and relevant strategies that would be needed at each level to produce impacts [11].

Since multilevel interventions in rural communities are still in their infancy, further development and testing are needed to better understand how multilevel interventions work and what strategies are needed at different levels in order to produce greater impacts in comparison to individual level only interventions. One way to identify potential mechanisms that produce positive behavior changes within a multilevel intervention is to utilize mediation analysis to test mediating variables that are designed to encourage behavioral changes [17, 18].

Strong Hearts, Healthy Communities (SHHC) was a 6-month, community-based, multilevel cardiovascular disease prevention randomized trial that was designed based on an ecological perspective to improve physical activity and diet among rural women through in-class physical activity sessions and skill-building activities, field-based learning, and other activities that were aimed to foster supportive social and built environments for positive behavioral changes [19]. The SHHC intervention resulted in improvements in participants' weight status, walking habits, and fruit and vegetable intake [20, 21]. Since there is a scarcity of knowledge on the mechanisms of how multilevel behavior change interventions work in rural settings, the present study aimed to use mediation analysis to explore the pathways that might have contributed to intervention participants' physical activity and diet changes. Because the original study was not powered to examine mediators, the present mediation analysis is exploratory in nature. Through this exploratory analysis, we hope to encourage future studies to develop theory-informed interventions and identify mediators so that such knowledge can be used to develop more effective interventions to improve rural health. The hypotheses were as follows:

1. SHHC participation was associated with improved self-efficacy for physical activity and healthy eating, improved social support for physical activity and healthy eating, and changes in perception of the built environment for physical activity and healthy eating;
2. Impacts of SHHC on physical activity and diet were mediated by changes in participants' self-efficacy, social support, and built environment perception.

METHODS

Study design and participants

Study rationale, methods for recruitment, enrollment, data collection, and participant characteristics have been described elsewhere [19–21]. Briefly, the SHHC study was conducted in 16 medically underserved rural towns in Montana and New York between 2015 and 2016. Local health educators recruited 194 participants through posters/flyers, radio, social media, newspapers, targeted mailings, recruitment events, and word of mouth. Eligible participants were female, ≥40 years old, sedentary, had a BMI ≥ 25, and obtained physician's approval to participate. Figure 1 is the CONSORT flow diagram for SHHC.

Randomization was done at the community level. Participants in eight towns received the SHHC intervention (n = 101)—a 48-session (twice a week for 24 weeks) multilevel intervention focusing on improving physical activity and diet quality. At the individual level, educational sessions (e.g., health benefits of physical activity and healthy eating), experiential activities (e.g., in-class exercise and recipe tasting), and goal setting and monitoring sessions were designed to improve rural women's self-efficacy in exercising and healthy eating. At the interpersonal level, group-based activities with peer participants and out-of-class materials designed to encourage family and friends' engagement in physical activity and healthy eating (e.g., group exercises/activities and program discussion/peer support sessions) were used to improve participants' social support for behavior change. At the physical environment level, a civic engagement component, comprised of community audits and asset mapping, was designed to target participants' perception of the built environments related to physical activity and healthy eating. Supplementary Table S1 outlines the specific intervention strategies that were designed to target participants' perceived self-efficacy, perceived social support, and built environment perceptions for behavior change.

Participants in the other eight towns received a six-session (once a month for 24 weeks) education-only control intervention, known as Strong Hearts, Healthy Women (SHHW), that provided general education about healthy living including women and heart disease, healthy eating, physical activity, and stress management (n = 93). All participants gave their informed consent to participate. The study was reviewed and approved by Cornell University and Bassett Healthcare Network institutional review boards.

Measures

Participants' physical activity data were collected using ActiGraph Model GT3XE accelerometers (ActiGraph LLC, Pensacola, FL) and self-reported by participants using the International Physical Activity Questionnaire—short form [22–24]. Dietary intake data were collected using automated self-administered 24-hr dietary recalls (ASA24) [25]. Additional details of physical activity and diet data collection and analyses were described elsewhere

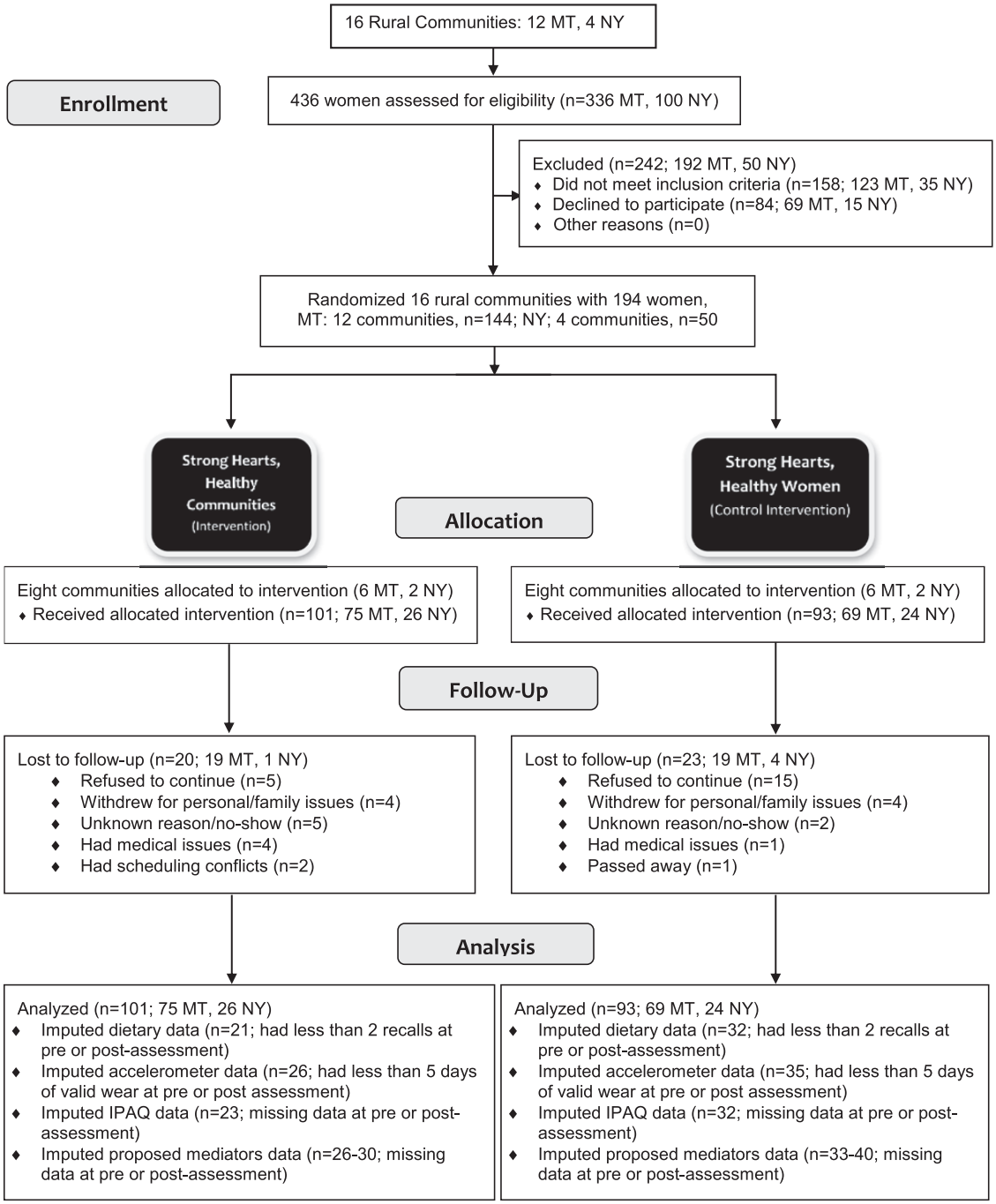

Fig 1 | CONSORT flowchart describing participant flow through Strong Hearts, Healthy Communities (SHHC). IPAQ, International Physical Activity Questionnaire; MT, Montana; NY, New York.

[21]. Data were collected at baseline and at intervention completion (24 weeks).

All of the proposed mediators were measured by a set of previously tested questionnaires self-administered at baseline and at the end of the 24-week study period. A scale score was calculated for each proposed mediator by taking the mean of the survey items, with a high score indicating greater perceived self-efficacy, greater perceived social support, and better perception of the built environment. Supplementary Table S1 shows all of the survey items. The internal consistency of all the proposed mediators was acceptable (all Cronbach alphas ≥ 0.70) [26].

Perceived self-efficacy for physical activity and healthy eating were measured using the Self-Efficacy for Diet and Physical Activity Behaviors Questionnaire, which includes 16 items for diet and 13 items for physical activity [27, 28]. The Social Support for Diet (5 items) and Physical Activity (10 items) Questionnaire was used to measure participants' perceived social support received from family members and friends for physical activity and

healthy eating [29]. Perceived built environment for physical activity was measured using 10 survey items developed by Boehmer et al. [30]. Perceived food environment for healthy eating was measured using six survey items developed by Echeverria et al. [31].

Statistical analyses

Prior to mediation analysis, we examined patterns of missing values in our data: baseline demographic differences between participants who had complete follow-up data on the proposed mediators and those without, and baseline demographic differences by treatment group; *t* tests were used for continuous variables and chi-square tests were used for categorical variables. Missing data were then handled by employing the same multiple imputation approach that was reported in our physical activity and diet outcomes paper [21] in order to ensure methodological consistency and relevant interpretation of findings. Briefly, PROC MI in SAS was used to impute 30 datasets and PROC MIANALYZE was then used to combine model results from each imputed dataset into one summary output. Figure 2 shows the conceptual model for the mediation analysis.

Guided by the mediation strategy proposed by Baron and Kenny [32], the statistical analysis was conducted in three steps:

Step One (Path a) examined the intervention's effects on participants' perceived self-efficacy, perceived social support from family and friends, and built environment perceptions for physical activity and healthy eating. Each of the proposed mediators were regressed independently, and any statistically significant changes of the constructs between the treatment groups would indicate potential mediators (Δ of proposed mediator = treatment group + control variables + baseline value of proposed mediator).

Step Two (Path c) tested the intervention's effects on participants' physical activity and diet; results have been published elsewhere (Δ of behavioral outcome = treatment group + control variables + baseline value of behavioral outcome): compared to controls, intervention participants significantly improved weekly walking minutes (113.5 metabolic equivalent [MET] minutes) and combined fruit and vegetable intake (0.6 cup per day) [21].

Step Three explored the combined effect of the intervention and the potential mediators on participants' physical activity and diet changes. Step Three examined (i) if change in the potential mediators had a significant relationship with the behavioral changes, after controlling for the effect of the intervention (Path b) (Δ of behavioral outcome = Δ of proposed mediator + baseline value of proposed mediator + treatment group + control variables + baseline value of behavioral outcome), and (ii) if the indirect intervention effect through Path a*b was statistically significant. PROC CALIS was used to test the statistical significance of the indirect intervention effect through Path a*b. To minimize the number of models being tested, we would only proceed to Step Three (ii) with the potential mediator(s) that exhibited statistically significant changes in Path a and changes in these potential mediator(s) had statistically significant associations with physical activity and diet changes that were identified in Path b.

Models in all the steps controlled for participants' age, education, relationship status, and baseline value of outcome of interest as fixed effects. Models also included study sites as random effects to control for the clustering effects of study sites. However, the random effect of the study sites was

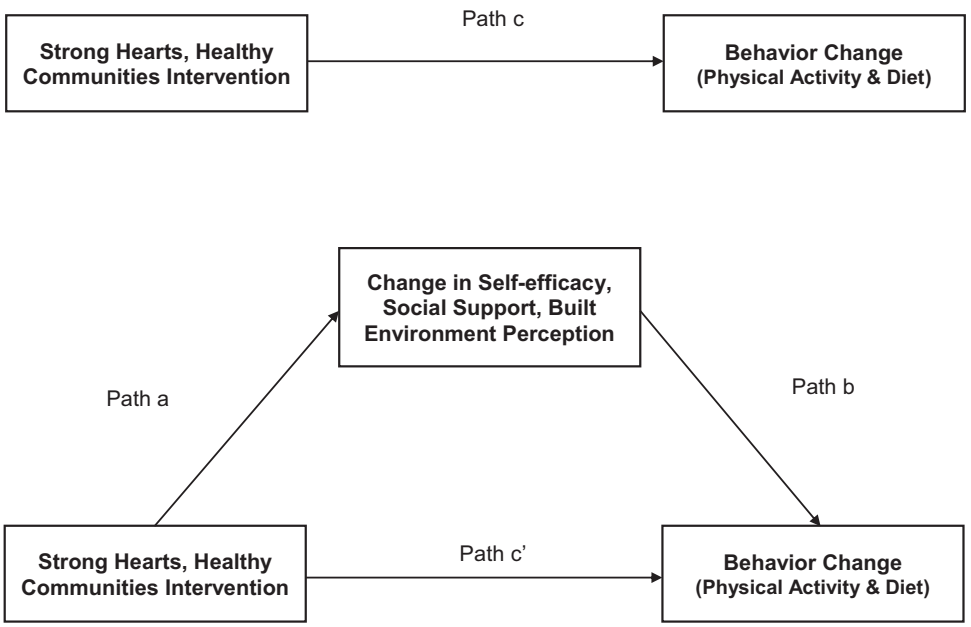

Fig 2 | Strong Hearts, Healthy Communities (SHHC) mediation analysis conceptual model.

not controlled when testing the indirect intervention effect through Path a*b in Step Three (ii) because the PROC CALIS function in SAS 9.4 does not support controlling for random effects. Instead, for the indirect intervention effect model that was tested in Step Three (ii), we examined the intraclass correlation coefficient (ICC) for the model's associated Path a and Path c models. We found that the ICCs were deemed negligible (all <0.01); therefore, we simplified our indirect intervention effect model in Step Three (ii) by removing the random effects of study sites so that we could fit the model using PROC CALIS.

Sensitivity analysis using a complete case analysis approach was performed to examine the potential differences between the multiple imputation and the complete case analyses.

All analyses were conducted using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). Type 1 error was set at 0.05.

RESULTS

The percentage of missing follow-up data on the eight proposed mediators varied between 29.9% and 33.5%. Those with and without follow-up data on the proposed mediators did not differ in terms of income, relationship status, education level, employment status, or baseline values of BMI, age, or any of the proposed mediators (all $p > .05$).

Details of study participants' key demographics are outlined in Table 1; additional details on baseline physical activity and diet have been reported elsewhere [21]. Overall, there were no major baseline differences between intervention and control groups' demographics, physical activity levels, and diet. A marginally greater proportion of participants in the control group were employed for wages or self-employed in comparison to those in the intervention group (76.7% vs. 63.5%, $p = .051$). Proposed mediators at baseline were similar between intervention and control groups except that control participants had a better perception of their built environment for physical activity than participants in the intervention group (2.65 vs. 2.51 on a 1–4 point scale, $p = .028$).

Similar study findings were found in the complete case analysis; therefore, we only present findings from the multiple imputation analysis in the following sections.

Intervention effect on proposed mediators (Path a)

The effect of the intervention on the proposed mediators is presented in Supplementary Table S2. At 6 months, there were intervention effects on improving participants' perceived friends' support for physical activity (between-group Δ = +0.53 on a 1–5 point scale; 95% CI: +0.13, +0.92; $p = .009$) and healthy eating (between-group Δ = +0.60 on a 1–5 point scale; 95% CI: +0.05, +1.14; $p = .032$). No intervention effects were observed for perceived self-efficacy for physical activity/healthy eating, perceived family support for physical activity/healthy eating, or perceived built environment to facilitate physical activity/healthy eating.

Relationships between changes in proposed mediators and physical activity changes (Path b)

Supplementary Table S3 summarizes the associations between changes in the proposed mediators and changes in physical activity. Improvements in perceived self-efficacy for physical activity were associated with increases in moderate to vigorous physical activity (MVPA) minutes per day (β = +4.87; SE = 2.18; $p = .029$), % MVPA (β = +0.55; SE = 0.24; $p = .024$), and walking MET-minutes per week (β = +79.56; SE = 29.70; $p = .008$). Improvements of perceived social support from family and friends for physical activity were associated with walking MET-minutes per week (β = +176.45; SE = 57.69; $p = .003$; β = +87.06; SE = 41.33; $p = .039$).

Relationships between changes in proposed mediators and dietary changes (Path b)

We did not observe any meaningful associations between changes in the proposed mediators and changes in diet (Supplementary Table S4).

Indirect effect of intervention on behavioral outcomes (Path a*b)

Based on our criteria, only the potential indirect effect of the SHHC intervention upon walking MET-minutes per week, through perceived social support for physical activity from friends, exhibited statistical significance of both Path a and Path b and thus was the only mediating effect examined for statistical significance.

Changes in perceived friends' support for physical activity only marginally mediated the intervention effects for walking MET-minutes per week, explaining 40.5% of the total effect (a*b = +45.24; 95% CI: −1.51, +91.99; $p = .059$) (see Supplementary Table S5). An intervention effect of 45.24 walking MET-minutes per week increase co-occurred with each one-point increase in perceived friends' support for physical activity (indirect effects); the remaining walking MET-minutes per week increase occurred independently (direct effect). Complete case analysis revealed the same observation that changes in perceived friends' support for physical activity marginally mediated the intervention effects for walking MET-minutes per week, explaining 42.1% of the total effect (a*b = +51.61; 95% CI: +1.01, +102.00; $p = .046$).

DISCUSSION

Overall, the present exploratory mediation analysis found that the multilevel SHHC program had meaningful positive impacts on participants' perceived social support from friends for physical activity and healthy eating, although no effects were found for

TABLE 1 | Baseline Characteristics of Participants by Treatment Condition

Characteristic	Total	Intervention	Control	*p*
Age, mean (SD)	58.89	59.03	58.74	.834
(Control *n* = 93; intervention *n* = 101)	(9.50)	(9.37)	(9.69)	
Income, *n* (%)				.121
<$25,000	37	24	13	
	(21.3)	(27.3)	(15.1)	
$25,000–$50,000	53	23	30	
	(30.5)	(26.1)	(34.9)	
>$50,000	84	41	43	
	(48.3)	(46.6)	(50.0)	
Relationship status, *n* (%)				.471
In a relationship (married or member of an unmarried couple)	132	70	62	
	(71.4)	(73.7)	(68.9)	
Not in a relationship (divorced, widowed, separated, or never been married)	53	25	28	
	(28.6)	(26.3)	(31.1)	
Educational level, *n* (%)				.904
High school or less	42	22	20	
	(22.8)	(23.4)	(22.2)	
Technical or vocational school/some college	55	30	25	
	(29.9)	(31.9)	(27.8)	
College graduate	58	28	30	
	(31.5)	(29.8)	(33.3)	
Postgrad/professional	29	14	15	
	(15.8)	(14.9)	(16.7)	
Employment status, *n* (%)				.051
Employed for wages or self-employed	130	61	69	
	(69.9)	(63.5)	(76.7)	
Not working or retired	56	35	21	
	(30.1)	(36.5)	(23.3)	
BMI, mean (SD)	35.18	34.90	35.48	.532
(Control *n* = 93; intervention *n* = 101)	(2.96)	(6.12)	(6.84)	
Perceived self-efficacy for physical activity (on a scale between 1 and 5), mean (SD)	2.96	2.97	2.94	.815
(Control *n* = 91; intervention *n* = 98)	(0.84)	(0.78)	(0.90)	
Perceived family's support for physical activity (on a scale between 1 and 5), mean (SD)	1.53	1.55	1.50	.506
(Control *n* = 91; intervention *n* = 98)	(0.53)	(0.53)	(0.52)	
Perceived friends' support for physical activity (on a scale between 1 and 5), mean (SD)	1.48	1.44	1.53	.251
(Control *n* = 91; intervention *n* = 97)	(0.57)	(0.57)	(0.57)	
Perceived built environment for physical activity (on a scale between 1 and 4), mean (SD)	2.58	2.51	2.65	**.028***
(Control *n* = 91; intervention *n* = 97)	(0.45)	(0.37)	(0.51)	
Perceived self-efficacy for healthy eating (on a scale between 1 and 5), mean (SD)	3.55	3.52	3.58	.624
(Control *n* = 91; intervention *n* = 98)	(0.77)	(0.83)	(0.71)	
Perceived family's support for healthy eating (on a scale between 1 and 5), mean (SD)	1.76	1.78	1.74	.795
(Control *n* = 90; intervention *n* = 97)	(0.91)	(0.88)	(0.95)	
Perceived friends' support for healthy eating (on a scale between 1 and 5), mean (SD)	1.51	1.48	1.55	.506
(Control *n* = 90; intervention *n* = 96)	(0.73)	(0.67)	(0.78)	
Perceived food environment for healthy eating (on a scale between 1 and 5), mean (SD)	3.20	3.20	3.20	.991
(Control *n* = 91; intervention *n* = 96)	(1.06)	(1.02)	(1.11)	

Boldface indicates statistical significance (*$p < .05$, **$p < .01$, ***$p < .001$).

perceived self-efficacy and perceptions of the built environment related to facilitating physical activity and healthy eating. Increases in perceived social support from friends for physical activity marginally mediated participants' walking MET-minutes per week with increases in perceived social support from friends explaining 40.5% of the total intervention effect on walking MET-minutes per week. Change in participants' perceived social support from friends for healthy eating, however, did not mediate the intervention's effect on any of the diet outcomes.

Perceived self-efficacy

Although SHHC incorporated strategies that were previously shown to be effective in improving perceived self-efficacy for physical activity and healthy eating [33, 34], there are several potential reasons why we did not observe changes in participants' perceived self-efficacy. First, because our sample had moderate levels of perceived self-efficacy to engage in physical activity (2.96 on a 1–5 scale, SD = 0.84) and healthy eating (3.55 on a 1–5 scale, SD = 0.77) at baseline, there might have been a ceiling effect for some participants to further increase their self-efficacy. In fact, sub-group analyses revealed that intervention participants with lower baseline perceived self-efficacy for physical activity and healthy eating saw increases in their perceived self-efficacy in comparison to the controls. Second, our process evaluation revealed that there was inadequate time in the class schedule to complete all of the SHHC curriculum offerings. This might have prevented the opportunity to allow for in-depth discussion about ways to improve self-efficacy when barriers to physical activity and healthy eating appeared. Third, particularly for perceived self-efficacy for physical activity, because our participants were older and overweight or obese, some of the in-class physical activities might have been challenging for them, contributing to our null findings. Although the intervention offered exercise modifications for participants, the intensity of the modified exercises was lower and thus this might have reduced the intended impacts of the intervention. In future developments of the intervention, complementary exercises of similar intensity and progression exercises should ideally be included. Fourth, considering only a few diet outcomes had positive changes after the intervention, discouragement from failing to make positive diet changes could have limited participants' ability to increase their diet self-efficacy.

Perceived social support

The positive increases in perceived friends' social support for physical activity and healthy eating may be attributed to the nature of our group-based intervention that provided a venue for participants to socialize with peers who played a role in promoting exercising and healthy eating, offered positive feedback for meeting goals, and provided general support towards healthier behavioral changes. However, with our analysis reported herein, we were not able to determine if increased social support from friends was through friends outside of SHHC or participants' peers in the program. Our process evaluation provided a potential explanation that peer support and social interaction among participants were key sources of accountability and motivation [35]. The marginally statistically significant meditation of perceived social support from friends for increasing walking aligned with a previous systematic review that group-based interventions were effective in increasing walking [36].

In contrast, although we observed an increase among participants' perceived social support from friends for healthy eating, this was not sufficient to translate into improved diet quality during the study observation period. Notably, our process evaluation focus groups found that although participants felt that the nutrition component in the SHHC program enhanced their existing knowledge of healthy eating, there were other contextual limitations that made healthy eating challenging, including time, financial constraints, and limited access to healthy food options in rural communities [35].

Moreover, the absence of significant findings about perceived social support from family members may be an indication that the SHHC materials needed to provide more directive strategies for engaging family members in active living and healthy eating practices [35]. At baseline, participants perceived infrequent social support from family members for both physical activity (1.53 on a 1–5 scale, SD = 0.53) and healthy eating (1.76 on a 1–5 scale, SD = 0.91). Therefore, participants might have been surrounded by family members who do not highly value active living and healthy eating, which might have been a barrier for them to gain family members' support for behavioral change. Future interventions should consider evaluating the consistency (or inconsistency) between how participants perceive the amount of social support they receive from their family members and friends and how family members and friends perceive the amount of social support they give to participants. This could potentially provide insights for developing tailored strategies to enhance social support for participants in future interventions since such support is deemed crucial to initiate behavioral change in other studies [37, 38]. Future multilevel interventions might also consider involving family members and friends as part of the intervention strategies.

Perceived built environment

Participants' built environment perception related to physical activity did not change, nor did their built environment perception change related to healthy eating. It was assumed that through various program

activities (e.g., outdoor walking, community audits, asset mapping, and education on local resources), SHHC could help participants become more aware of the realities (i.e., facilitators and barriers) of the built environments related to healthy living.

There are several potential reasons why we did not observe intervention effects on participants' perception of the built and food environments. First, our intervention strategies were only intended to increase participants' sensitivity to their own environments; they were not designed to change participants' perception of the built environment in a particular direction. Therefore, different directions of change in participants' built environment perception could have attenuated the overall effect of the intervention. Second, the survey instrument used might not have captured all of the key built environmental constructs that are relevant to rural communities. Third, the survey instrument only asked about the built environment in the area where participants lived, but these areas might not have been the actual areas where the SHHC program was conducted. That is, participants might have changed the perception of the built environment of the area where they participated in SHHC but not necessarily the perception of the built and food environments of the area where they lived or areas where they performed physical activity or shopped for foods. Finally, our null findings could be explained by the fact that people's perceptions of the environment are highly individualized and are continually developed through ongoing interactions with the environment, in which these perceptions are also influenced by other personal factors (e.g., age, values, past experience, health status, etc.) and social factors (e.g., economic conditions, social norms, and cultural influences). In other words, even though the SHHC program introduced certain environmental facilitators and barriers to healthy living to participants, exposures to these environmental realities were not sufficient to change participants' perceptions of the environment. It may be helpful for interventions to target multiple factors simultaneously to change perceptions of the environment. For instance, because of time limitations, financial constraints, and the general lack of access to healthy food options in rural communities, there were barriers to healthy eating among our participants [35]. Future iterations of the intervention should consider targeting these contextual barriers simultaneously to change rural women's perceptions of the environment, which might in turn generate bigger impacts on changing their behaviors.

Limitations

Few limitations must be considered when interpreting the findings. Although validated tools were used to collect self-reported physical activity and diet data in the present study, some of the large standard errors in Supplementary Tables S3 and S4 might be reflective of the inherent limitations of using self-reporting tools, including reporting errors (e.g., those related to recall bias) and the tools' inadequacy to capture individuals' day-to-day variations [39, 40].

Differential self-reporting measurement errors might have also existed between intervention and control participants, in which intervention participation might have influenced how intervention participants self-reported their behaviors (e.g., enhanced accuracy due to greater behavior awareness or reduced accuracy due to social desirability) [41]. To minimize potential biased estimates, we examined outliers during data analysis, and all the models were able to converge. In addition, as indicated earlier, the present mediation analysis was exploratory in nature and the sample size was powered for SHHC's primary outcome: BMI changes. Similarly, the minimal effects on participants' behaviors in the present study might have also hindered us from identifying effective mediators. In addition, participants in our study were predominantly white, midlife to older rural women in Montana and New York, which limits the generalizability of our findings to other populations. In particular, our study recruited a group of motivated rural women who were interested in losing weight and were willing to attend a class for 6 months. Our participants might have also been limited to those who had access to transportation to attend. Since rural residents tend to face more transportation challenges in comparison to their non-rural counterparts [42], future research should consider developing strategies to mitigate rural residents' burdens and barriers to participation in programs and interventions. Finally, the present study did not examine the potential reverse relationships between the behavioral outcomes and the proposed meditators.

Implications

Along with our other work from the trial, the present exploratory mediation analysis contributes better understanding to the ways in which the intervention may—or may not—have worked. These results, along with comprehensive process evaluation findings, are critical to making revisions to the content and implementation strategies for similar programs and advancing the science related to multilevel, multicomponent interventions.

CONCLUSION

Increasing social support from friends partially contributed to rural women becoming more active. Although none of our proposed mediators adequately explained the intervention's effect on behavior change, it is not unusual that intervention effects on behavior have not been completely

accounted for by the proposed mediators [43–45]. Our intervention might have worked through other unmeasured pathways. Further investigations are needed to understand how multilevel interventions work in rural communities.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *Translational Behavioral Medicine* online.

Acknowledgments

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Compliance with Ethical Standards

Conflict of Interest: The authors declare that they have no conflict of interest.

Human Rights: All procedures performed in studies involving human participants were in accordance with the ethical standards of the Cornell University and Bassett Healthcare Institutional Review Boards and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent: Informed consent was obtained from all individual participants included in the study.

Welfare of Animals: This article does not contain any studies with animals performed by any of the authors.

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