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Lifestyle Intervention's Effect and Predictive Value on Weight Loss for University Employees

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Abstract: Obesity is a costly and pervasive risk factor that requires attention to reduce chronic disease rates. This study evaluated the effect of a lifestyle medicine intervention, Complete Health Improvement Program (CHIP), on reducing weight, blood pressure, lipid levels, and hemoglobin A1c. A secondary aim was to build a preliminary predictive model for computing new participants' potential weight change from CHIP. We evaluated pre- and post-intervention biometric data of 68 individuals who completed a 10-week CHIP intervention at a Midwestern university clinic. Significant reductions ($p < 0.05$) were observed in weight, diastolic blood pressure, total cholesterol, low-density lipoprotein, and A1c. Regression analyses indicated the best linear model for predicting change in weight was a one-predictor model with systolic blood pressure. The CHIP intervention effectively promoted weight loss and meaningful reductions in chronic disease risk factors. Larger samples are needed for future regression analyses to create a more robust linear model.

Keywords: biomarkers, chronic disease, healthy lifestyle, obesity, risk factors

The National Center for Chronic Disease Prevention and Health Promotion (NCCDPHP, 2019a) and the World Health Organization (WHO, 2017) report behavioral risk factors that lead to chronic diseases, including poor nutrition marked by diets low in fruits and vegetables yet high in sodium and saturated fats, obesity, physical inactivity, tobacco use, exposure to secondhand smoke, and excessive alcohol use. Of these risk factors, obesity is of particular concern as a leading contributor to cardiovascular disease, stroke, type 2 diabetes, renal disease, and different types of cancer (Centers for Disease Control and Prevention [CDC], 2020a). Overweight and obesity are most commonly classified using body mass index (BMI) as the screening tool, with overweight BMI ranging from 25 to less than 30 and obesity correlating with a BMI of 30 or higher (CDC, 2020b).

Obesity in the United States (US) is on the rise with an alarming prevalence of 42.4% in 2017-2018, up from 30.5% in 1999-2000 (CDC, 2020a). This translates to 88.7 million US adults who live with this serious condition. In addition, rates of severe obesity (BMI $\geq$ 40) have nearly doubled from 4.7% in 1999-2000 to 9.2% in 2017-2018 (CDC, 2020a). Weight gain during adulthood, specifically from 18 to 55 years old, is associated with a considerably elevated risk of chronic diseases, as well as diminished likelihood of healthy aging (Zheng et al., 2017). Not only is obesity closely linked to the rise in chronic diseases, it also negatively impacts the mental health and quality of life of affected individuals (Salas-Salvadó et al., 2018). Obesity has a significant annual cost burden of $147 billion due to the direct and indirect medical costs associated with this epidemic. The annual per capita medical cost for people with obesity was $1,429 more, or 42% higher than those of healthy weight (CDC, 2020a; Gillis, 2019). These striking statistics point to the need for change, given the close relation between obesity and the leading causes of preventable, premature death. Therefore, effective strategies to alleviate the

national burden of obesity are necessary to reduce the adverse health consequences and increasing mortality associated with this major risk factor.

Prior research shows that moderate weight loss (5-10% of initial body weight) along with a decrease in abdominal fat can lower blood pressure and blood glucose levels, thereby decreasing the risk of developing hypertension, type 2 diabetes, and other cardiometabolic abnormalities associated with being overweight or obese (Gillis, 2019; Salas-Salvadó et al., 2018). Greater weight loss offers greater cardiometabolic benefit; however, even weight loss as little as 3% is associated with favorable changes in lipid levels, blood pressure, and other biomarkers (Kaikkonen et al., 2019). Dietary changes and physical activity are considered the hallmarks for first-line treatment of obesity. A hypocaloric diet is adequate for losing weight, while physical activity is critical for modifying body composition in a way that reduces visceral fat and maintains muscle mass (Hernández-Reyes et al., 2019). Evidence shows that exercise training is also vital for long-term weight maintenance, increasing cardiorespiratory fitness, and improving insulin sensitivity, regardless of weight status (Kaikkonen et al., 2019).

Lifestyle medicine involves the adoption of healthy eating, regular physical activity, and avoidance of substance use as a primary method of preventing and treating chronic disease (Katz et al., 2018). Ford et al. (2009) estimated that approximately 80% of chronic diseases could be prevented by adhering to four healthy lifestyle factors, including not smoking, eating healthily, being physically active for greater than 3.5 hours per week, and maintaining a BMI less than 30. Research supports the implementation of weight loss strategies that incorporate a combination of interventions, such as dietary changes, physical activity, behavioral therapy, counseling, and support groups. According to Curry et al. (2018), the United States Preventive Services Task Force (USPSTF) found strong evidence that intensive, multicomponent behavioral interventions

lead to clinically significant weight loss and reduced incidence of type 2 diabetes among obese adults. In a study on the effects of varying degrees of physical activity during a weight loss program, Hernández-Reyes et al. (2019) discovered that intense physical activity, coupled with a hypocaloric diet and nutritional counseling, was the most effective protocol for reducing body fat and maintaining muscle mass. Results from a randomized controlled trial suggested that the most effective weight loss regimen in the study combined intensified behavioral modification, with routine weight maintenance counseling by a nutritionist, along with triweekly exercise training introduced at the start of the weight loss period to produce best results (Kaikkonen et al., 2019).

The Prevención con Dieta Mediterránea (PREDIMED)-Plus trial found that the intensive lifestyle intervention involving a Mediterranean diet, physical activity promotion, and behavioral support was effective for producing clinically meaningful weight loss, decreasing adiposity, and improving cardiovascular risk factors in obese adults with metabolic syndrome (Salas-Salvadó et al., 2018). Likewise, Gillis (2019) determined that a community-based lifestyle intervention incorporating weekly information meetings, nutritional counseling, and social support and accountability led to statistically significant weight and fat loss after the 12-week study period. Based on this research, it would be judicious to implement weight loss strategies that incorporate multiple tactics, as these have demonstrated powerful effects on curbing the threat of obesity.

A promising solution that utilizes a combination of weight loss methods is the Complete Health Improvement Program (CHIP), a lifestyle medicine intervention unique not only for its holistic approach to healthy living, but also its ability to be implemented and adapted to clinical, corporate, or community settings (Morton et al., 2016). It is an intervention precisely designed to address chronic disease risk factors, including poor nutrition, physical inactivity, and obesity, by promoting a holistic health approach that supports how individuals eat, move, manage stress,

sleep, and manage emotional well-being, self-worth, and happiness. The CHIP intervention is both clinically effective for improving overall health and well-being, as well as economically beneficial for organizations seeking to reduce healthcare spending and productivity costs (Remy et al., 2017). Clinical benefits may include reducing the risk of heart disease and diabetes, normalizing blood pressure, as well as reducing total cholesterol, triglycerides, fasting blood sugar, and BMI, which help prevent and arrest chronic diseases. In terms of economic benefit, Baicker et al. (2010) suggests that lifestyle interventions are highly cost-effective as they decrease corporate healthcare costs by $3.27 and absenteeism costs by $2.73 for every $1 spent annually on workplace wellness programs. These reduced costs can lead to the reallocation and investment of funds from healthcare savings to other areas of organizations.

Theoretical Framework

Theory of Planned Behavior provides the groundwork for the CHIP intervention, as the theory explains that an individual's intention to engage in a behavior is influenced by attitudes concerning the likelihood that a given behavior will generate the expected outcome (Ajzen, 1991). Behavioral achievement depends on both intentions and perceptions of behavioral control. Furthermore, intentions can be predicted from attitudes toward the behavior, subjective norms, and perceived behavioral control (Ajzen, 1991). CHIP targets all three components (Figure 1), as its strong educational element modifies participants' mindsets surrounding healthy living, thereby improving health literacy and behaviors (Morton et al., 2016). Education is delivered through video presentations, cooking demonstrations, group exercises, and mindfulness discussions. Additionally, CHIP takes place in a locally-facilitated group context to cultivate social norms and accountability. Group programs have been found to more effectively promote weight loss than individual programs (Morton et al., 2016). Finally, the combination of CHIP's

intensive nature and regular health risk assessments are designed to increase self-efficacy and perceived control. The program facilitates behavioral achievement by discussing the consequences of unhealthful practices and provides comprehensive resources that boost one's ability and perceived behavioral control to apply lifestyle recommendations to their daily routine.

Purpose

There is a gap in existing literature concerning the effect of CHIP on chronic disease risk factors in an urban Midwestern clinic setting, despite the fact that the Midwest region has the second highest prevalence of obesity in the US following the South at 33.1% (CDC, 2019). Additionally, there is no prior research on the value of using risk factors as predictors for weight loss following the CHIP intervention. Because obesity is a major contributor to preventable chronic diseases, it is essential to determine if holistic lifestyle interventions like CHIP are effective solutions for weight reduction. The purpose of this study was to evaluate the effect of the CHIP lifestyle intervention on the primary variable of change in weight, as well as secondary variables of blood pressure, body fat, lipid levels, and A1c using retrospective data from a university employee clinic in the Midwest. We hypothesized that the CHIP intervention facilitates weight loss in overweight adults and reduces blood pressure, body fat, lipid levels, and A1c among participants. A secondary purpose of the study was to examine the usefulness and predictive value of each risk factor for determining the extent of weight loss from CHIP using linear regression models, which has not been explored in previous research. This predictive model could be used to compute the potential weight change that would result from the CHIP intervention, given one's baseline biomarkers, or risk factors.

Methodology

Study Design, Sample, and Setting

A pretest-posttest study was conducted from a retrospective chart review between January and May 2020. The study involved reviewing the demographic and biometric data of all CHIP participants who completed the program at an occupational health clinic at a large Midwestern university since program implementation in the summer of 2018. We used a convenience sample of 68 adults, the total number of participants who completed CHIP from all four classes offered by the clinic between July 2018 and November 2019. The inclusion criteria for the sample comprised adults aged 18 years or older who completed one of the four CHIP offerings, regardless of weight status. This study was conducted following institutional review board (IRB) approval of exemption.

Description of CHIP Intervention

The intensive CHIP lifestyle intervention promotes whole-food, plant-based eating, daily moderate- to high-intensity physical activity, adequate water intake, as well as stress reduction practices (Morton et al., 2014). The program's intent is to foster self-care and prevention through enriched knowledge of the causes, effects, and risk factors linked to the development of chronic diseases (Leibold et al., 2016). It targets the attitudes, social norms, and perceived control associated with the Theory of Planned Behavior (Figure 1). Each CHIP class at the university clinic consists of 20 sessions total, two sessions per week for the program's 10-week duration, including the initial orientation and final commencement. All past participants' data were evaluated in terms of the primary outcome of change in weight in the course of 10 weeks from pre-CHIP to post-CHIP weight, in addition to changes in ten secondary biometric outcomes.

Participants who enroll in CHIP at the university clinic complete before-and-after lifestyle evaluations that include a number of biomarker tests. They receive a comprehensive toolkit containing a reference book, workbook, exercise book, and cookbook, which are valuable

resources that follow the content of the videos closely. Each group session was led by two health coaches with backgrounds in nursing and dietetics trained to implement the CHIP intervention. Sessions typically involves viewing a prerecorded educational video, group activities (e.g. grocery store tour), physical exercises and fitness tips, cooking demonstrations and healthy food samples, as well as group discussions. Each session lasts between one to two hours and is organized around a model of learning, experiencing, and reflecting (Morton et al., 2016).

In the first section of the CHIP intervention (sessions 1 to 11), participants learn about the causes of chronic disease and the benefits associated with constructive lifestyle changes (Morton et al., 2016). The program advocates a whole-food, plant-based diet because of these foods' high nutrient density and low energy density. A diet rich in whole grains, fresh fruits, legumes, and vegetables is recommended, as is limiting cholesterol, fats, sodium, and refined sugars. Drinking adequate amounts of water daily and engaging in routine moderate-intensity cardiovascular and resistance exercises are also fundamental. The second part of CHIP (sessions 12 to 18) focuses on surmounting barriers and creating strategies to aid participants in behavior modification maintenance (Morton et al., 2016). Participants are encouraged to engage in self-monitoring, goal-setting, and problem-solving to help counter internal and external resistance to change. In this stage, they become mindful of social and physical environmental forces that impact lifestyle patterns. Other disease determinants are addressed in this latter section, including sleep, stress, substance use, and emotional and mental health. Positive psychology concepts related to self-esteem and personal fulfillment are also explored (Morton et al., 2016).

Recruitment Procedure

In its effort to improve overall health and wellness throughout the campus community, a large Midwestern university took on the initiative of offering CHIP to its employees at no cost.

The clinic, in conjunction with the Lifestyle Medicine Institute, implemented the CHIP intervention for its first class in the summer of 2018. The program is currently only open to university employees and is advertised in the official email newsletter distributed to faculty and staff. The clinic accommodates 20 people per CHIP class, and spots are filled on a first come, first served basis. Those who are interested can call the clinic for more information and complete an online registration form on the clinic portal. For program screening purposes, all interested participants are required to meet with a health coach for 30 minutes prior to registration. If spots are full, those who are interested can be added to a wait list. Participants who complete CHIP at the university health clinic receive a certificate if they attend at least 10 out of 20 total CHIP sessions, though this was not enforced for one participant who only attended 9 sessions. Therefore, all 68 participants were included in data analysis regardless of true completion.

Biometric measures

Biometric assessments were conducted at baseline and near the conclusion of the CHIP intervention at 8-10 weeks. Prior to the program, demographic and static data like age, gender, and height were collected on each participant. Number of sessions attended was documented for each participant after CHIP. Biometric data collected at baseline prior to CHIP intervention and following program completion included weight, BMI, body fat mass (BFM), percent body fat (PBF), systolic blood pressure (SBP), diastolic blood pressure (DBP), total cholesterol (TC), low-density lipoprotein (LDL), high-density lipoprotein (HDL), triglycerides (TG), and hemoglobin A1c, which were measured by a certified health coach or nurse. An on-site InBody composition analyzer, a safe and inexpensive bioelectrical impedance analysis method that provides valid and reliable body fat measurements, was used to assess weight, BMI, BFM, and

PBF (Shantavasinkul et al., 2015). Data for each participant were recorded in a Microsoft Excel document solely accessible by the clinic's health coaches who run the program.

Statistical Analysis

The statistical software used for analysis was R version 3.6.2. Descriptive statistics were computed to obtain measures of central tendency (e.g. mean and median) and measures of variability (e.g. standard deviation, minimum, and maximum values) for each biomarker before and after CHIP. Mean change (baseline mean minus post-intervention mean) and percent mean change (100 times mean change divided by baseline mean) were also calculated to understand the extent of change for each biomarker. Shapiro-Wilk test was conducted to assess the data for normality. Paired *t*-tests were applied to mean changes to determine if biomarker variations were statistically significant from baseline to post-intervention. This was performed for both the overall and stratified data of CHIP participants across several risk categories. In addition, Cohen's *d* statistic was computed for each stratum to learn about effect size.

Participant data were split into training (80%) and test (20%) sets for all regression analyses. All 15 independent variables were assessed for multicollinearity and adjusted accordingly prior to running regressions. The regression analyses conducted to create predictive models of weight loss based on the training data ($n = 55$) include best subsets, stepwise, and ordinary least squares regressions. Best subsets and stepwise regressions were exploratory methods used to identify useful predictors for inclusion in our least squares regression. Statistically significant factors were incorporated into a linear model that demonstrated the most potential for predicting an individual's change in weight following the completion of CHIP based on our dataset. The test data ($n = 13$) was used to calculate the mean square error to evaluate the predictive validity of the final model.

Results

Sample Characteristics

A total of 68 adults completed the CHIP intervention, with a mean age of 46.9 ± 11.7 years and a range of 26-71 years. Of these 68 participants, 11.8% were male (n = 8) and 88.2% were female (n = 60). The mean number of CHIP sessions attended out of 20 was 16.3 ± 2.8, with a range of 9-20 sessions.

Mean Changes in Risk Factors

Based on the Shapiro-Wilk normality test, the distribution of data is not significantly different from normal distribution; therefore, we can assume normality (p = 0.212). Mean changes from baseline to post-intervention biometric risk factors are presented in Table 1. After 8-10 weeks, participants achieved significant mean reductions in nine out of eleven chronic disease risk factors, including the primary outcome of weight (p < 0.001), as well as secondary outcomes of BMI (p < 0.001), BFM (p < 0.001), PBF (p = 0.017), DBP (p = 0.003), TC (p < 0.001), LDL (p = 0.006), HDL (p < 0.001), and A1c (p = 0.027). Additionally, the TC-to-HDL ratio slightly worsened from 3.19:1 at baseline to 3.21:1 after intervention (p < 0.001). Although there was a mean reduction in systolic blood pressure and triglyceride levels following CHIP, these changes were not statistically significant (p > 0.05).

Table 2 displays stratified data using conventional risk factor categories. The data in all substrata improved for all risk factors excluding those in the normal range for SBP, DBP, LDL, and TG, in addition to those in the second category for TG. This is demonstrated by the stratified p-values and Cohen's d effect sizes. Participants who enrolled with the highest risk factor classifications often experienced the most marked improvements by the end of the intervention with large effect sizes. Many participants in the highest-risk categories for each risk factor,

except for triglycerides, moved to lower-risk classifications following CHIP. Two-thirds of participants in the highest-risk category for TC (> 240 mg/dL), and one-half of participants in the highest-risk categories for SBP (> 140 mmHg), DBP (> 90 mmHg), and LDL (> 160 mg/dL) dropped to lower-risk groups by the end of the program. More notably, both participants with A1c levels in the diabetic classification (≥ 6.5%) moved to the prediabetic classification (5.7%-6.4%), leaving zero participants left in the diabetic category at the conclusion of CHIP.

Regression Analyses

Five variables, BFM, PBF, weight, TC, and DBP, were removed from the original 15 to minimize multicollinearity in our regressions. These five variables were removed due to their strong correlation ($|r| \geq 0.7$) with other independent variables. The resulting 10 variables, including age, gender, height, sessions attended, as well as baseline BMI, SBP, LDL, HDL, TG, and A1c, were introduced as independent variables in best subsets and stepwise regressions. Results from the best subsets regression are displayed in Figure 2, which depicts a specified set of predictors that creates the best-fitting model from 1 to 10 predictors, graphed against the corresponding Bayesian information criterion (BIC) and R^2 values for each model. The cumulative order in which variables should be included based on number of predictors is SBP for the one-predictor model, then the addition of sessions attended, age, LDL, gender, BMI, A1c, HDL, TG, and height. The model that yielded the highest adjusted R^2 was the four-predictor model, while the model that yielded the Mallows' C_p-statistic with the least bias and the lowest BIC value was the one-predictor model. Stepwise regression also selected the one-predictor model with SBP as the most statistically significant.

A statistical comparison between the one-predictor and four-predictor models is presented in Table 3. It showed that adding three predictors in the latter did not lead to a

significantly improved fit over the simpler, one-predictor model. Ordinary least squares regression was conducted on the one significant variable, SBP ($p < 0.001$). The negative correlation shows that the higher the baseline SBP, the more weight loss one experiences from the CHIP intervention. Specifically, the coefficient value signifies that a participant can expect to lose a mean of 2.31 pounds more for every one millimeter of mercury higher the baseline SBP. The relationship between SBP and change in weight is exhibited in Figure 3.

A test for the exclusion of all variables except for SBP was performed using the *F*-statistic, which yielded a non-significant *p*-value ($F = 0.4833$; $p = 0.8779$). This indicates that the inclusion of all 10 noncollinear predictors did not lead to a significantly improved fit over the one-predictor model. Based on our dataset, the best predictive linear model for weight loss contains SBP as the sole independent variable. The final model's mean square error was 56.145.

Discussion

The aim of this study was to evaluate the effect of the CHIP intervention on weight, as well as other risk factors including blood pressure, body fat, lipid levels, and A1c. Our findings validate the short-term effectiveness of CHIP for weight loss and reduction of cardiovascular risk factors in a Midwestern community setting. The significant decrease in weight, BMI, DBP, TC, and LDL is consistent with nine previous studies that evaluated the short-term effectiveness of the 30-day CHIP intervention, which all reported statistically significant reductions in BMI, SBP, DBP, TC, LDL, fasting plasma glucose (FPG), and TG among U.S. adults (Kent et al., 2013b; Remy et al., 2017), Canadian adults (Morton et al., 2014), North American adults (Morton et al., 2017), Australasian adults (Kent et al., 2014; Kent et al., 2018; Morton et al., 2013), and rural Appalachian adults in the US (Drozek et al., 2014; Leibold et al., 2016). The main difference is that the present study did not identify statistically significant differences in

SBP or TG for our sample. In addition, three of these past studies reported that participants in the highest tiers of BMI, SBP, TC, LDL, FPG, and TG at program initiation experienced the most notable reductions in these measures after 30 days (Kent et al., 2014; Morton et al., 2013; Morton et al., 2014). Likewise, our results showed that participants with the highest classifications of BMI, SBP, TC, LDL, and TG experienced the greatest reductions in these measures following 8-10 weeks of intervention.

An interesting finding to note from the present study is the substantial decrease in HDL levels following CHIP, despite improvement in all other measures of cardiovascular risk. This is consistent with previous research studies, where HDL significantly decreased along with BMI, SBP, DBP, TC, LDL, TG, and FPG (Kent et al., 2013b; Kent et al., 2018; Remy et al., 2017). In a study by Kent et al. (2013b), while 323 participants with metabolic syndrome at baseline no longer had this status after 30 days of intervention, 112 participants acquired the metabolic syndrome classification due to reduced HDL levels. One possible explanation for this phenomenon is the decreased need for reverse cholesterol transport with a plant-based diet (Morton et al., 2013). Although all other indicators of cardiovascular risk improved, the decreased HDL levels raise questions regarding the value of including HDL as a predictor of cardiovascular risk in those who do not consume a typical western diet (Kent et al., 2013b). Because HDL is one of the risk factors that comprise metabolic syndrome, further research is needed to evaluate the validity of classifying individuals with metabolic syndrome when they have applied a plant-based eating pattern to their lifestyle.

Although the present study focuses on the short-term impact of CHIP, other studies affirm the potential for these health changes to be sustained in the long term. One study investigated the long-term effectiveness of CHIP for maintaining lowered biometric levels at a

four-year follow-up with participants (Kent et al., 2013a). The results showed that adults with elevated biomarkers at program entry maintained significantly lowered BMI, DBP, TC, and TG after three or more years. However, SBP, HDL, LDL, and FPG did not differ significantly from baseline. Another important note is that the 67% of follow-up participants who had elevated baseline biomarkers while maintaining compliance with the CHIP lifestyle observed even greater reductions in BMI, DBP, and FPG (Kent et al., 2013a). Although CHIP is a short-term intervention that lasts 10 weeks or less, these findings demonstrate the power of this tool for effecting long-term change for years following program completion.

Results from our linear regression analyses affirmed the one-predictor model with SBP as the best model for predicting change in weight following the CHIP intervention. SBP was the only statistically significant variable for predicting weight loss, demonstrating that changes in SBP are associated with changes in weight at the population level. It is the most useful predictor of weight loss out of all 10 noncollinear variables investigated. The negative regression coefficient suggests that the higher the baseline SBP, the more weight one can expect to lose through CHIP, barring confounding factors. The association between weight and blood pressure is supported by past epidemiological studies, which revealed that weight gain is a key risk factor in the development of hypertension (Mertens & van Gaal, 2000). Weight loss has long been recommended as the most effective nonpharmacological treatment for obese hypertensive patients. In addition, modest weight loss of 5-10% has been associated with blood pressure-lowering effects in both hypertensive and nonhypertensive patients (Mertens & van Gaal, 2000). The fact that SBP was found to be the only statistically significant predictor in our linear model reinforces the well-documented association between blood pressure and body weight.

One strength of this study is the population examined, as it was one of the first to validate the effects of CHIP on employees at a large Midwestern university. Findings can be used as a driver for organizations to offer workplace wellness programs, which could facilitate decreased healthcare costs. Another key strength includes the regression analyses conducted to build a preliminary linear model projecting how much weight loss a new participant might experience following CHIP, based on their baseline biomarkers. This can have important implications. With more data, a robust model can motivate adults to participate in lifestyle interventions when they see how much weight they are likely to lose, if that is their primary goal. An advantage of CHIP is that there are many motivators for joining the program, whether it is to achieve a healthier weight, adopt a plant-based diet, or implement lifestyle habits that lower one's risk factors.

One limitation of this study is that only one setting was used; therefore, the results from this study may not be extrapolated for conclusion in the context of other settings. The inclusion of a single setting also contributed to a small sample size ($N = 68$) relative to a large university employee population, which may increase variability and the margin of error. This limitation is made particularly evident in Table 2, where all 68 participants are stratified by risk category. The four participants who suffered from the highest levels of LDL (> 160 mg/dL) experienced a substantial 28% mean decrease of 50.8 mg/dL with a large effect size of 4.131. However, the *p*-value was insignificant, which could be attributed to the small subsample limiting the ability of the paired *t*-test to identify a significant difference, if one exists.

It is important to mention that for the specific CHIP data used in this study, A1c was collected instead of FPG, the most frequently measured biomarker for diabetes screening in previous CHIP studies. Although A1c and FPG are both effective methods of screening for diabetes, there are a few key distinctions to note. FPG is the most widely-accepted diagnostic

criterion for diabetes, as an FPG level of at least 126 mg/dL on more than one occasion qualifies for diagnosis (Sacks, 2011). Contrarily, A1c represents long-term glycemic exposure, reflecting the average glucose concentration over the past two to three months due to the approximate 120-day life span of erythrocytes (Sacks, 2011). It would have been more justifiable to collect FPG instead of A1c due to the minimal change in A1c expected to occur in the intervention span of 8-10 weeks. However, despite the short-term nature of the CHIP intervention, there was still a significant mean reduction in A1c, with those in the diabetic category at baseline experiencing the largest percentage decrease in A1c.

It is vital to take the small sample size and R^2 into account as limitations for the chosen one-predictor model. A small sample size can affect the accuracy of the final predictive model. The chosen model's low R^2 would be concerning if the goal of the model was to generate precise predictions, as it implies that the model contains more error and can therefore lead to imprecise predictions. However, the R^2 does not negate which predictors are statistically significant, nor how changes in the predictor variable, SBP, influence the response variable of change in weight. Further research needs to be conducted on larger samples to create a more robust predictive model. With more data, an improved linear model can deliver more precise predictions on the amount of weight loss that could result from a short-term lifestyle intervention like CHIP.

In conclusion, the CHIP intervention was effective for producing significant health outcomes in university employees in less than 10 weeks. Our findings show that CHIP facilitated significant mean weight loss among participants, as well as substantial decreases in chronic disease risk factors such as BMI, BFM, PBF, DBP, TC, LDL, and A1c. The final linear model consisted of SBP as the only significant predictor for change in weight, demonstrating the important relationship between blood pressure and body weight. However, predictions made by

the model should be interpreted with caution due to the small sample size and low R^2 value. Future research and regression analyses on larger samples are warranted to create a more robust linear model for accurately predicting weight loss from holistic lifestyle interventions like CHIP.

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179-211. https://doi.org/10.1016/0749-5978(91)90020-T

Baicker, K., Cutler, D., & Song, Z. (2010). Workplace wellness programs can generate savings. *Health Affairs, 29*(2), 304–311. https://doi.org/10.1377/hlthaff.2009.0626

Centers for Disease Control and Prevention. (2020a, February 27). *Adult obesity facts*. https://www.cdc.gov/obesity/data/adult.html

Centers for Disease Control and Prevention. (2019, October 29). *Adult obesity prevalence maps*. https://www.cdc.gov/obesity/data/prevalence-maps.html

Centers for Disease Control and Prevention. (2020b, April 3). *Defining adult overweight and obesity*. https://www.cdc.gov/obesity/adult/defining.html

Curry, S. J., Krist, A. H., Owens, D. K., Barry, M. J., Caughey, A. B., Davidson, K. W., Doubeni, C. A., Epling, J. W., Grossman, D. C., Kemper, A. R., Kubik, M., Landefeld, C. S., Mangione, C. M., Phipps, M. G., Silverstein, M., Simon, M. A., Tseng, C. W., & Wong, J. B. (2018). Behavioral weight loss interventions to prevent obesity-related morbidity and mortality in adults: US Preventive Services Task Force recommendation statement. *JAMA, 320*(11), 1163. https://doi.org/10.1001/jama.2018.13022

Drozek, D., Diehl, H., Nakazawa, M., Kostohryz, T., Morton, D., & Shubrook, J. H. (2014). Short-term effectiveness of a lifestyle intervention program for reducing selected chronic disease risk factors in individuals living in rural appalachia: A pilot cohort study. *Advances in Preventive Medicine, 2014*, 798184. https://doi.org/10.1155/2014/798184

Ford, E. S., Bergmann, M. M., Kröger, J., Schienkiewitz, A., Weikert, C., & Boeing, H. (2009).

Healthy living is the best revenge: Findings from the European prospective investigation into cancer and nutrition–Potsdam study. *Archives of Internal Medicine, 169*(15), 8. doi:10.1001/archinternmed.2009.237

Gillis, L. J. (2019). The effect of a lifestyle intervention on weight loss for university employees. *Journal of Community Health Nursing, 36*(4), 208–223. https://doi.org/10.1080/07370016.2019.1665309

Hernández-Reyes, A., Cámara-Martos, F., Molina-Luque, R., Romero-Saldaña, M., Molina-Recio, G., & Moreno-Rojas, R. (2019). Changes in body composition with a hypocaloric diet combined with sedentary, moderate and high-intense physical activity: A randomized controlled trial. *BMC Women's Health, 19*. https://doi.org/10.1186/s12905-019-0864-5

Kaikkonen, K. M., Saltevo, S. S., Korpelainen, J. T., Vanhala, M. L., Jokelainen, J. J., Korpelainen, R. I., & Keinänen-Kiukaanniemi, S. M. (2019). Effective weight loss and maintenance by intensive start with diet and exercise. *Medicine & Science in Sports & Exercise, 51*(5), 920–929. https://doi.org/10.1249/MSS.0000000000001855

Katz, D. L., Frates, E. P., Bonnet, J. P., Gupta, S. K., Vartiainen, E., & Carmona, R. H. (2018). Lifestyle as medicine: The case for a true health initiative. *American Journal of Health Promotion, 32*(6), 1452–1458. https://doi.org/10.1177/0890117117705949

Kent, L. M., Grant, R. S., Watts, G., Morton, D. P., Rankin, P. M., & Ward, E. J. (2018). HDL subfraction changes with a low-fat, plant-based Complete Health Improvement Program (CHIP). *Asia Pacific Journal of Clinical Nutrition, 27*(5), 1002–1009. https://doi.org/10.6133/apjcn.052018.05

Kent, L., Morton, D., Hurlow, T., Rankin, P., Hanna, A., & Diehl, H. (2013a). Long-term

effectiveness of the community-based Complete Health Improvement Program (CHIP) lifestyle intervention: A cohort study. *BMJ Open, 3*(11), e003751. https://doi.org/10.1136/bmjopen-2013-003751

Kent, L. M., Morton, D. P., Rankin, P. M., Mitchell, B. G., Chang, E., & Diehl, H. (2014). Gender differences in effectiveness of the Complete Health Improvement Program (CHIP) lifestyle intervention: An Australasian study. *Health Promotion Journal of Australia: Official Journal of Australian Association of Health Promotion Professionals, 25*(3), 222–229. https://doi.org/10.1071/HE14041

Kent, L., Morton, D., Rankin, P., Ward, E., Grant, R., Gobble, J., & Diehl, H. (2013b). The effect of a low-fat, plant-based lifestyle intervention (CHIP) on serum HDL levels and the implications for metabolic syndrome status—A cohort study. *Nutrition & Metabolism, 10*(1), 58. https://doi.org/10.1186/1743-7075-10-58

Leibold, C., Shubrook, J. H., Nakazawa, M., & Drozek, D. (2016). Effectiveness of the Complete Health Improvement Program in reducing risk factors for cardiovascular disease in an Appalachian population. *The Journal of the American Osteopathic Association, 116*(2), 84–91. https://doi.org/10.7556/jaoa.2016.020

Mertens, I. L., & van Gaal, L. F. (2000). Overweight, obesity, and blood pressure: The effects of modest weight reduction. *Obesity Research, 8*(3), 270–278. https://doi.org/10.1038/oby.2000.32

Morton, D. P., Kent, L., Rankin, P., Mitchell, B., Parker, K., Gobble, J., & Diehl, H. (2017). Optimizing the intensity of lifestyle medicine interventions: Similar outcomes for half the sessions. *American Journal of Lifestyle Medicine, 11*(3), 274–279. https://doi.org/10.1177/1559827615612420

Morton, D., Rankin, P., Kent, L., & Dysinger, W. (2016). The Complete Health Improvement Program (CHIP): History, evaluation, and outcomes. *American Journal of Lifestyle Medicine*, *10*(1), 64–73. https://doi.org/10.1177/1559827614531391

Morton, D., Rankin, P., Kent, L., Sokolies, R., Dysinger, W., Gobble, J., & Diehl, H. (2014). The Complete Health Improvement Program (CHIP) and reduction of chronic disease risk factors in Canada. *Canadian Journal of Dietetic Practice & Research*, *75*(2), 72–77. https://doi.org/10.3148/75.2.2014.72

Morton, D. P., Rankin, P., Morey, P., Kent, L., Hurlow, T., Chang, E., & Diehl, H. (2013). The effectiveness of the Complete Health Improvement Program (CHIP) in Australasia for reducing selected chronic disease risk factors: A feasibility study. *The New Zealand Medical Journal*, *126*(1370), 43–54.

National Center for Chronic Disease Prevention and Health Promotion. (2019, October 23). *About chronic diseases*. Centers for Disease Control and Prevention. https://www.cdc.gov/chronicdisease/about/index.htm

Remy, C., Shubrook, J. H., Nakazawa, M., & Drozek, D. (2017). Employer-funded Complete Health Improvement Program: Preliminary results of biomarker changes. *The Journal of the American Osteopathic Association*, *117*(5), 293–300. https://doi.org/10.7556/jaoa.2017.054

Sacks, D. B. (2011). A1C versus glucose testing: A comparison. *Diabetes Care*, *34*(2), 518–523. https://doi.org/10.2337/dc10-1546

Salas-Salvadó, J., Díaz-López, A., Ruiz-Canela, M., Basora, J., Fitó, M., Corella, D., Serra-Majem, L., Wärnberg, J., Romaguera, D., Estruch, R., Vidal, J., Martínez, J. A., Arós, F., Vázquez, C., Ros, E., Vioque, J., López-Miranda, J., Bueno-Cavanillas, A., Tur, J. A., …

Martínez-González, M. (2018). Effect of a lifestyle intervention program with energy-restricted Mediterranean diet and exercise on weight loss and cardiovascular risk factors: One-year results of the PREDIMED-Plus Trial. *Diabetes Care, 42*. https://doi.org/10.2337/dc18-0836

Shantavasinkul, P. C., Phanachet, P., Puchaiwattananon, O., Chailurkit, L., Lepananon, T., Chanprasertyotin, S., Ongphiphadhanakul, B., & Warodomwichit, D. (2015). Vitamin D status is a determinant of skeletal muscle mass in obesity according to body fat percentage. *Nutrition*, *31*(6), 801–806. https://doi.org/10.1016/j.nut.2014.11.011

World Health Organization. (2017, May 17). *Cardiovascular diseases (CVDs)*. https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)

Zheng, Y., Manson, J. E., Yuan, C., Liang, M. H., Grodstein, F., Stampfer, M. J., Willett, W. C., & Hu, F. B. (2017). Associations of weight gain from early to middle adulthood with major health outcomes later in life. *Journal of the American Medical Association, 318*(3), 255. https://doi.org/10.1001/jama.2017.7092

Table 1

Mean Changes in Chronic Disease Risk Factors from Baseline to Post-Intervention

Factor	N	Baseline mean (SD)		Post-intervention mean (SD)		Mean change	% Mean change	*t*-statistic	*p*-value
Weight (lb)	68	199.2	54.1	193.5	52.6	-5.6	-2.8	8.3	<0.001
BMI (kg/m^2)	68	32.2	7.7	31.3	7.4	-0.9	-2.8	8	<0.001
BFM (lb)	67	85.5	37	82.2	36.2	-3.4	-3.9	4.2	<0.001
PBF (%)	67	41.5	8.1	41.1	8.2	-0.5	-1.1	2.4	0.017
SBP (mmHg)	68	120.8	15.8	119.1	13.3	-1.7	-1.4	1.1	0.256
DBP (mmHg)	68	80.5	9.9	77.9	8.1	-2.6	-3.2	3.1	0.003
TC (mg/dL)	68	189.9	41.9	172.3	36.9	-17.6	-9.3	5.3	<0.001
LDL (mg/dL)	60	106.4	33.2	96.2	29.1	-10.2	-9.6	2.9	0.006
HDL (mg/dL)	68	59.6	17.3	53.6	12.9	-6	-10	5.2	<0.001
TG (mg/dL)	67	135.5	89	129.1	77.3	-6.3	-4.7	0.7	0.458
A1c (%)	68	5.3	0.4	5.2	0.4	-0.1	-2	2.3	0.027

Note. BMI = body mass index; BFM = body fat mass; PBF = percent body fat; SBP = systolic blood pressure; DBP = diastolic blood pressure; TC = total cholesterol; LDL = low-density lipoprotein cholesterol; HDL = high-density lipoprotein cholesterol; TG = triglycerides; A1c = glycated hemoglobin; SD = standard deviation

Table 2

Changes in Chronic Disease Risk Factor Levels within 10 Weeks According to Initial Risk Factor Classification

Risk factor	Baseline number	Post-intervention number	Baseline mean (SD)	Post-intervention mean (SD)	Mean change	% Mean change	*p*-value	Cohen's *d*
BMI (kg/m^2)								
18.5-24.99	13	14	23.1 (1)	22.5 (1.2)	-0.6	-2.6	0.001	0.634
25-30	16	17	27.2 (1.4)	26.7 (1.4)	-0.5	-1.8	0.015	0.355
>30	39	37	37.3 (6.1)	36.2 (6)	-1.2	-3.1	<0.001	0.192
SBP (mmHg)								
<120	32	37	106.9 (7.1)	110.7 (8.7)	3.8	3.6	0.019	-0.538
120-140	28	27	128.8 (6.3)	125.1 (12.4)	-3.7	-2.9	0.111	0.59
>140	8	4	148 (4.9)	131.5 (11.6)	-16.5	-11.1	0.001	3.368
DBP (mmHg)								
<80	31	37	72.1 (5.3)	73.6 (6.2)	1.5	2.1	0.105	-0.289
80-90	31	28	85.3 (3.8)	79.9 (6.4)	-5.4	-6.4	<0.001	1.434
>90	6	3	99.7 (6.7)	90.3 (8)	-9.3	-9.4	0.004	1.384
TC (mg/dL)								
<160	17	25	137.7 (15.8)	135.4 (23.1)	-2.3	-1.7	0.658	0.146
160-199	26	29	182.2 (10.8)	163.4 (22)	-18.8	-10.3	<0.001	1.74
200-240	16	11	218.1 (12.1)	205.8 (27.1)	-12.4	-5.7	0.065	1.021
>240	9	3	260.6 (20.1)	207.9 (25.5)	-52.7	-20.2	0.001	2.625
LDL (mg/dL)								
<100	28	42	77 (17.7)	80 (19.9)	3	3.9	0.539	-0.168
100-129	26	16	111.7 (8.7)	97.2 (22.7)	-14.5	-13	0.002	1.675
130-160	10	8	145 (8)	125.2 (29.1)	-19.8	-13.6	0.088	2.486
>160	4	2	181.2 (12.3)	130.5 (40.3)	-50.8	-28	0.136	4.131
HDL (mg/dL)								
<40	7	7	37.3 (1.7)	36.1 (4.3)	-1.1	-3.1	0.544	0.671
40-60	32	41	50.1 (5.5)	49.4 (8)	-0.8	-1.5	0.554	0.136
>60	29	20	75.3 (14)	62.4 (12.1)	-12.9	-17.2	<0.001	0.921
TG (mg/dL)								
<100	27	26	74.6 (16.2)	90.8 (39.9)	16.3	21.8	0.022	-1.003
100-199	33	33	136.4 (29.2)	139.1 (70.6)	2.6	1.9	0.83	-0.09
200-300	3	4	250.3 (32.1)	130.3 (14.2)	-120	-47.9	0.046	3.733
>300	5	5	389.2 (89.9)	270 (119.2)	-119.2	-30.6	0.017	1.327
A1c (%)								
<5.7	57	57	5.2 (0.2)	5.1 (0.3)	0	-0.5	0.549	0.128
5.7-6.4	9	11	5.9 (0.2)	5.5 (0.3)	-0.5	-7.9	0.001	2.985
≥6.5	2	0	6.8 (0.5)	6.2 (0.4)	-0.7	-10.2	0.451	1.414

Note. BMI = body mass index; SBP = systolic blood pressure; DBP = diastolic blood pressure; TC = total cholesterol; LDL = low-density lipoprotein cholesterol; HDL = high-density lipoprotein cholesterol; TG = triglycerides; A1c = glycated hemoglobin; SD = standard deviation

Table 3

Comparison of Linear Regression Models with 4 Predictors (Model 1) vs. 1 Predictor (Model 2)

	Model 1 Est. (SE)	Model 2 Est. (SE)
(Intercept)	-4.89 ***	-4.89 ***
	(0.62)	(0.62)
BP.systolic	-2.24 **	-2.31 ***
	(0.65)	(0.63)
Sessions	-0.85	
	(0.65)	
Age	0.92	
	(0.68)	
LDL	-0.71	
	(0.66)	
R^2	0.255	0.203
F	4.281	13.497
p	0.005	0.001
N	55	55

Note. Est = estimate of coefficient; SE = standard error. All continuous predictors are mean-centered and scaled by 1 standard deviation.

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$

Figure 1

Main Concepts of Theory of Planned Behavior Applied to the CHIP Intervention

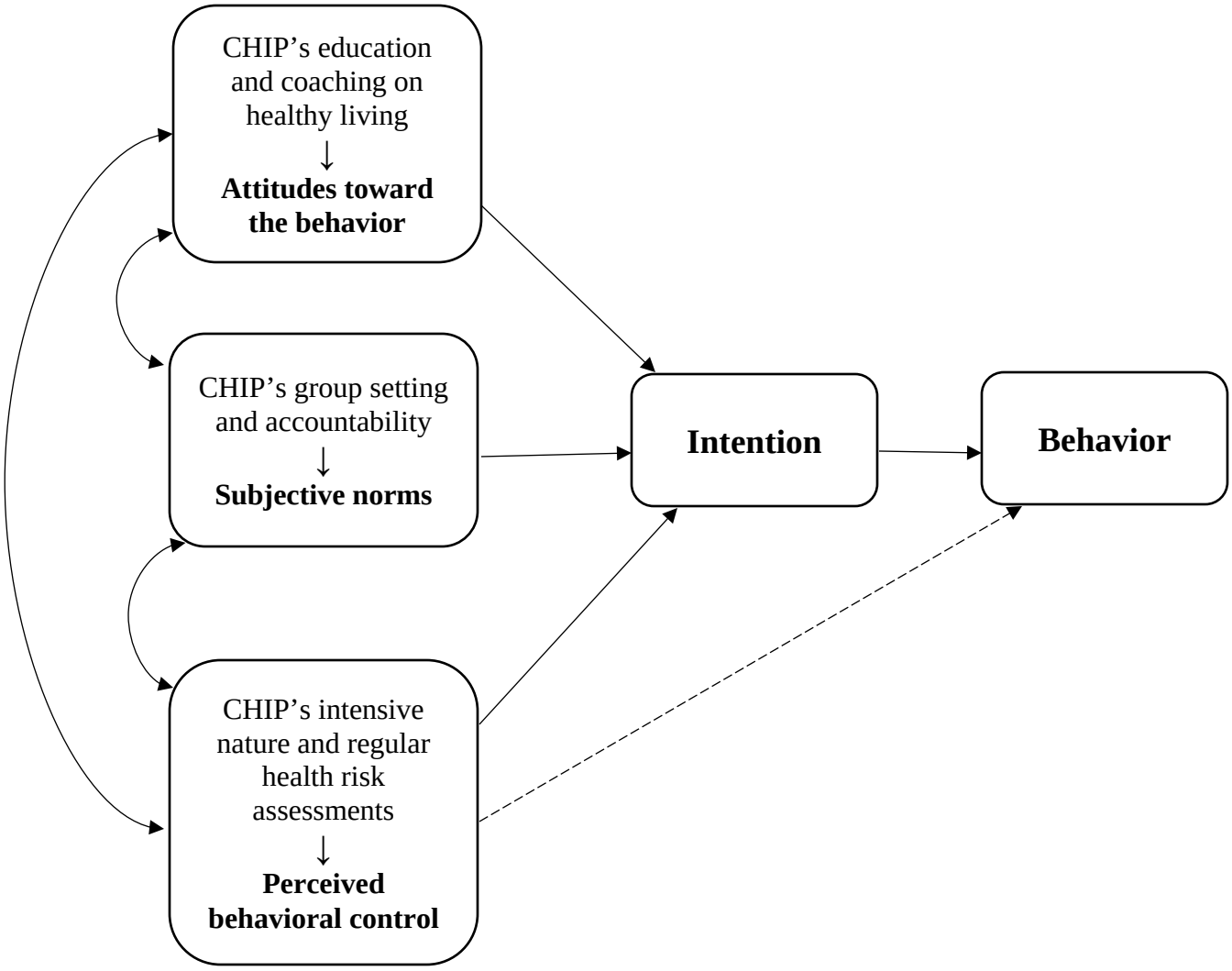
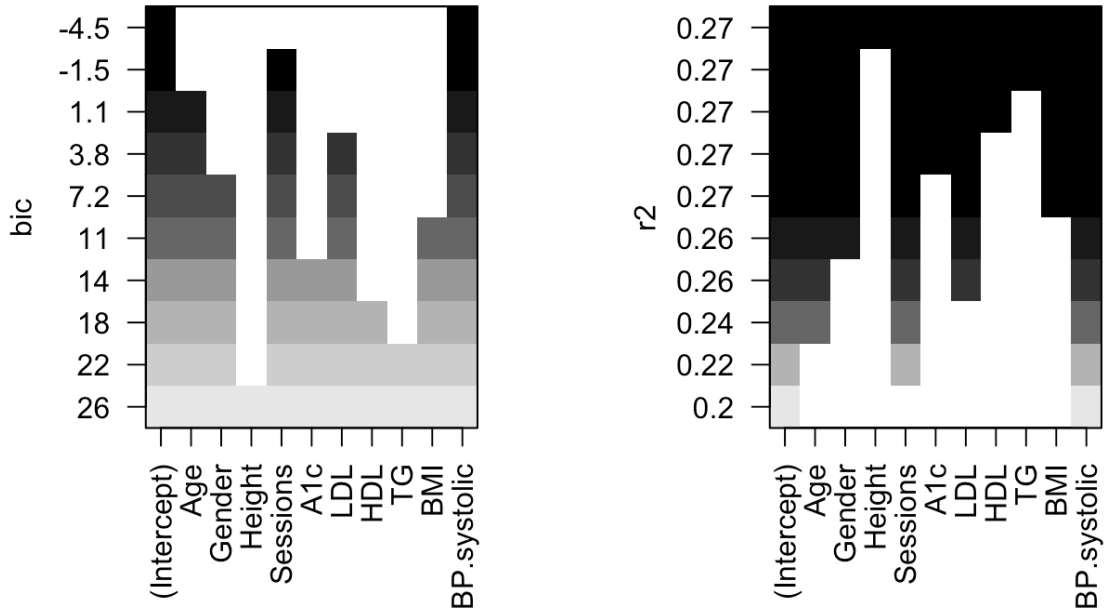


Figure 2

Graphical Plots of Best Subsets Model at Each Variable Number with Evaluation Metrics (BIC, R^2)



Note. BIC = Bayesian information criteria; R^2 = proportion of variance for weight loss based on independent predictors

Figure 3

Relationship between Systolic Blood Pressure and Weight Difference with Line of Best Fit