Received: 29 August 2021 | Revised: 6 December 2021 | Accepted: 10 December 2021

DOI: 10.1002/osp4.583

ORIGINAL ARTICLE

Obesity Science and Practice WILEY

Do outcomes from a behavioral weight loss intervention differ in Alabama versus Colorado?

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Funding information

The Beef Checkoff

Abstract

Background: There are well-established regional differences in obesity prevalence in the United States but relatively little is known about why or whether success in weight loss differs regionally.

Objective: The objective of this study was to determine whether changes in body weight, engagement in physical activity (PA), and psychosocial factors differed in Alabama (AL) versus Colorado (CO) in response to a 16-week behavioral weight loss program.

Design: This is an ancillary study to a weight loss intervention being conducted simultaneously in AL and CO with identical intervention content and delivery in 70 participants ($n = 31$ AL and $n = 39$ CO). Body weight, objective (accelerometry) PA, and responses to psychosocial questionnaires (reward-based eating, stress, social support) were collected at baseline and at Week 16.

Results: There were no differences in percent weight loss between states (AL: 10.98%; CO: 11.675%, $p = 0.70$), and weights at Week 16 were not different for participants in AL and CO (AL: 101.54 ± 4.39 kg, CO: 100.42 ± 3.67 kg, $p = 0.84$). Accelerometry-derived step count, stepping time, and activity score were all greater at Week 16 for participants in AL compared to participants in CO. Hedonic eating scores were more favorable for participants in AL at baseline (AL: 24.08 ± 2.42; CO: 34.99 ± 2.12, $p = 0.0023$) and at Week 16 (AL: 18.62 ± 2.70; CO: 29.11 ± 2.19, $p = 0.0023$). Finally, participants in AL presented more favorable social support scores at Week 16 compared to participants in CO.

Conclusions: Weight loss did not differ between states, suggesting that factors contributing to higher obesity rates in some regions of the United States may not be barriers to weight loss. Further, participants in AL experienced greater improvements in some factors associated with weight maintenance, indicating the need to

Abbreviations: AL, Alabama; BMI, Body Mass Index; BREIF-A, Behavior Rating Inventory of Executive Function-Adult Version; CO, Colorado; HP, High Protein; IOCQ, Important Other Climate Questionnaire; ITT, Intention to Treat; MET, Metabolic Equivalent; NCT, National Clinical Trial; NP, Normal Protein; PA, Physical Activity; RED, Reward-Based Eating Drive; REDCap, Research Electronic Data Capture; RWPB, Ryff's Scales of Psychological Well-Being; SAS, Statistical Analysis Software; SD, Standard Deviation; SOS, State of Slim; T2D, Type 2 Diabetes.

Drs. Hill and Wyatt are also co-owners of Shakabuku, LLC.

study regional differences in weight loss maintenance. National Clinical Trial 03832933.

KEYWORDS
behavior, environment, intervention, obesity, physical activity, weight loss

1 | INTRODUCTION

Obesity risk and treatment responses are widely believed to be influenced by a complex set of behavioral, psychosocial, metabolic, and environmental factors.[1-5] Obesity prevalence varies greatly across different regions of the United States.[6] For example, as of 2020 the prevalence of obesity in Colorado (CO) is 24.2%, while states in the southeast hovering between 35% and 40%. Specifically in Alabama (AL), the prevalence of obesity was reported at 39% in 2020.[7] However, a relative paucity of research has investigated whether weight loss interventions are more or less effective in different geographical regions. The purpose of this study was to investigate whether the effectiveness of a comprehensive behavioral weight loss program differed when delivered concurrently in Birmingham, AL (high-obesity prevalence) and Denver, CO (low-obesity prevalence).

With regard to environment, both the physical or built environment and the social environment may impact weight management. The physical or built environment can impact the accessibility of healthy diets and physical activity (PA). The social environment can impact the motivation for healthy lifestyles.[8,9] Factors in the physical environment that impact weight management include access to recreational spaces and access to healthy food.[10,11] AL and CO have different food and activity environments. For example, AL has a higher availability of fast food restaurants when compared to CO, both in terms of restaurants per square mile and restaurants per person,[12] which could promote poorer diet quality. Looking more closely at Denver and Birmingham's food environments and grocery stores, from 2011 to 2016 Denver saw an increase of 15.8% in numbers of grocery stores (101 to 117 stores), where Birmingham saw an increase of only 4.9% (102 to 107), which could indicate less access to these stores and possibly a dependence on ready-made foods in Birmingham.[13]

Engaging in outdoor physical activities such as walking and bicycling are also widely accepted as being more dangerous in AL compared to CO.[14] When comparing Birmingham, AL and Denver, CO these cities have starkly different walk and bike scores. These scores were developed to measures walkability (access to walking routes to stores, schools, parks etc., safety of walking) and biking (accessibility to bike routes, road connectivity etc.). Birmingham's score is 35 for walking and 31 for biking, where Denver has a score of 61 for walking and 73 for biking.[15] The average daily step count in CO has been reported as higher than in other states, including those in the southeast,[16,17] which demonstrates that individuals in CO not only have a more favorable PA environment but actually do engage in more PA when compared to other states. Climate is another non-modifiable environmental factor that could affect weight management. Merrill et al.[18] concluded that areas with the highest level of PA had a more dry and moderate climate. CO's climate is drier and more moderate when compared to AL.[19]

The social environment could impact weight management through social norms for diet (e.g., widespread consumption of fried foods and sweetened iced tea) and exercise (cultural pressure to either avoid or engage in exercise). Psychosocial factors, such as perceived stress,[20] can also influence weight status. Guite et al.[21] reported that factors of the physical environment, such as greenspaces, neighborhood noise, and community facilities have a significant impact on psychological well-being. Colorado has a more favorable environment for activity, but this could suggest it has a more favorable environment for psychological outcomes, as well.

The environment can have a significant impact on obesity rates, there is still an incomplete understanding of how strong this influence is. The fact that rates of obesity vary greatly between regions in the U.S. could be due in part to differences in the food and PA environments. For example, it may be easier to lose weight in some parts of the U.S. than in others. No known previous trial has sought to compare the effectiveness of behavioral weight management programs in different environments. This study is a secondary analysis which took advantage of a clinical weight loss trial (parent study) being conducted in AL (Birmingham) and CO (Denver). The same weight loss intervention was delivered in both locations.

The purpose of this study was to determine how the state in which one lives (i.e., environment) affects the outcomes of a 16-week behavioral weight loss intervention in terms of body weight and factors associated with weight loss (PA and psychosocial factors). The hypothesis was that participants in CO would have greater weight loss, greater increase in PA, and greater improvements in psychosocial factors when compared with participants in AL after a 16-week weight loss intervention.

2 | METHODS

2.1 | Participants

This study is an ancillary study to a clinical trial being conducted in AL and CO for which participants with type 2 diabetes (T2D) are randomized to either a high protein (HP) or normal protein (NP) diet and asked to follow a weight management program (National Clinical Trial [NCT] 03832933). Participants were randomly assigned to either group using Statistical Analysis Software (SAS) and were stratified by sex (male or female), body mass index (BMI; <35 kg/m^2 and ≥35 kg/m^2), age (<50 years and ≥50 years), and time since T2D diagnosis (<3 years or ≥3 years). The HP group was asked to consume four or more servings of lean beef per week and avoid all other red meat, and the NP group was asked to avoid all red meat for the duration of the study. Participants attended weekly group classes for the 16-week intervention, which used the State of Slim (SOS) weight management program.[22] This program is designed to target both diet and PA. A copy of the *State of Slim* (SOS) book was given to participants the first day of class along with class materials and access to the online SOS community.

For the parent trial, 70 participants (39 CO, 31 AL; 23 male, 47 female) were recruited between May and December 2019 in the Birmingham, AL, and Denver, CO, areas using letters, Internet advertisements, and news advertisements. Participants were required to be at least 18 years old, have a BMI ≥27 kg/m^2, have a T2D diagnosis within the past 6 years, be weight stable (±3 kg in the past 3 months), and be stable on all medications for the past 3 months. Exclusion criteria were: hemoglobin A1c ≥ 12%, current eating disorder (anorexia or bulimia), dependence on illicit drugs or alcohol, untreated hypothyroidism, currently using insulin or other drugs known to cause weight loss or gain, following a vegetarian or vegan diet, any illness or injury that would make it unsafe to follow a diet and/or exercise up to 70 min at a moderate intensity regularly, and women who were pregnant, lactating, trying to become pregnant, or who had been pregnant or lactating in the last six months. Criteria for diabetes diagnoses were confirmed through medical records or doctor reports, blood biomarkers were confirmed via a blood test at the screening visit, and all other criteria were confirmed by self-report means. Of the 70 participants who provided consent for the study, 51 (21 AL, 30 CO) completed the 16-week intervention for an overall retention rate of 72.9%. A CONSORT diagram for each state can be seen in Figure 1 for AL and Figure 2 for CO. All participants of the parent trial were included in this study. The study was approved by the University of Alabama at Birmingham Institutional Review Board (IRB 300002928).

2.1.1 | Diet intervention

The SOS diet plan was used for the intervention.[22] Typically, the SOS plan is low in fat and high in protein and emphasizes non-starchy vegetables and whole-grain carbohydrates. This diet plan consists of three distinct phases in which participants choose from specific food options. The SOS plan also has five diet rules that are to be followed throughout each phase: (1) Eat five to six times per day. (2) Eat breakfast within 1 h of waking. (3) Do not count calories; instead, measure portions. (4) Have the right protein mix at each meal (one carbohydrate and one protein at each meal). (5) Eat a healthy fat twice a day.

Participants were given food lists as well as recommended portion sizes in ounces or cups for each food at each phase of the diet plan, consistent with the lists in the book, with the exception of the red meat recommendation. The HP and NP groups were given food lists specific to their proposed macronutrient intake. The HP group was designed to have a reduction in carbohydrates and an increase in protein intake when compared with the NP group. Dietary fat was designed to be similar between groups. Table 1 illustrates the targeted macronutrient content of each group. Additionally, the HP group was instructed to consume ≥4 servings of lean beef per week, while avoiding all other red meat, and the NP group was instructed to avoid red meat for the duration of the intervention.

2.1.2 | Anthropometrics

Body weight was measured at baseline using a DETECTO BRW1000 scale (DETECTO, Webb City, MO). Participants were weighed in a fasted state (≥8 h fast) and were asked to void and remove heavy clothing. Due to restrictions placed on clinical research activities during the COVID-19 pandemic, Week 16 visits were completed remotely with video teleconferencing, and participants used home scales to weigh themselves at that visit, following the same protocol as the baseline visit (e.g., following an ≥8-h fast, void prior to weighing, wearing light clothing).

2.1.3 | Physical activity

Physical activity was measured using an ActivPAL4 accelerometer (PALTechnologies, Glasgow, Scotland).[23] Participants wore an accelerometer at baseline and Week 16 for 7 days at each time point. At baseline, a staff member attached the device to each participant's right thigh, and participants were given instructions for reattaching the device, should it come off. At the Week 16 visit, participants were mailed the accelerometer and asked to place it on their right thigh during a teleconferencing call, to confirm proper placement. The device was worn all day and was used to estimate number of steps, amount of active time (light activity and moderate-to-vigorous activity), and overall activity score.

2.1.4 | Psychological assessments

A series of questionnaires were given to participants at baseline and at Week 16 to measure factors of psychological status. The assessments used were the Cohen Perceived Stress Scale,[24] the Reward Based Eating Drive (RED) scale,[25] the Behavior Rating Inventory of Executive Function-Adult Version (BRIEF-A)[26] assessment, and the Ryff's Psychological Well-being (RPWB) scale. All questionnaires were sent via email to the participants to be completed directly within Research Electronic Data Capture (REDCap).

The 10-item version of the Cohen Perceived Stress Scale was used to determine stress exposure in the past month at baseline and at Week 16 of the intervention. The scale measures the degree to which respondents view their lives as stressful (e.g., overwhelming,

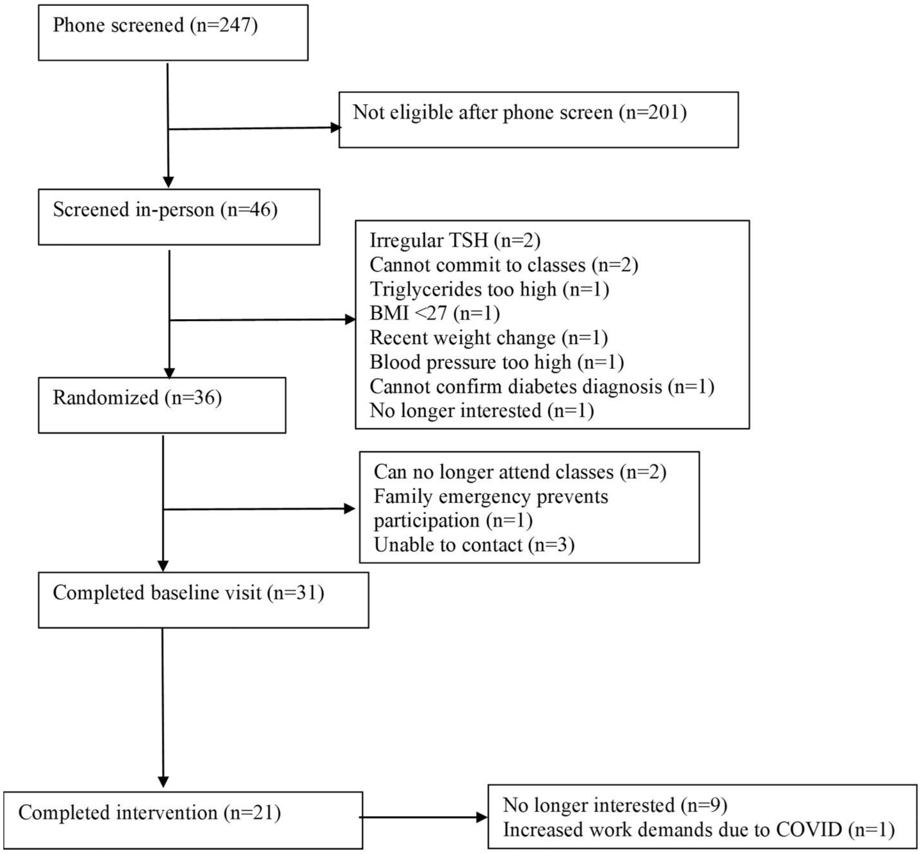

FIGURE 1 Consort diagram representing participant flow in Alabama (AL). AL, Alabama; BMI, body mass index; TSH, thyroid-stimulating hormone

unpredictable). It uses a 5-point Likert scale of 0 (never) to 4 (very often) to assess how often the respondent has felt a certain way in the previous month. This survey has demonstrated reliability and validity in a number of populations.[24,27,28]

The RED scale is designed to assess participants' control over their eating. It uses a 5-point Likert scale, from Strongly Disagree to Strongly Agree, to assess factors that drive overeating and lack of control overeating. The scale shows high internal validity and reliability across demographic factors.[25] The 13-question version developed in 2017 was used in this analysis, as it is broader and has demonstrated greater validity and reliability than the nine-question version.[29]

The BRIEF-A is an assessment used to determine executive function in adults created as an extension of the original BRIEF assessment developed by Gioia et al. to determine executive function in children.[30] Executive function includes abilities such as autonomy, self-regulation, working memory, problem solving, and planning and organizing.[26] The version used is a 34-question modified version using a 7-point Likert scale from Never a Problem to Always a Problem.

An 18-question modified version of RPWB was used to assess psychological functioning. The assessment uses a 6-point scale from Strongly Disagree to Strongly Agree to measure six domains of well-being—self-acceptance, positive relations with others, autonomy, purpose in life, personal growth, and environmental mastery.[31] The RPWB has demonstrated reliability and validity in multiple demographics.[32]

2.1.5 | Social support assessment

A series of questionnaires were given to participants at baseline and at Week 16 to evaluate their social support. The three assessments used were the Social Support and Eating Habits Survey,[33] the Social Support and Exercise Survey,[33] and the Important Other Climate Questionnaire (IOCQ).[34] Questionnaires were sent to participants via a link in an email, which they used to access and complete the questionnaires.

The Social Support and Eating Habits survey is a 10-question assessment that uses a 6-point scale from None to Very Often and includes Does Not Apply. Participants are asked to answer each question separately for friends and family to determine support for healthy eating habits based on each group. The assessment is used to determine support for healthy eating habits over the previous 3 months. This assessment shows good internal consistency as well as test-retest reliability.[33]

The Social Support and Exercise Habits survey is a 13-question assessment that uses a 6-point scale from None to Very Often and

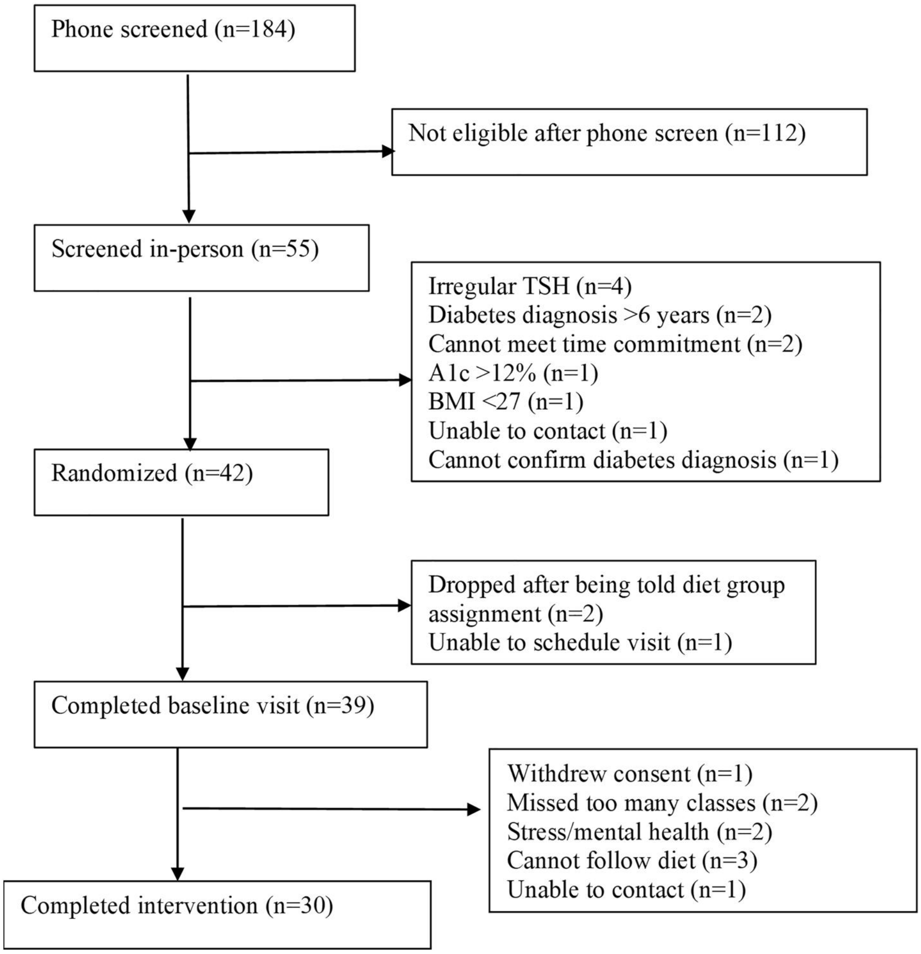

FIGURE 2 Consort diagram representing participant flow in Colorado (CO). A1c, Hemoglobin A1c; BMI, body mass index; CO, Colorado; TSH, thyroid-stimulating hormone

TABLE 1 Approximate macronutrient % by group

Nutrient	HP	NP
Carbohydrate %	32	53
Protein %	40	21
Fat %	28	25

Note: Diet plan approximate macronutrient percentage by group. Does not reflect actual intake of participants.
Abbreviations: HP, High Protein; NP, Normal Protein.

includes Does Not Apply. Participants are asked to answer each question separately for friends and family to determine support for participating in PA based on each group. The assessment is used to determine support for exercise habits over the previous three months. This assessment shows good internal consistency as well as test-retest reliability.[33]

The IOCQ is a six-question assessment that uses a 7-point Likert scale from Not True at All to Very True. This assessment is used to determine perceived support for reaching health goals (e.g., weight loss, exercise, etc.) from important people in the participant's life. This assessment has demonstrated strong reliability and validity in other dietary intervention trials.[34]

2.1.6 | Changes due to COVID-19

Due to the COVID-19 pandemic, certain study procedures had to be altered. First, the group classes were switched to online for both AL and CO at Weeks 4–5 and 7–8, respectively. Instead of meeting in-person, the participants were sent a link to the group video call every week for the remainder of the study. The calls were still led by trained coaches each week. Additionally, the Week 16 study visits became at-home study visits. Participants were sent a link to a video call with research staff, who conducted the visit. All the questionnaires were sent to the participant via email, just as was done for the baseline visit. The major change to the Week 16 visit was that participants were weighed using their at-home scales as opposed to using the scale for the study. Participants were still weighed following a ≥8-h fast, were asked to void, and removed any heavy clothing prior to weighing. Additionally, participants attached the accelerometers themselves following instructions and under the

TABLE 2 Baseline characteristics of participants

Parameter	Total	Alabama	Colorado
Age (years)	53.86 ± 11.95	53.65 ± 12.88	54.03 ± 11.33
Body weight (kg)	108.42 ± 29.97	108.49 ± 27.34	108.37 ± 21.29
BMI (kg/m^2)	38.77 ± 6.69	38.77 ± 7.43	38.77 ± 6.14
n	70	31	39
Female (*n*)	47	22	25
White (*n*)	46	17	29
Black (*n*)	18	12	6
Asian (*n*)	3	2	1
Other race (*n*)	3	0	3
Hispanic or Latino (*n*)	9	0	9

Note: Table 1 shows baseline and demographics for baseline of both states as well as the total population. Results are presented as least squares mean ± standard deviation. Data are presented as mean ± standard deviation.

Abbreviations: kg, kilograms; kg/m^2, kilograms per meter squared.

supervision of research staff to ensure correct placement. After the 7-day period, the accelerometer was sent back to research staff in the mail.

2.2 | Statistical analysis

All study data were collected and managed using REDCap electronic data capture tools hosted at the University of Alabama at Birmingham.[35,36] REDCap is a secure, web-based software platform designed to support data capture for research studies, providing (1) an intuitive interface for validated data capture; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data downloads to common statistical packages; and (4) procedures for data integration and interoperability with external sources. All analyses were completed using SAS (version 9.4, 2002–2012 by SAS Institute Inc.). The sample size is constrained due to the study being an ancillary study of an ongoing clinical trial (NCT03832933: Dr. James O. Hill). Therefore, the statistical power calculations reflect an observable effect size given the constrained number of participants. Using an intention-to-treat approach, statistical power calculations indicate that the sample size provides 80% power to detect an effect size of 0.67 given an alpha-error probability of 0.05.

Baseline characteristics were assessed by state (AL and CO), as well as the total of the whole sample. These were assessed using descriptive statistics and are reported as the mean ± the standard deviation (SD). Differences in baseline characteristics were assessed using Student's *t*-tests or Chi-squared tests. Changes in weight, PA, and psychosocial factors were the primary outcomes for this study. A generalized linear model (PROC GENMOD) was used to test effects of time (baseline vs. Week 16), state (AL vs. CO) and their interaction term on changes in weight (kg), PA (number of steps, stepping time activity score), and psychosocial factors (hedonic eating, perceived stress, executive function, psychological well-being, and friend and family support). For the weight outcomes, an intention-to-treat analysis was performed and are shown in Table 4. Physical activity outcomes were analyzed using an intention-to-treat approach, and psychosocial outcomes were analyzed using a completers analysis to determine the effect within the population that completed the intervention. Models were adjusted for sex, race, and treatment group (HP vs. NP). Changes in these measures reported as LSMEANS ± SE, with α = 0.05 being used to determine statistical significance.

TABLE 3 Education and income by state

Parameter	Alabama *n* (%)	Colorado *n* (%)
Education		
High school diploma	5 (16.12)	6 (15.38)
Some college	5 (16.12)	8 (20.51)
Bachelor's degree	17 (54.84)	11 (28.21)
Master's degree	3 (9.68)	12 (30.77)
Doctorate	1 (3.23)	1 (2.56)
Did not disclose	0 (0.00)	1 (2.56)
Income		
<$25,000	3 (9.68)	1 (2.56)
$25,000–45,000	6 (19.35)	2 (5.13)
$45,000–70,000	6 (19.35)	11 (28.21)
$70,000–110,000	9 (29.03)	11 (28.21)
$110,000+	6 (19.35)	14 (35.90)
Did not disclose	1 (3.23)	0 (0.00)

Note: Table 2 shows baseline income and education data for each state. Results are reported as number of participants (*n*) as well as the percentage of participants within that state.

TABLE 4 Weight loss outcomes

State	Baseline weight (n)	Week 16 weight (n)	% Weight loss	p value[a]
Alabama	114.06 ± 3.66 kg (31)	101.54 ± 4.39 kg (21)	10.98	0.84
Colorado	113.00 ± 3.32 kg (39)	100.42 ± 3.67 kg (31)	11.65	

Note: Table 3 shows change from baseline to Week 16 by state for body weight (kg) and change (%). Results are presented as least squares mean ± standard error.
Abbreviation: kg, kilograms.
[a]*p* values are presented for differences between AL and CO at the week 16 time point for all outcomes.

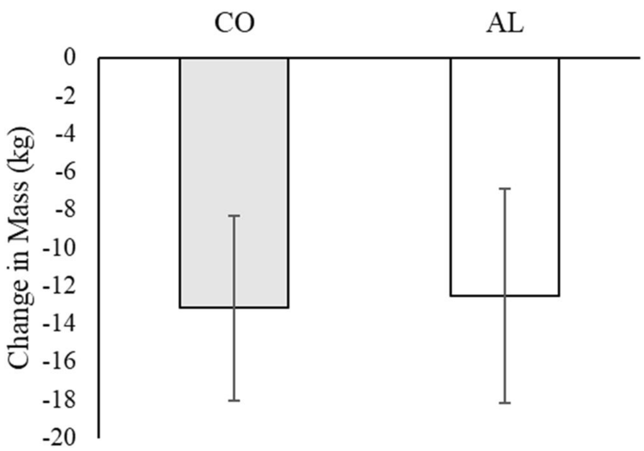

FIGURE 3 Changes in mass by state according to the Intention to Treat Analysis. AL, Alabama; CO, Colorado; kg, kilograms

3 | RESULTS

3.1 | Baseline participant characteristics

Baseline participant characteristics are presented in Tables 2 and 3. Participants in the study were mostly female and had an overall average age of 53.86 ± 11.95 years and a BMI of 38.77 ± 6.69 kg/m^2. With the exception of differences in racial and ethnic composition, participants in AL and CO were not significantly different. The sample in CO had a higher percentage of white participants when compared to participants in AL (CO: 74.36% vs. AL: 54.84%, X^2 (1, $N = 64$) = 4.61, $p = 0.03$) and a higher percentage of Hispanic participants when compared to participants in AL (CO: 23.08% vs. AL: 0.00%, X^2 (1, $N = 70$) = 8.21, $p = 0.004$). Income and education distribution also differed in these two states, with participants in CO having a higher income and education level when compared to participants in AL (Table 3).

3.2 | Weight loss

Both states had significant weight loss from baseline to Week 16, and there were no differences between states (Table 4). This data is also represented in Figure 3, which shows kg lost by each state (Table 4). Analyses demonstrated that 64.5% and 61.2% of participants in AL and CO, respectively, achieved ≥5% weight loss, and 41.9% and 30.8% achieved ≥10% weight loss in AL and CO, respectively.

3.3 | Physical activity

There were no differences in any PA measures at baseline between the two states, and both states saw significant improvement in step counts, stepping time, and activity scores from baseline to Week 16. However, step counts, stepping time, and activity scores were greater in participants in AL versus CO at Week 16 (Table 5).

3.4 | Psychological and behavioral assessments

Executive function, perceived stress, and psychological well-being were not different between states, nor did they change from baseline to Week 16 (Table 6). Alabama participants reported significantly lower reward-based eating as measured by the RED score at both baseline and Week 16, but neither state reported a significant change in RED score over time.

3.5 | Social support

Baseline measures of social support did not differ between the states. At Week 16, friends diet support was significantly greater for participants in AL compared to CO. During the intervention, participants in AL saw significant improvements in family diet support, friends diet support, family exercise participation, and the IOCQ. Participants in CO saw significant improvement only in the family diet support outcome (Table 7).

4 | DISCUSSION

No indication that weight loss was more difficult in a region with higher rates of obesity (AL) versus one with lower rates (CO) was found. Participants in both states experienced equivalent and clinically significant weight loss after completing a 16-week behavioral weight loss program. While there were no between-states

TABLE 5 Physical activity outcomes by state

Parameter	Group	Baseline (*n*)	Week 16 (*n*)	*p* value[a]
Step count	AL	6272.72 ± 581.45 (31)	10,266.97 ± 697.11 (21)	
	CO	6320.49 ± 524.62 (38)	8428.99 ± 598.42 (30)	**0.04**
Step time (min)	AL	83.22 ± 6.63 (31)	119.14 ± 7.91 (21)	
	CO	81.52 ± 5.93 (38)	101.96 ± 6.82 (30)	0.09
Activity score	AL	33.13 ± 0.21 (31)	34.54 ± 0.32 (21)	
	CO	32.93 ± 0.20 (38)	33.83 ± 0.31 (30)	**0.04**

Note: Table 4 shows baseline and Week 16 PA levels by state. Results are presented as least squares mean ± standard error. All results are calculated using the intention-to-treat approach.

Abbreviation: min, minutes.

[a]*p* values are presented for differences between AL and CO at the week 16 time point for all outcomes. Bolded values represent statistical significane ($p < 0.05$).

TABLE 6 Psychological outcomes by state

Assessment	Group	Baseline score (*n*)	Week 16 score (*n*)	*p* value[a]
Cohen perceived stress	AL	18.42 ± 1.79 (20)	1 14.81 ± 1.68 (17)	0.60
	CO	17.21 ± 1.33 (39)	1 13.72 ± 1.29 (28)	
RED scale	AL	24.08 ± 2.42 (20)	18.62 ± 2.70 (17)	**0.0023**
	CO	34.99 ± 2.12 (39)	29.11 ± 2.19 (28)	
BRIEF-A	AL	74.24 ± 6.42 (20)	80.31 ± 6.12 (17)	0.65
	CO	83.31 ± 4.67 (39)	76.79 ± 4.81 (28)	
RPWB	AL	91.61 ± 3.10 (20)	89.92 ± 2.98 (17)	0.73
	CO	84.99 ± 2.33 (39)	88.62 ± 2.41 (28)	

Note: Table 5 shows baseline, Week 16, and average change in psychological questionnaire scores by state. Results are presented as least squares mean ± standard error. All results are calculated using completers analysis.

Abbreviations: BRIEF-A, Behavior Rating Inventory of Executive Function-Adult Version; RED, Reward-Based Eating Drive; RPWB, Ryff's Psychological Well-Being.

[a]*p* values are presented for differences between AL and CO at the week 16 time point for all outcomes. Bolded values represent statistical significane ($p < 0.05$).

differences in weight loss, it is notable that participants in AL and CO did differ in several factors measured, including objectively measured PA and social support measures. This indicates a potential need to examine regional differences in weight loss maintenance, as these factors may become more influential once intervention intensity is reduced or discontinued entirely.

These results are somewhat surprising, given that there are strong data suggesting that physical and social environments can impact diet and PA. The hypothesis was that weight loss would be better for participants in CO than AL, but this was not the case, suggesting that the way those with overweight and obesity in the two states are interacting with the physical and social environments may not be different. Both healthy and unhealthy behavioral choices are available in both locations, and participants in this study may have been making similar behavioral choices within their respective locations at baseline. Further, it has been suggested that those with overweight and obesity tend to have social circles enriched in others with overweight or obesity.[37] If so, it may not be surprising that participants in both states responded similarly to a behavioral weight loss program. Put another way, while macro-level differences in physical environments may partially explain population-level differences in obesity prevalence, it may be that people with obesity are interacting within similar individual-level physical and social environments, regardless of their geographic location.

As an example, the fact that PA levels were not higher at baseline for participants in CO versus AL participants was surprising. It has been previously reported that steps/day are higher in CO than in other states, particularly those in the South.[33,34] However, these were the results of the general population, not specific to those with obesity. Similarities between states on most of the questionnaires further suggest that individuals with obesity may not be differentially affected by regional environments. Individuals with obesity may constitute a relatively homogenous population, regardless of the state in which they reside.

The differences in demographic factors found in this study are not surprising given the demographics of the two cities. The racial and ethnic make-up of these two cities differs greatly, with Denver reporting a racial make-up of 76.1% white, 9.2% Black or African

TABLE 7 Social support outcomes by state

Assessment	Group	Baseline score (*n*)	Week 16 score (*n*)	*p* value[a]
Family diet support	AL	9.23 ± 1.22 (21)	13.64 ± 1.11 (17)	0.51
	CO	11.29 ± 0.91 (39)	14.62 ± 0.93 (28)	
Family diet sabotage	AL	11.01 ± 0.96 (21)	12.70 ± 1.04 (17)	0.20
	CO	10.46 ± 0.82 (39)	11.11 ± 0.80 (28)	
Friends diet support	AL	7.63 ± 1.04 (21)	12.59 ± 1.01 (17)	**0.03**
	CO	9.12 ± 0.83 (39)	10.04 ± 0.81 (28)	
Friends diet sabotage	AL	9.62 ± 0.80 (21)	10.31 ± 0.84 (17)	0.18
	CO	9.30 ± 0.62 (39)	9.04 ± 0.61 (28)	
Family exercise participate	AL	18.99 ± 2.20 (21)	27.22 ± 2.23 (17)	0.33
	CO	20.21 ± 1.70 (39)	24.63 ± 1.71 (28)	
Family exercise punish	AL	3.54 ± 0.32 (21)	3.91 ± 0.34 (17)	0.65
	CO	3.41 ± 0.20 (39)	3.74 ± 0.22 (28)	
Friends exercise participate	AL	17.40 ± 2.11 (21)	20.49 ± 2.14 (17)	0.63
	CO	16.78 ± 1.61 (39)	19.22 ± 1.73 (28)	
Important other climate	AL	24.22 ± 2.41 (21)	29.34 ± 2.30 (17)	0.93
	CO	26.23 ± 1.77 (39)	29.61 ± 1.84 (28)	

Note: Table 6 shows baseline, Week 16, and average change in social support questionnaire scores by state. Results are presented as least squares mean ± standard error. All results are calculated using completers analysis.

[a]*p* values are presented for differences between AL and CO at the week 16 time point for all outcomes. Bolded values represent statistical significane ($p < 0.05$).

American, and with regard to ethnicity, 29.9% of the population identifying as Hispanic or Latino in Denver.[38] The median household income for Denver is $68,592 and has a poverty rate of 12.9%.[38] In Birmingham, 25.8% of the population is white, 69.9% are Black or African American, with 3.9% of people identifying as Hispanic or Latino. Median household income is $37,375 in Birmingham and the percentage of persons in poverty is 25.9%.[39] This was reflected in the present sample, with Birmingham having a higher percentage of black participants in Birmingham, lower income status, and fewer Hispanic or Latino individuals when compared to Denver. It could be argued that the cost of living in Denver being higher than Birmingham offsets this difference, but since the income cap for screening was $110,000 it makes it difficult to conclude the true socioeconomic differences between the two samples. More participants in Denver also had advances degrees (master's level or higher) when compared to Birmingham, which is also representative of the population.[38,39] So, while these samples do not provide a perfect representation of the population of these two cities, the evident demographic differences between the two cities within the sample for this study helps support the findings, since the sample was not homogenous.

Retention rate of both states, as well as the difference in when dropouts occurred are important to note. Overall retention was 72.86% (51 of 70 completing), with 67.74% in AL (21 of 31 completing) and 76.92% retention in CO (30 of 39 completing). Interestingly, in AL, the majority of the dropouts occurred after attending one class. In CO, the dropouts occurred at varying points throughout the program. Part of this could be explained by the fact that this program has been used in CO before, while it had not been delivered in AL previously, but the difference in timing in dropouts between states would be important to investigate in the future.

This study involved weight loss over 16 weeks. The long-term implications of these differences in unclear. Evidence suggests that PA is critical for weight loss maintenance,[16,17,40,41] which could pose a problem for regions that appear less responsive to PA interventions. Similarly, lower control over eating has been associated with weight regain,[17,42] which could be problematic for CO, as it showed poorer control over eating at baseline and at Week 16 when compared with AL. While many factors of weight loss maintenance are still not yet well understood, it could be possible that some of the differences from this study could lead to differences in long-term maintenance, even though no differences in weight loss were observed. Future research should focus on how the environment can affect weight loss maintenance outcomes in addition to weight loss outcomes.

The COVID-19 pandemic required significant changes to the study. The intervention, which began in person, was changed to a virtual intervention (using Zoom.) Further, data that had previously been collected in person was collected virtually. A few participants dropped out of the program citing COVID as a primary reason for leaving (i.e., increased work demands due to COVID). In terms of modifying the intervention, the program was initially delivered in person and then moved to an online delivery method. Fortunately, the SOS program has previously been adapted to an online intervention, which protected the integrity of the program. This could have possibly reduced the sense of community within the group, resulting in poorer weight loss outcomes. Due to the unprecedented nature of the pandemic, the group was able to adapt swiftly in order to continue the intervention and collect data, despite the challenges.

The greatest strength of this trial was the use of a commercially available, evidence based weight loss program, SOS.[22] Another strength was the use of accelerometers to capture objective PA data, as well as the use of well-validated questionnaires for the objective psychosocial and behavioral data. Additionally, the trial was conducted simultaneously in the two states, eliminating potential seasonal differences that could have occurred. This trial also had several weaknesses, including the small sample size, however, as mentioned in the text, the sample size was adequate to detect a moderate effect size. COVID-19 also interrupted the trial, which was an obvious weakness, but the study team made appropriate and timely changes resulting in minimal disturbance of the trial.

The most important message from this study is that obesity treatment can be as successful in states with a high prevalence of obesity as in those with a low prevalence of obesity. This should provide optimism to those in states most impacted by obesity. Although the believe was that AL has a less favorable built and social environment when compared with CO, this did not impact weight loss during the intervention, and participants in AL actually had greater increases in many factors associated with weight loss. Whether or not weight loss maintenance is harder in AL than CO remains unknown.

ACKNOWLEDGMENTS

The authors acknowledge Jeanne Anne Breen and Aaron Chestnut for their substantial effort in the recruitment, retention, and completion of study visits. The authors would also like to acknowledge Marsha Miller for coaching the SOS classes at the CO site. Funding for the parent trial was provided by the Beef Checkoff.

CONFLICT OF INTEREST

Drs. Hill and Wyatt have received royalties from the book *State of Slim* and are co-owners of Shakabuku, LLC. Julianne G. Clina, R. Drew Sayer, Caroline W. Cohen, and Navneet Kaur Baidwan report no conflicts of interest.

AUTHOR CONTRIBUTIONS

Julianne G. Clina, R. Drew Sayer, Holly R. Wyatt, and James O. Hill designed research; Julianne G. Clina and Caroline W. Cohen conducted research; Navneet Kaur Baidwan and Julianne G. Clina performed statistical analysis; Julianne G. Clina prepared the first draft of the manuscript; Holly R. Wyatt was the SOS coach at the AL site. R. Drew Sayer, Caroline W. Cohen, Holly R. Wyatt, Navneet Kaur Baidwan, and James O. Hill provided critical edits and feedback in preparation of the final manuscript; Julianne G. Clina had primary responsibility for final content. All authors have read and approved the final manuscript. Julianne G. Clina used these data as a portion of a master's thesis, and as a published abstract.[43]

DISCLAIMER

Drs. Hill and Wyatt have received royalties from the book *State of Slim*.

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How to cite this article: Clina JG, Sayer RD, Cohen CW, Wyatt HR, Baidwan NK, Hill JO. Do outcomes from a behavioral weight loss intervention differ in Alabama versus Colorado? *Obes Sci Pract*. 2022;8(4):455-465. https://doi.org/10.1002/osp4.583