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A quasi-experimental study on adult weight loss using a multidimensional approach among a rural population

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Abstract

Objectives: The study aimed to investigate the effectiveness of a yearlong digital multidimensional weight-loss intervention among residents in a southern rural community. The intervention utilized a quasi-experimental design to assess weight loss and lifestyle habit changes in volunteer individuals living in a rural community in western North Carolina.

Methods: The quasi-experimental design featured pre- and post-in-person health assessments, including anthropometric measures such as body composition, blood pressure, and lifestyle habits, through a health risk questionnaire. Upon completion of the in-person pre-assessment, participants received digital health education and challenges via email and challenge runner for 1 year. Following 12 months, participants were asked to complete the post-assessment to review their results. The multidimensional weight-loss intervention was communicated via newspaper and social media to promote participation among community members, utilizing a volunteer sample. Univariate analyses were conducted to determine age, weight, BMI, and body fat percentage. A paired sample *t*-test was conducted on pre- and post-weight as well as pre- and post-health scores. The health score was derived from the health risk questionnaire. A bivariate Pearson correlation was conducted for post-weight and post-health score analyses.

Results: The average participant was female in their mid-40s ($N=67$). Results showed insignificant statistical mean differences between pre- and post-weight and pre- and post-health scores. A Pearson correlation indicated a moderate correlation $r=-0.36$, $p=0.003$) between post-weight and post-health score. The negative correlation indicates changes in health behavior reflected in the health score improving as weight decreased.

Conclusion: The weight-loss intervention proved unsuccessful in clinical weight loss but demonstrated an association between healthy behavior changes and weight loss. However, further research is needed to solidify the current findings, as there were limitations identified in COVID-19.

Keywords

Weight, obesity, rural, quasi experimental, health education

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Introduction

Obesity continues to emerge as a leading public health concern as the prevalence rate soared to 42% among adults in 2020–2021.[1] While obesity has been a significant issue everywhere, the prevalence among rural areas was 34% greater compared to urban areas.[2] A nationally representative cross-sectional sample study ($n=10,302$) was conducted on the rural–urban obesity disparity, finding the odds of rural areas to be higher compared to urban areas ($p<0.001$).[3] Dixon et al.[4] stated that obesity-related conditions produce devastating effects among rural areas at a disproportionate rate.

Residents living in rural Appalachia have an elevated mortality rate due to obesity and obesity-related conditions compared to those living outside of the Appalachia area.[5,6] Further, residents in rural Appalachia have been reported to have experienced some of the nation's worst health

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outcomes.[7–9] The Appalachian region covers over 206,000 mi^2, containing 423 counties across 13 states, including North Carolina.[10] The proportion of obesity in the five Appalachian subregions was higher compared to the entire country, with Central Appalachia (34.7%) and North Central Appalachia (33.4%) having the most impactful percentages.[5] Further, physical inactivity among Central Appalachia (33.8%) residents was the highest compared to all of Appalachia, and they are among the greatest economically distressed communities in the region.[7] Central Appalachia is considered the heart of the Appalachian region and includes western North Carolina (WNC).

Residents in rural areas have limited access to resources that aid in weight loss and are predisposed to risk factors such as sedentary behavior and poor dietary habits. A recent community health assessment indicated that only 5.6% of residents in WNC consume one cup of fruits or vegetables per day, with one rural county reaching as low as 2.8%.[11] According to Whitfield et al.[12], 25% of urban residents met physical activity recommendations in 2017 compared to 20% of rural residents. To corroborate this data, only 21% of WNC residents reported meeting the physical activity guidelines in 2021.[11] Rural residents reported barriers to exercise as a lack of understanding concerning the impact of the activity on health, a lack of knowledge on how to exercise correctly, and a lack of individual motivation to exercise.[7]

In light of this literature, this study evaluated a multidimensional approach to combating obesity in rural Central Appalachia, specifically in WNC. The multidimensional approach was designed to increase participation in physical activity and promote education about healthy eating habits in WNC communities.

Methodology

Study design and period

This study pursued the following research questions: what is the relationship between participating in a wellness program and weight reduction among residents in a rural community in WNC? What is the relationship between health scores and weight among residents in a rural community in WNC? What is the relationship between participating in a wellness program and health scores among residents in a rural community in WNC? Based on these research questions, a quantitative research methodology was used. More specifically, a correlational research design was used. Residents in Swain County volunteered to participate in a 12-month weight-loss program composed of monthly nutrition and physical activity education, as well as challenges. Education included elements found in standard health programs such as self-monitoring, goal setting, modifications of eating habits, local in-season produce, and the connection between healthy eating and chronic disease risk factors. Participants were encouraged to participate in healthy eating and physical activity through fun and engaging challenges each month. The education and challenges were delivered using email and a web-based platform wherein participants could track their participation in challenges via the internet. Each month, participants could log their participation in challenges. The virtual platform tracked individual and team participation in challenges and allowed participants to view their ranking of points compared to other individuals anonymously. The challenges focused on nutrition, physical activity, and stress management; for example, a nutrition challenge provided local seasonal fruits and vegetables with recipes. Participants gained points each day they tried a different seasonal fruit or vegetable. Participants also received videos providing health education and tips for success. Participants were informed of challenges and program updates via email.

During the summer of 2019 (July and August), all participants engaged in an in-person pre-assessment for enrollment in the program. The assessment included blood pressure, height, body composition, and a health risk questionnaire. The health risk questionnaire produced individual health scores. Following a year of participation in the program, participants were asked to complete another in-person post-screening in the summer of 2020 (July and August). The post-assessment utilized the same procedures as the pre-assessment.

Study area

The study area was conducted in Swain County, North Carolina, located on the far western border of the southern state. The county has 541 mi^2 and holds more of the Great Smoky Mountains National Park than any other county in North Carolina or Tennessee. In addition, the federally recognized Eastern Band of Cherokee Indians is partially based in Swain County, known as the Qualla Boundary. The population is roughly 14,000 people and has an average population density of less than 250 people per square mile, which makes the study area a rural county.

Study population

The analysis was based on a convenience sample of 67 participants, composed of participants ranging in age from 25 to 78 years, presenting before and after participation in a voluntary weight-loss program offered by the local health department and hospital. Inclusion criteria were based solely on age and residency; participants had to be 18 years or older and a Swain County, North Carolina resident. Participants were only included if they completed the pre- and post-assessments. The study was reviewed by an ethics committee and determined to require Institutional Review Board's (IRB) oversight. Data were fully de-identified and did not contain the names of participants but did include age, gender, weight, and appropriate anthropometric measures. There were 69 participants who participated in the pre- and

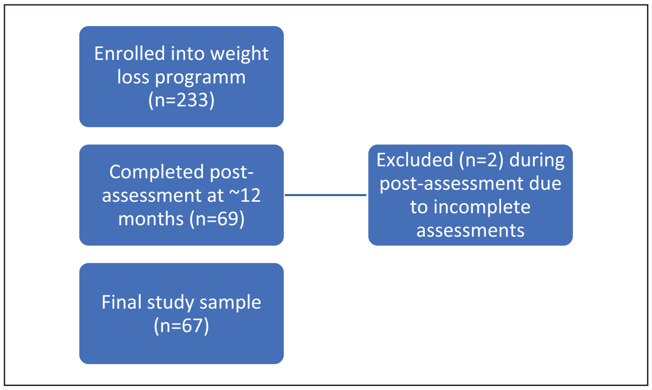

Figure 1. Weight-loss program retention flow chart.

post-assessments, but 2 were excluded due to incomplete post-assessments, leaving a sample of $n=67$ participants (see Figure 1).

Method of data collection

Written informed consent was obtained from all participants prior to the pre- and post-assessment. The IRB approved the written informed consent before dissemination and use (see Supplemental Appendix A). The intervention was for 12 months with an in-person pretest and a posttest. The data collected included anthropometric and hemodynamic metrics. The anthropometric measures were height, weight, BMI, and body fat. The hemodynamic measures were blood pressure. A paper health risk questionnaire was provided to all participants at pre- and post-assessment.

Study variables

The pre- and post-assessments included: height, weight, blood pressure, body composition, and a health risk questionnaire. Height was assessed using a standard stadiometer.[13] Weight and body composition were assessed using a Tanita tbf-400 BIA scale.[14] Blood pressure was assessed using a standard Omron 3 series upper arm blood pressure monitor.[15] An Omron wrist blood pressure monitor used on the upper arm cuff did not fit the participant. The health score was generated from an adapted version of the General Mills Health Number Screening Tool.[16]

The General Mills Health Number Screening Tool was designed to assess 10 lifestyle factors utilizing a stoplight reporting method (i.e., green is positive, yellow is intermediate, and red is negative). The adapted paper health risk questionnaire employed the stoplight reporting method to accommodate low health literacy in rural areas and guide recommendations for improvement.[17] Further, the health risk questionnaire expanded upon the original 10 lifestyle factors, including BMI, blood pressure, cholesterol, diabetes, exercise, nutrition, stress management, tobacco, and alcohol use (see Supplemental Appendix B). The health risk questionnaire produced a health score based upon the cumulative responses to 17 individual questions; each question was scored as the following: a green response equated to 10 points, yellow equated to 5 points, and red equated to 0 points. A greater health score indicated quality health decisions and the potential for minimal chronic disease risk or prevalence. The greatest individual health score possible was 170, and the lowest health score possible was 0.

Literature yielded no previously established measures of validity or reliability for the General Mills Health Number Screening Tool. The current study was a pilot test for the health risk questionnaire, where reliability and validity were tested. Statistical analyses were conducted for the adapted health risk questionnaire to prove reliability and validity. A Cronbach's alpha test was conducted to ascertain the reliability of the questionnaire ($\alpha=0.728$), which determined the questionnaire to be reliable. In addition, a factor analysis was conducted to assess construct validity.[18] The Kaiser–Meyer–Olkin measure of sampling adequacy was 0.644, providing adequate sampling measures for the questionnaire used ($p<0.001$). Questions used in the health risk questionnaire were compared to the subject matter of risk factors associated with obesity, matching the behaviors associated with obesity or a healthier lifestyle. The questions on the health risk questionnaire measured healthy behaviors, indicating face validity.

Statistical analysis

Univariate analyses were conducted to describe age, weight, BMI, and body fat percentage. In addition, a paired sample *t*-test was conducted on pre- and post-weight as well as pre- and post-health scores with a statistical significance set at $\alpha=0.01$. A bivariate Pearson correlation with a two-tailed test of significance and statistical significance at the $\alpha=0.01$ levels was conducted for post-weight and post-health score analyses.

Results

The participants in the convenience sample presented at 46 ± 12 years ($M=46.39$, $SD=12.26$), 88% female, 188 lbs, 38% body fat, and had a BMI of 31.5 m/kg^2 (Table 1). Baseline systolic blood pressure averaged 123.7 mm Hg, diastolic blood pressure was 82.9 mm Hg, and 9% of participants were hypertensive (>140/90) at pre-assessment. Following the 12-month weight-loss intervention, the participants weighed 186.9 lbs, 38.8% body fat, and had a BMI of 31 m/kg^2. Follow-up systolic blood pressure averaged 126 mm Hg, diastolic blood pressure was 81 mm Hg, and 8% of participants were hypertensive.

The baseline average health score was 112.3 ($SD=23.4$), with the greatest available score being 170. Following the 12-month weight-loss intervention, the average health score was 115.3 ($SD=25.3$). The health score indicated average

Table 1. Univariate analysis of the sample.

Measures	Pre-results		Post-results		Difference (%)
Male weight	213 lbs		211 lbs		−2
Female weight	186 lbs		185 lbs		−1
Male body fat %	26.6%		28%		+1
Female body fat %	40%		40%		0
Male BMI	30		29.5		0
Female BMI	32		31.8		0
Male health score	110		116		+6
Female health score	112		115		+3
Male BP	Systolic: 138	Diastolic: 88	Systolic: 129	Diastolic: 81	
Female BP	Systolic: 122	Diastolic: 82	Systolic: 125	Diastolic: 82	

Table 2. Paired sample *t*-test on post-weight and pre-weight.

Paired sample *t*-test	Mean	SD	*t*	df	Two-sided *p*
Post-weight and pre-weight	−1.12	9.56	−0.96	66	0.34

improvements from pre- to post-assessment among participants. The weight-loss intervention indicated a 15% increase in physical activity and a 13% increase in vegetable consumption among participants after 12 months (see Supplemental Appendix C). Further, salt and sugar consumption decreased from pre- to post-assessment; 6% decreased their consumption of table salt, and 4% decreased their regular consumption of processed sugar.

Anthropometry

When examining the sample, there were insignificant trends for changes in weight at baseline ($p < 0.01$). A paired sample *t*-test was used to evaluate the relationship between pre- and post-weight. Prior to conducting the analysis, the assumption of normally distributed difference scores was examined; skew levels were estimated at 0.25 and 0.42, respectively, and kurtosis levels were estimated at −0.81 and −0.69, respectively, which was less than the maximum allowable values for a *t*-test (i.e., skew <2 and kurtosis <9). The post-weight intervention means were not statistically lower than the pre-weight intervention mean, $t_{(66)} = -0.96$, $p = 0.34$ (Table 2). The mean difference between pre- and post-weight was roughly one pound in total. Based on these statistical results, the 1-year weight-loss intervention did not produce statistically significant weight-loss results among participants.

Health score

Another paired sample *t*-test was computed to evaluate the relationship between pre- and post-health scores (see Table 3). Before conducting the analysis, the assumption of normally distributed difference scores was examined. The assumption was considered satisfied, as the skew levels were estimated at 0.19 and 0.05, respectively, and kurtosis levels

Table 3. Paired sample *t*-test on post-health score and pre-health score.

Paired sample *t*-test	Mean	SD	*t*	df	Two-sided *p*
Post-health score and pre-health score	2.99	9.56	1.24	66	0.22

were estimated at −0.39 and −0.83, respectively. The correlation suggested an association between variables, implying the potential for a meaningful difference to be evaluated. There was not a significant average difference between post-health score and pre-health score ($t_{(66)} = 1.24$, $p < 0.001$). As a result, there was no statistically significant difference between pre- and post-health scores found among participants.

Weight and health score

A Pearson correlation coefficient was computed using the post-health score measure and the post-weight measure. There was a negative correlation between the two variables, and the relationship was significant at the $\alpha = 0.01$ level of significance, $r_{(65)} = -0.36$, $p = 0.003$. The post-assessment health score did appear to be associated with post-assessment weight among participants. The moderate, negative correlation ($r = -0.36$) indicated the appropriate relationship, meaning weight decreased as positive health behavior increased. While the correlation was significant, it was a moderate, negative correlation, as the coefficient value was closer to $r = 0$ than −1 or +1 significance values. The Pearson correlation indicated a significant relationship between post-health scores and post-weight measurements following the 1-year weight-loss intervention.

Discussion

This study evaluated a multidimensional weight-loss intervention within a rural community in southern Appalachia over 12 months. This study is the first to implement a new health risk questionnaire that approaches health holistically and utilizes the stoplight reporting method. The primary hypotheses were that the intervention would produce weight loss, increase health scores, and identify a relationship between health scores and weight. Although the mean health score increased over 12 months ($M = 112.3$ and $M = 115$), there was no statistically significant difference in weight.

Approximately 21% of rural residents in Swain County reported experiencing food insecurity in 2021, with only 2.8% of residents consuming five or more servings of fruits or vegetables in a day.[11] Following the 12-month intervention, participants reported increasing their daily vegetable consumption to the recommended two to three cups (53.7% pre-assessment and 66.7% post-assessment). Inversely, participants reported the same amount of fruit intake from pre- to post-assessment, with 53% consuming one to two cups of fruit per day. While fruit remained the same, the daily consumption of processed sugar decreased over 12 months, yielding a 4% decrease from pre- to post-assessment(24% and 19.7%). To further validate the health education gained throughout the intervention, participants reported an increase in whole grains (38% and 44%) and lean protein (63% and 74%) consumption, as well as a decrease in added table salt to food (9% and 3%; see Supplemental Appendix C). All measures of nutrition improved or remained the same from pre- to post-assessment except for water intake, which decreased by 2% over 12 months. As hypothesized, participants also increased their physical activity from pre- to post-assessment, moving from 28.4% to 43.9%, almost always achieving 150 min/week.

Changes over time among participants were more evident and favorable within mean differences. Healthier eating and physical activity choices improved for participants from the pre- to post-assessment. Interestingly, the participants made healthier choices, however, they did not produce statistically significant weight loss ($t_{(66)} = -0.96$, $p = 0.34$). While weight loss was not statistically significant, a significant relationship between post-health score and post-weight was identified ($r_{(65)} = -0.36$, $p = 0.003$). The negative relationship highlighted the hypothesis that weight decreases as the health score increases due to healthier decisions. It could be the case that participants were consciously making healthier decisions due to the intervention, but the weight loss was slow or delayed. According to Delahanty et al.,[19] retention among weight-loss programs was more successful with a dietician support team. Participants dropped out 1.41 times faster without a dietician during year 1 of the weight-loss intervention. This evidence suggests the importance of guidance and dietary education, prompting the need for future research to include monthly dietician support for participants in rural communities.

Like the intervention utilized, Tate et al.[20] evaluated dietary self-monitoring compared to a do-it-yourself approach among participants for 3 and 12 months. The participants in the self-monitoring group yielded weight loss at 3 and 12 months. The current study utilized a dietary self-monitoring approach; however, it yielded no significant weight loss results, unlike Tate et al.[20] As the intervention demonstrated mean differences in healthy behaviors from pre- to post-assessment, the intervention's length should be tested further. In addition, the timeline of the current intervention should be investigated further to assess adequate timing for weight loss, such as an advanced program lasting 3 months versus 12 months. Beyond time and other program facets, it should be noted that females in their mid-40s comprised 88% of the study sample, imposing curious implications related to weight-loss results.

Changes in hormones, mainly estrogen, can influence body composition regarding body fat distribution. According to the National Institute on Aging, the menopausal transition traditionally begins between the ages of 45 and 55 years.[21] As the current sample was comprised of women around the age of 46 years, it is important to address the hormonal impact of menopause on weight loss. During the perimenopause and early postmenopausal years among women, fat mass can accumulate due to diminishing estrogen levels. Proietto[22] shared that weight gain during menopause is associated with reduced spontaneous activity. Further, the literature advises women already overweight or obese, as noted in this study[22] (BMI of $M = 31$), that rapid weight loss is achieved through an extreme energy deficiency. Greendale et al.[23] conducted a longitudinal study evaluating weight gain and menopause transition, finding accelerated gains in fat mass related to menopause transitioning, indicating the detrimental effect of menopause on body composition. Women during the menopause transition experience accelerated gains in fat mass, juxtaposing the current research goals.

The current study has several strengths and limitations. As noted in a recent community health assessment,[11] health disparities among rural communities, specifically in Central Appalachia, are overwhelming, indicating a distinct need for obesity prevention and treatment programs. The prevalence of obesity is 6.2 times greater in rural America, with obesity being a significant risk factor for type 2 diabetes, cardiovascular disease, and certain types of cancer.[2] Low income, food deserts, and a lack of physical activity have been identified as risk factors associated with obesity in rural communities, such as WNC. The current intervention targeted health education related to nutrition and physical activity, providing opportunity to curb the risk factors associated with obesity. Additional strengths of the intervention included multiple intervention components concurrently targeting healthy eating and physical activity, developing a health risk questionnaire utilizing the stoplight reporting method, and providing in-person health assessments that individuals in rural areas could not afford otherwise. Also, all adult residents were allowed to participate, positively influencing normative targeted behaviors. This broader volunteer sample likely impacted the retention rate of the intervention.

Several limitations should be addressed in future research endeavors. First, relying on a volunteer sample insufficiently represents the entire community, and can generate response biases. The characteristics of a volunteer sample depend on the willingness and awareness of the intervention, and strong opinions or ethical reasons for participating. As a result, volunteer samples produce biases that could be avoided if random sampling was implemented in future studies. As a volunteer sample was used, a power analysis was not conducted, which is a quantitative limitation. Second, the health risk assessment is a self-report method, subjecting it to social desirability bias. Although the research protocols attempted to mitigate potential measurement error by incorporating standardized metrics, the questionnaire may provide over or underestimates. Further, the adopted General Mills Health Number Screening Tool did not establish quantifiable validity or reliability measures established.[16] The current health risk questionnaire was piloted in this study and needs further testing to solidify validity measures for future studies.

Another unforeseen limitation was the pandemic. The pandemic began after the intervention started, potentially causing additional stress and weight gain due to quarantine. A national assessment was conducted after the first year of the pandemic, indicating that 48% of participants in the study gained weight, and 65% of the individuals who reported being obese before the pandemic were most likely to gain weight compared to those only slightly overweight.[24] According to Ammar et al.,[25] the COVID-19 pandemic negatively affected physical activity intensity levels; daily sitting time increased by 3 h/day; and food consumption was unhealthier during confinement.

As the post-assessment was in person, it is highly conceivable that the COVID-19 pandemic heavily influenced the high abandonment in multiple ways. Negative health behaviors, such as increased sitting time and poor nutritional choices, could demonstrate a negative appeal to attend an in-person post-assessment where participants feel disheartened or potentially judged for their lack of success in weight loss. Balkhi et al.[26] found that adults who are 35 years and older had significantly elevated levels of fear of leaving their homes during the pandemic, and more than three-fourths of participants in the study reduced physical contact, canceled plans, and did not visit healthcare facilities. Participants in the current study were in their mid-40s, indicating that they potentially experienced elevated levels of fear of leaving their homes, which was required to finish the program. Further, the post-assessment required physical contact for blood pressure readings and body composition, elevating the fear and risk for the participant.

Participants were provided incentives by the local health department if the participants demonstrated improvement in weight, BMI, body fat percentage, and health score from pre- to post-assessment. The incentives were outside of the scope of this study and were not integrated into the study itself; however, it is important to acknowledge the utilization of incentives. Although intended to help with retention and behavior change, using incentives also created an undue bias. Incentives can create a discordance between participants' beliefs about their health and their desire for external support to motivate weight loss.

Conclusion

The multidimensional weight-loss intervention method holds promise to provide rural community members with free health education and allow researchers to gather anthropometric and lifestyle data. Capturing lifestyle data in a newly developed survey may differ from previous studies, and the multidimensional approach. The present study found a correlation between lower weight and higher health scores, validating the hypothesis that healthy behavior change correlates to weight loss. Researchers who develop and maintain weight-loss interventions, specifically in rural communities, should continue to assess various methods of health education and health behavior surveys to improve interventions. This study also demonstrated that despite using a virtual platform and accountability components, there were rapid declines in retention over time, which could have been related to the COVID-19 pandemic. Future research should validate the health risk questionnaire, examine whether to include additional components to enhance engagement, and identify the appropriate length for weight-loss programming.

Declaration of conflicting interests

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Ethical approval

Ethical approval for this study was obtained from Western Carolina University's Institutional Review Board, and the indicated number is 1451921-1.

Informed consent

Written informed consent was obtained from all subjects before the study.

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Supplemental material

Supplemental material for this article is available online.

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