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Research

Predictors of Success in a Weight Loss Intervention

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Abstract

Objective

Examine components of a lifestyle intervention most beneficial in promoting weight loss.

Design

Descriptive, survey-based with administration at intervention site.

Participants

Subsample of 49 participants from the intervention study.

Intervention

Participants engaged in a 3-month intervention of diet and exercise designed to invoke modest weekly weight loss.

Main Outcome Measures

Self-identified stage of change (SOC), markers of diet intake and components of study most beneficial in promoting weight loss.

Analysis

Kruskal Wallis chi-squared, Pearson's correlation, and multiple linear regression.

Results

Ending SOC had a statistically significant correlation with weight loss (WL). Calories from protein had a statistically significant relationship with WL; non-statistically significant trends were witnessed between vitamin D consumption (r = 0.230, p=0.058) and percent of calories from carbohydrates (r = -0.195, p=0.093) with WL. For fat loss (FL), calcium and vitamin D had statistically significant correlations with FL. Belief that one had made changes to improve their diet, daily weigh-ins being a motivating factor, intention to continue to use nutrition information, and recording of food logs were important predictors for WL.

Conclusions and Implications

Lifestyle interventions combining several components can promote success in weight loss, including use of SOC.

Keywords: Weight Loss; Stage of Change; Daily Weigh-In

Introduction

Approximately two-thirds of U.S. adults are classified as overweight or obese. Overweight or obese adults are at a greater risk of developing a variety of metabolic and cardiovascular diseases [1,2]. Excess weight may make it difficult to participate in routine physical activity, which is known to decrease the risk of these same disease processes [3].

Diet and exercise are important components of healthy behavior and lifestyle that promote weight maintenance, weight loss as needed and prevention of weight regain [4]. Provision of nutrition education is vital in promoting changes to intake that can lead to health improvement [5,6]. Other positive mediators of diet change and subsequent weight loss or weight maintenance are recording of food diaries and frequent weigh-ins [7,8].

A person's stage of change (SOC), as outlined by Prochaska., et al. [9], is often predictive of how well an individual responds to behavior change education and implementation of the targeted behavior change. The SOC Model states that individuals can be assigned to one of five stages. Those in the first two stages, pre-contemplative and contemplative, may not respond as well to an intervention as those in the later stages of preparation, action, and maintenance [10]. Interventions can be costly in terms of time and money for healthcare practitioners,human resource departments in organizations providing healthcare, researchers, and participants.Those individuals who self-identify at lower SOC may need to defer intervention involvement until they progress to a later stage. An alternative to deferment is to implementstrategies to progress participants

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at the lower end of SOC quickly to later stages in order to maximize intervention success.

The purpose of this descriptive study was threefold: (1) first to describe self-identified SOC among participants in a lifestyle intervention study designed to promote weight loss, (2) to examine the relationship between select markers of diet intake and weight loss, and (3) to identify what participants perceived to be the most beneficial for them in order to change and maintain behavior change. We hypothesized that SOC and components of the study such as nutrition education, calorie (kcal) prescription, weigh-ins and recording of food diaries by participants would be correlated with weight loss at study conclusion. Findings can help researchers design future weight loss intervention studies to promote the greatest success.

Methods

Participants and Recruitment

This study was approved by an Institutional Review Board. Participants in a three-month weight loss study were recruited for the short survey; there were 58 participants and 49 (85%) agreed to complete the survey. Descriptive statistics are used to describe the sample, see Table 1. The three-month intervention of diet and exercise was designed to invoke modest weekly weight loss of no more than two pounds per week [11]. Informed consent was obtained from each participant prior to the survey being administered.

Table 1: Demographic characteristics of study participants

	Male (n = 21)	Female (n = 28)
Age (years)	47 ± 2	48 ± 3
BMI - Overweight	20	20
BMI - Obese	11	18
Weight Change (kg)	-2.34 ± 2.53	-1.25 ± 1.77
% Body Fat Change	-2.98 ± 2.51	-3.66 ± 1.97
Ending Stage of Change	4.1	4.3

BMI calculated as weight in kilograms divided by height in meters squared. Overweight = BMI 25 to 29.9 kg/M^2; Obese = BMI > 30 kg/M^2. Age, weight and body fat percentage change reported as mean ± standard deviation.

Survey

The survey had two sections. The first section asked participants to rate each question based on a five-point Likert scale with "1" indicating disagree to "5" equaling agree. The survey questions addressed the components of the weight loss intervention to include nutrition specific questions, perceived benefit of weigh-ins, and recording of food diaries. As this survey was intervention specific, it has not been validated (see Table 2). The second portion of the survey asked participants to identify their SOC at beginning and end of the intervention. An investigator provided verbal instruction to each participant regarding meaning of the five-point scale in relation to the questions asked and a brief description of SOC categories.

Table 2: Lifestyle intervention based survey

This Set of Questions are Rated on a Likert Scale
1. I believe proper nutrition will help me lose weight
2. I made significant changes to improve my daily diet
3. Eating healthier is too time consuming
4. Eating healthier is more expensive for me
5. I do not like the taste of most fruit and vegetables
6. I did NOT make significant changes to improve my daily diet
7. The nutrition component has been helpful to me in this study
8. I will use the nutrition information I have received even after study completion
9. I want to continue to lose weight
10. I want to live a healthier lifestyle
11. The nutrition education has been informative
12. Daily weigh-ins motivated me to want to lose weight
13. Weigh- ins were informative and added value to me
14. I believe all I need to do to lose weight is exercise
15. Recording of the 7-day food records motivated me to make quality food choices
16. I want to make healthy nutrition/lifestyle changes

Physiological Beasurements

Anthropometrics were collected by trained exercise specialists and included height and weight measured with participants in exercise clothing, without shoes, but in stocking feet. Weight was measured to the nearest 0.10 kilogram on a calibrated, digital scale (Tanita®, SC 331S). Height was measured to the nearest 0.10 centimeter utilizing a stadiometer. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Body fat percentage was measured using dual energy x-ray absorptiometry (DXA) bone densitometer (Hologic® Discovery QDR, Bedford, MA).

Diet Recommendations and Assessment

At the beginning of the lifestyle intervention study, each participant had kcal needs to promote weight loss estimated using the Harris-Benedict formula for resting metabolic rate [12], with additional items of daily activity, exercise kcal expenditure and weight loss kcal needs factored in. This kcal estimate was compared to their baseline seven-day diet record kcal average to ensure kcal prescriptions for each participant were appropriate. A registered dietitian nutritionist (RDN) co-investigator conducted or supervised all analyses of the diet records and kcal prescriptions.

Nutrition Education

Participants were provided nutrition education by the RDN, with individualization to address specific habits of each person. Throughout the study, participants had access to the RDN for any nutrition questions or concerns. On-going education was provided on a variety of topics ranging from basic good nutrition to fluid needs, with individual kcal prescription adjusted as required to support weight loss success.

Exercise Program

Participants engaged in a planned, supervised exercise program five days per week, and were instructed to maintain their routine daily activities, but not engage in any other structured exercise activity. The exercise regimen incorporated aerobic conditioning and exercises to improve musculoskeletal strength. Each training program lasted approximately 50 minutes and included a warm-up, exercise session and cool down period.

Statistical Analysis

The variables include age, sex, race/ethnicity, weight loss (WL), fat loss (FL), SOC, survey answers, and select diet variables.

Kruskal-Wallis chi-squared tests were performed to examine how SOC was related to WL and FL.

Diet variables included kcal level prescribed versus consumed, calcium/vitamin D intake, fiber, and saturated fat intake. Pearson's correlations were utilized to examine relationships of diet variables with WL and FL.

Survey answers from each participant were analyzed using stepwise, backward, multiple linear regression. A regression model was created to determine the effect of each survey variable on WL. The best fit regression model was found using Akaike's information criteria (AIC), corrected AIC (AICc), Bayesian information criterion (BIC) and R^2 values [13]. The best fit model was chosen when the removal of additional variables did not improve AIC, AICc, and BIC indices of fit. For each step of variable removal, AIC, AICc, BIC, and R^2 values all agreed on the variable to eliminate from the model. Multi co-linearity assessed using variance inflation factors. Missing data were removed using case-wise deletion.

The level of significance was set at $p < 0.05$. Data analyses were performed using the R© statistical software version 3.3.3.

Results

The sample consisted of 49 participants, 57% female and 43% male, with a mean age of 47 years (25 to 65 years). Eighty-eight percent of the participants were non-Hispanic white with the remainder being African American, Hispanic or Asian. Fifty-nine percent of our sample were obese as indicated by a body mass index (BMI) of ≥ 30 kg/m^2 (Table 1) [14]. Twenty-seven percent of this sample was able to achieve the modest weekly weight loss goals over the three-month period. The compliance rate for exercise session participation was over 95%, with a study drop-out rate of 15%.

Kruskal-Wallis chi-squared was performed between of end of study perceptions of SOC and WL. Beginning SOC did not have a statistically significant relationship with WL or FL; however, ending SOC had statistically significant associations with WL($x^2 = 10.105$, $p < 0.05$) and FL($x^2 = 11.82$, $p < 0.05$), see Table 3.

Table 3: Significant results

Category	P value
Ending SOC and weight loss	$x^2 = 10.105$, $p < 0.05$*
Ending SOC and fat loss	$x^2 = 11.82$, $p < 0.05$*
% kcal protein and weight loss	$r = 0.322$, $p < 0.05$**
Calcium intake and fat loss	$r = 0.334$, $p < 0.05$**
Vitamin D intake and fat loss	$r = 0.442$, $p < 0.05$**
Survey items and weight loss:	intercept -0.93, $p < 0.05$***
Made changes to improve diet	
Use nutrition information after study	
Daily weigh-ins	
Recording food diaries	

*Kruskal-Wallis chi-squared, **Pearson's correlations, ***Multiple regression analysis

Pearson's correlations were used to investigate the relationships between select diet variables with WL and FL. Of the eleven variables tested, only percent of calories from protein had a statistically significant relationship with WL ($r = 0.322$, $p < 0.05$). Non-statistically significant trends were witnessed between vitamin D consumption ($r = 0.230$, $p = 0.058$) and percent of calories from carbohydrates ($r = -0.195$, $p = 0.093$) and WL. For FL, calcium ($r = 0.334$, $p < 0.05$) and vitamin D ($r = 0.442$, $p < 0.05$) had statistically significant correlations with FL, both with medium effect sizes. Variables that did not show a statistically significant correlation ($p > 0.05$) include: kcal level prescribed versus consumed, percent of calories from saturated fat, and fiber consumption (Table 3).

In the multiple regression analysis, a variety of parameters were used to find the best model for predicting WL from survey items. Age, gender, and race were not significant predictors of WL. Four variables were found to be important to model fit: a belief that one had made changes to improve their diet (CNG), finding daily weigh-ins to be a motivating factor (DAILY), an intention to use nutrition information even after study completion (USEAFT), and recording food records (REC). Of these four variables, CNG, DAILY, and USEAFT were statistically significant ($p<0.05$). The WL regression model had an intercept of -0.93 (Table 3).

Discussion

Many studies have tested the effect of diet and exercise on weight loss. The purpose of this study was to evaluate the relationship between participant's self-identified SOC and weight loss. Secondly, to look at the relationship between select diet variables and weight loss. Finally, identify the specific components of the weight loss intervention that were the most beneficial to participants in supporting positive diet and body composition changes.

We observed statistically significant relationships between end SOC,WL and FL. One reasonable explanation for this is that participants moving toward the higher levels of SOC during the intervention may imply that they were adapting and willing to make the behavior changes necessary to lose weight. One of the key behavior changes was adherence to the exercise sessions, with the compliance rate over 95%. These results correspond to findings from nutrition and lifestyle intervention studies that assessed SOC and determined that subjects rating themselves as ready to change and those with the highest SOC had the greatest positive improvements on body composition [15,16]. Stage of change can be used as a screening tool to identify those that are ready to start an intervention or need additional coaching during the intervention to enhance success. In contrast, a study by Jeffery., et al. [17] found no predictive impact of SOC and weight loss. They posited that the complex nature of weight loss success could not be predicted by the simple categorization scheme of the SOC [17].

Several diet variables were assessed regarding body composition changes. Considering that SOC was predictive of WL, we inferred that participants positively changed their eating habits. Adequate protein intake is important during weight loss efforts to preserve lean tissue [18]. In this study, percent of calories from protein had a statistically significant relationship with WL. Interestingly when FL was separated out for analysis only two diet variables were significantly related; calcium and vitamin D intake. Adequate calcium intake may increase fat oxidation and when coupled with a restricted kcal diet promote fat loss [19-21].

Adequate vitamin D intake may enhance the thermal effect of a meal and fat oxidation [21]. Additionally, there is limited evidence that vitamin D may modify insulin sensitivity and in-turn control appetite, which may promote weight and fat loss over time [22].

Other investigators have reported on the usefulness of SOC to promote change in eating habits. In a nutrition intervention that strived to move those in the pre-action to higher stages during the intervention, they found that those moved to the action and maintenance stages had lower fat intake and increased vegetable and fruit consumption versus those that remained in the pre-action phases [23]. An intervention study using a diabetes self-care program reported more subjects moving to advanced SOC with the program versus standard treatment and had positive dietary changes [24]. Our findings coupled with these study results support that SOC of participants can be a valuable tool in promoting diet change.

Of the components evaluated via the survey ranging from nutrition education to recording of food diaries, four were found to be important predictors of WL. The first component was the perception that daily weigh-ins motivated participants to lose weight. Evidence indicates that frequency of weighing may be beneficial for those trying to lose weight. A review article by Van Wormer., et al. [8] evaluating several weight management studies, found that frequent weighing was predictive of moderate weight loss, defined as one body mass index unit greater than those that weighed only weekly. A behavioral weight loss intervention study, purposefully using weigh-ins three times per week, found those that adhered to the protocol had significantly greater weight loss. The researchers posited that the frequent weigh-ins had a positive mediation effect on adherence to energy intake prescribed, and subsequent weight loss [25].

The second component from the survey that was found to be predictive of WL was "I made significant changes to my diet". This statement infers that nutrition education or change was in fact beneficial for the participants. As advocated by the position statement of the Academy of Nutrition and Dietetics, nutrition education and subsequent positive changes in intake are vital to health promotion and treatment or prevention of chronic diseases such as overweight and obesity [6]. Interestingly, almost all our participants strongly agreed that proper nutrition would help them lose weight, and that nutrition education had been informative, however, this was not predictive of WL due to the similarity of responses between high and low responders.

The third component in the regression model, the statement of would use the nutrition information after study end, had a slight inverse association with WL. This also may have been due to the similarity of response between high and low responders.

Lastly, recording of food diaries as noted by findings from previous studies should have been an important predictor of WL, though we found a negative association [26-28]. Our participants were asked to record food intake on paper records at baseline and during the last week of each study month. In a study of 123 overweight or obese women enrolled in a diet and exercise based intervention, those that consistently kept food diaries lost approximately six pounds more than those that did not [26]. Wing.,

et al. [27],in an intervention that enrolled over 1,000 participants, found a positive correlation in the 49% that did use food diaries and ability to achieve a seven percent weight loss goal. The enhanced awareness of those who record their food intake is key tore-enforcing positive behavior change [28]. In an intervention that used a phone app versus paper records, the investigators found both an increase in compliance with phone app record keeping and an overall decrease in energy intake versus those using paper records. As there are a variety of nutrition apps available, use of this easier method of food tracking may be beneficial in terms of compliance and promotion of weight loss [29].

There are limitations to this study, the first being the relatively small sample size of mainly non-Hispanic white participants, recruited from an established intervention study. Reporting of intake via participant recorded food diaries is known to introduce some level of inaccuracy due to under- and over-reporting. As body weight increases, the level of under-reporting increases [30]. We asked the participants at the end of the three-month intervention to report self-identified SOC at start and end of study introducing some level of reporting bias. Success in overall weight loss per participant may have influenced how they rated the survey questions. Those who had greater success in WL may have been more likely to rate the questions in a positive manner versus those who did not do as well.

Concerning promotion of success in future weight loss interventions, consideration should be given to assessment of each participant's SOC prior to intervention. This can be an important tool to establish their start point with provision of coaching to move them toward advanced SOC during the study. As indicated by our findings those that had the greatest change in SOC during the study experienced greater WL. Other components of this lifestyle intervention that fostered success were the frequent weigh-ins and the perception that participants had made changes to their daily food intake. Recording of food records though found to have a slight negative association, should be included in future methodology to support success with emphasis placed on the importance of accuracy and detail prior to study start. Utilizing a phone app to decrease participant burden may be of benefit to adherence to the diet prescription and subsequent weight loss. Lastly, nutrition education should provide additional focus on those nutrients that may enhance weight loss when consumed in adequate amounts, such as calcium and vitamin D.

Implication for Research and Practice

It is important to continue to identify components or combinations thereof in lifestyle interventions that are the most beneficial for participants in promoting weight loss and positive changes in lifestyle. Future studies should examine the effect of coaching participants to rapidly progress through SOC during lifestyle interventions and the impact on success.

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