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DETERMINANTS AND PREDICTORS OF SMOKING-RELATED WEIGHT CONCERN IN
SMOKERS PARTICIPATING IN A COMMUNITY-BASED CESSATION PROGRAM

by

Cheri Kilmurray

A Dissertation

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Doctor of Philosophy

Major: Social and Behavioral Sciences

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DEDICATION

To my husband, Michael, whose love, support, and unwavering belief in me made this work possible.

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PREFACE

This dissertation is a compilation of three manuscripts that were products of a secondary data analysis of participants in a randomized controlled smoking cessation trial. The first manuscript is under review by the following peer reviewed journal: *Eating Behaviors*. The other two manuscripts are in preparation for submission to peer reviewed journals. Each of these manuscripts are presented in the following Chapters II, III, and IV.

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CHAPTER I

Overarching Introduction

Cigarette smoking is the chief cause of preventable death in the United States leading to cancer, chronic obstructive pulmonary disease (COPD) and cardiovascular diseases (U.S. Department of Health and Human Services, 2014). After hitting an all-time peak in 1964 (Cummings & Proctor, 2014), rates have steadily declined as knowledge about its health risks became known to the public. Subsequent public health measures have also contributed to this decline including advancements in cessation techniques, tobacco quit lines, increased taxes on tobacco products, and smoke free legislation. However, 11.5% of U.S. adults still smoke cigarettes, and 18.7% use any type of tobacco product (Cornelius et al., 2003).

Most adult smokers report wanting to quit smoking, and many make quit attempts each year. According to the 2020 Surgeon General's report, in 2015 nearly 70% of adult smokers reported wanting to quit (U.S. Department of Health and Human Services, 2020). Since the 1990s, many pharmacological and behavioral interventions for cessation at the individual level were developed to aid in cessation. These include nicotine replacement pharmacotherapy and two non-nicotine replacement medications, bupropion and varenicline (U.S. Department of Health and Human Services, 2020). Behavioral interventions for smoking cessation also continue to develop as researchers further understand psychosocial factors related to quitting such as self-efficacy, confidence, and motivation. Advancements in technology have led to new modalities for cessation such as computerized interventions, text messaging, and smart phone applications. Yet, despite these advancements, quit rates are low. Approximately 30-50% of U.S. smokers make a quit attempt each year with only 7.5% successfully quitting (U.S. Department of Health and Human Services, 2020).

There are several predictors for successful smoking cessation that have been examined extensively in the literature. Many studies have found that older age predicts successful cessation (Hymowitz et al., 1997; Monsó et al., 2001; Kaleta et al., 2012; Osler & Prescott, 1998; Yang et al., 2015). Level of nicotine dependence is another factor that predicts cessation with numerous studies showing that higher dependence results in lower quit rates (Gram et al. 2022; Hagimoto et al., 2010; Hymowitz et al., 1997; Transdisciplinary Tobacco Use Research Center (TTURC) Tobacco Dependence et al., 2007; Ussher et al., 2016). Results from a literature review examining eleven community-based cessation analyses concluded that White smokers are significantly more likely to quit smoking than Black smokers (Kulak et al., 2016). Similarly, a review of 126 efficacy or effectiveness cessation trials found that women are less likely to successfully quit smoking than men (Smith et al., 2016).

Concern about gaining weight has been examined extensively as another potential predictor of cessation success, with mixed findings. Weight concerns are highly prevalent among smokers (Bush et al., 2008; Clark et al., 2006; Kleges & Kleges, 1988; Weekley et al., 1992), and especially female smokers (Pisinger & Jorgensen 2007; Pomerleau et al., 2001; Sanchez-Johnson et al., 2001). However, some studies have found that weight concerned individuals are less likely to successfully quit (Clark et al., 2006; Meyers et al., 1997; Schauer et al., 2013; Weekley et al., 1992) while others have found no association (Borelli et al., 1998; Copeland et al., 2015; French et al., 1992; French et al., 1995; Glasgow et al., 1999; Pisinger & Jorgeson, 2007; Spring et al., 2004). Discrepancies are likely due to the inconsistent way weight concerns are conceived and measured and to varying methods of controlling for confounding. If weight concerns are significantly associated with cessation outcomes, it is important to address these concerns as part of a cessation intervention.

Weight concerns have also been examined in relation to weight gain during a quit attempt. Weight gain is common after quitting with individuals gaining on average 4-5 kg during the first 12-months (Aubin et al., 2012). However, it is unclear if having weight concerns prior to a quit attempt leads to greater weight gain. Some studies have found that weight concerned individuals do gain more weight than non-weight concerned individuals during a quit attempt (Borelli et al., 1998; Copeland et al., 2015; Glasgow et al., 2019), while others have found no association (Spring et al., 2004; Tan et al., 2021; Weekley, et al., 1992). Again, this could be due to inconsistent weight concern measures or failure to control for confounders such as nicotine dependence and body mass index. If weight concerns do predict greater post-cessation weight gain, methods to control weight would be an important part of a cessation intervention to reduce the risk of negative health outcomes related to excess weight.

Finally, understanding weight concerns by comprehensively examining its determinants could help elucidate this construct. To date, studies examining determinants of weight concerns have been mixed, likely due to inconsistent methods of measuring the construct in the literature (Germeroth and Levine, 2018). While the majority of studies conclude that females are more weight concerned than males (French et al., 1995; Jeffery et al., 2000; Landrau-Cribbs et al., 2015; Perkins et al., 2001; Pomerleau & Kurth, 1996; Rosenthal et al., 2013; Tuovinen et al., 2015), findings on other determinants such as age (Aubin et al., 2009; Clark et al., 2006; Meyers et al., 1997; Pinkser et al., 2017; Rosenthal et al., 2013; Weekley, et al., 1992), race (Borelli & Mermelstein, 1998; Clark et al., 2006; Pinsky et al., 2017; Pomerleau et al., 1993; Rosenthal et al., 2013;), and tobacco related factors (i.e. nicotine dependence, heaviness of smoking) (Aubin et al., 2009; Bennet & Pokhrel, 2018; Clark et al., 2006; French et al., 1992; Glasgow et al., 1999; Jeffery et al., 2000; Meyers et al., 1997; Pinkser et al., 2017; Pinto et al., 1999; Pomerleau

et al., 2001; Weekley et al., 1992), have had contradictory findings. Other potential determinants, such as physical activity perceptions and behaviors, and psychosocial factors related to smoking have had little attention related to weight concerns in the literature. Exploring determinants of weight concerns using validated instruments in the context of a community-based smoking cessation program would improve our understanding of factors that predict weight concerns among treatment seeking smokers. This could be an important contribution if weight concerns do predict weight gain and smoking cessation success.

Study Aims

This dissertation will include three separate studies that consist of secondary analyses of baseline and longitudinal data from a randomized controlled smoking cessation trial of adult smokers in Memphis. Study aims are as follows:

Study 1: (Cross sectional)

To assess the associations of two distinct measures of post-cessation weight concern – smoking behaviors related to weight control and willingness to tolerate post-cessation weight gain without relapsing with several potential determinants, including sociodemographic characteristics, smoking-related characteristics, psychological functioning, and health behaviors, using baseline data.

Study 2: (Longitudinal)

To analyze the two distinct measures of weight concern to determine their ability to predict weight gain over the course of a cessation attempt (7-weeks, 6-months, and 12-months after cessation) using baseline and three follow up waves of data.

Study 3: (Longitudinal)

To analyze the two distinct measures of weight concerns to determine their ability to predict cessation at the same follow-up points over the course of a cessation attempt (7-weeks, 6-months, and 12-months after cessation) using baseline and three follow up waves of data.

CHAPTER II

Determinants of smoking-related weight concern in smokers participating in a community-based cessation program

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Abstract

Background: Concern about weight gain is a barrier to smoking cessation, but determinants of post-cessation weight concern have not been adequately evaluated in the context of community-based cessation programs.

Methods: Baseline data were analyzed from a cessation trial of 392 adults randomized to physical activity (PA) or general wellness counseling as adjunctive treatment for cigarette smoking. Outcomes were 1) Use of smoking to control weight (“control”) and 2) Willingness to tolerate weight gain without returning to smoking (“intolerance”) using validated instruments. Independent variables were self-reported PA and perceptions, socio-demographics, psycho-social measures, smoking behavior and perceptions, diet, and body mass index (BMI). From bivariable models examining main and sex interaction effects, significant variables were entered into a linear or logistic regression model to identify determinants associated with control and intolerance outcomes, respectively.

Results: For both measures, weight concern was significantly ($p < 0.05$) greater for smokers who are female (standardized $b = 0.52$, $SE = 0.10$; $OR = .29$, $95\% \text{ CI} = 0.17-0.49$), White ($b = 0.12$, $SE = 0.05$; $OR = .39$, $95\% \text{ CI} = 0.23-0.66$), and less motivated to quit ($b = -0.14$, $SE = 0.05$; $OR = 0.77$, $95\% \text{ CI} = 0.59-1.0$). Higher control scores were associated with less PA ($b = -0.10$, $SE = 0.05$) and higher BMI ($b = 0.21$, $SE = 0.05$). For men, higher BMI was associated with greater anticipation of relapse if weight gain occurred ($OR = 2.54$, $95\% \text{ CI} = 1.42-4.56$) but for women, intolerance for post-cessation weight gain was not contingent upon BMI.

Conclusions: Among adults participating in a community-based cessation program, women, whites, and those less motivated to quit are more likely to smoke for weight control and be less likely to tolerate post-cessation weight gain. In addition, higher BMI was associated with greater

anticipation of relapse if weight gain occurred for men, but not for women. Weight concerns, measured by either use of smoking to control weight or intolerance of post-cessation weight gain were not related to smoking history, psychosocial functioning, PA engagement or attitudes, or dietary variables. These results suggest potential targets for efforts to address weight gain concerns among smokers undergoing a quit attempt.

Introduction

Cigarette smoking is associated with many chronic diseases including cancer, chronic obstructive pulmonary disease (COPD) and cardiovascular diseases (U.S. Department of Health and Human Services, 2014). Still, 11.5% of adults in the U.S. smoke cigarettes (Cornelius et al., 2023). Weight gain is common after quitting smoking, averaging 4-5 kg during the first 12-months (Aubin et al., 2012) and has been identified in multiple studies as a barrier to cessation (Aubin et al., 2010; Berkelmans et al., 2011; Pomerleau et al., 2001; Rosenthal et al., 2013; Tuovinen et al., 2015).

Although post-cessation weight concern has received attention in the literature, several issues remain unclear. One issue is a lack of consistency in how weight concern is defined. A variety of instruments have been used, from single item to multi-item scales and have focused on various dimensions of weight concern such as fear of gaining weight, expectation of relapse if weight gain occurs, smoking to control weight, and weight gain expectancies (Germeroth and Levine, 2018). This has likely contributed to mixed findings regarding the association of weight concern with cessation (Aubin et al., 2009; Borrelli & Mermelstein 1998; Copeland et al., 2006; Faseru et al., 2013; French et al., 1992; French et al., 1995; Jeffrey et al., 2000; Klesges et al., 1988; Levine et al., 2010; Meyers et al., 1997; Pisinger & Jorgensen 2007; Schauer et al., 2013; Tuovinen et al., 2018; Veldheer et al., 2014) and post-cessation weight gain (Borrelli &

Mermelstein, 1998; Copeland et al., 2015). In light of these inconsistencies, a better approach may be to consider various dimensions of post-cessation weight concern as separate constructs in the same study and conduct analyses that take into account these distinct dimensions. For example, smoking to control weight, and anticipating smoking relapse if one gains weight may capture different features of weight concern and have distinct correlates.

A second limitation of the literature is that determinants of post-cessation weight concern have not been systematically or comprehensively assessed. The most studied determinants relate to sociodemographic and tobacco related characteristics. Sex, race, and age are the most common sociodemographic determinants evaluated for post-cessation weight gain but have varying findings. Post-cessation weight concern is consistently more common in females than males (French et al., 1995; Jeffery et al., 2000; Landrau-Cribbs et al., 2015; Perkins et al., 2001; Pomerleau & Kurth, 1996; Rosenthal et al., 2013; Tuovinen et al., 2015). In terms of race, however, the evidence has been mixed. Some studies found post-cessation weight concern highest among White individuals (Clark et al., 2006) and lowest among Black and Hispanic individuals (Rosenthal et al., 2013). Yet, Pinsker et al. (2017) found that, among males, being Black was associated with significant weight concern. Likewise, Pomerleau et al. (2001a) found that Black women may be less tolerant of weight gain during a quit attempt compared to White women. Borelli and Mermelstein (1998) found no significant difference in post-cessation weight concern between White and Black smokers. Because there are some questions in the literature related to how weight concerns are conceived and conceptualized among Black smokers compared to White smokers (Cameron et al., 2018; Sanchez-Johnson, 2005; Watson et al., 2019) it will be valuable to learn if there are differences in race using these two weight concern measures. The evidence of an association between age and post-cessation weight concern has

also been mixed, with some studies finding greater weight concern among younger smokers (Aubin et al., 2009; Clark et al., 2006), some older smokers (Pinkser et al., 2017; Rosenthal et al., 2013), and others finding no association (Meyers et al., 1997; Weekley, et al., 1992). These discrepancies could be due to the types of populations studied. Pinsker et al. (2017) studied homeless adults participating in a cessation program. Weight concerns likely differ in this population from those of a traditional population. Likewise, Rosenthal et al. (2013) surveyed an ethnically diverse (61% Black, 20% Latino, 12% White), low-income population not currently participating in a cessation attempt. Aubin et al., (2009) studied individuals who intended to quit in the future, while Weekley et al. (1992) used a random survey sample of current smokers. These various stages in the quit process could lead to different feelings of weight concerns as an individual that does not have immediate plans to quit may be less concerned about the weight implication than an individual that is undergoing a quit attempt or plans to quit in the near future. However, discrepancies between Clark et al. (2006) and Meyers et al. (1997) in age as a predictor remain unclear as they both used samples of smokers undergoing a cessation attempt with similar mean ages (between 41 and 44) and also used the same scale for measuring weight concerns.

Tobacco-related factors such as nicotine dependence, heaviness of smoking, years of smoking, and withdrawal symptoms have also been widely assessed in relation to post-cessation weight concern, again with mixed results. Some studies have found greater weight concern associated with higher nicotine dependence, heaviness of smoking, and/or more withdrawal symptoms (Aubin et al., 2009; Bennet & Pokhrel, 2018; Glasgow et al., 1999; Jeffery et al., 2000; Pinkser et al., 2017; Pinto et al., 1999; Pomerleau et al., 2001). However, a study by French et al. (1992), found that higher weight concerns were associated with smoking fewer

cigarettes and lower reported nicotine dependence. These findings were similar to those of Clark et al. (2006), who found that among women, weight concerned smokers reported lower nicotine dependence and fewer years smoking. Yet, several studies have found a null association between weight concerns and several smoking related factors such as previous quit attempts (French et al., 1992; Glasgow et al., 1999; Jeffrey et al., 2000; Weekley et al., 1992), number of cigarettes smoked per day (Meyers et al., 1997; Weekley et al., 1992), the number of years of smoking (Meyers et al., 1997), and nicotine dependence (Levine et al., 2001). Reasons for these discrepancies are unclear but could be related to diversity in samples, inconsistent measurement of weight concerns, and inconsistencies in how confounding was addressed.

The influences of psychosocial determinants on smoking status have been heavily researched; however, there is not as much research evaluating how these factors contribute to post-cessation weight concern. Because eating concerns and disorders are often associated with psychological problems such as depression and anxiety, it is useful to examine whether post-cessation weight concern is linked to psychological states. Few studies have assessed broader psychosocial factors related to post-cessation weight concern such as distress intolerance, negative affect, anxiety and depression (Burr et al., 2020; Pinto, 1999; Pinsker et al., 2017) and motivation, confidence, and self-efficacy to quit (Glasgow et al., 1999; Jeffery et al., 2000; Tuovinen et al., 2015). In general, this limited research indicates that weight concern is correlated with less ability to withstand distress and less confidence and self-efficacy in ability to quit smoking.

Finally, post-cessation weight concern may be related to a clustering of unhealthy lifestyle factors including excessive saturated fat intake, elevated body mass index (BMI), excessive alcohol use, and physical inactivity. While studies have examined dietary restraint,

defined as consciously controlling or restricting food intake (Savage et al., 2009), related to weight concern in general (French et al., 1995; Landrau-Cribbs et al., 2015; Pinto et al., 1999; Weekley et al., 1992), fewer studies have assessed diet or alcohol use related to post-cessation weight concern specifically (Luostarinen et al., 2013; Pinto et al., 1999). Evidence is mixed regarding the association between post-cessation weight concern and BMI, with some studies finding greater weight concern among those with higher BMI (Aubin et al., 2009; Beebe & Bush 2015; Levine et al., 2013; Luostarinen et al., 2013; Pinsker et al., 2017) and other studies finding an inverse relationship (Clark et al., 2006; Landrau-Cribbs et al., 2015; Meyers et al., 1997). Although physical activity (PA) may be a useful strategy to promote smoking cessation (Haasova et al., 2013; Roberts et al., 2012) and prevent weight gain (Farley et al., 2012), few studies (Luostarinen et al., 2013; Pinto et al., 1999) have examined whether PA engagement or psychosocial aspects (e.g., self-efficacy, perceived barriers and facilitators, enjoyment) are associated with weight concern.

Thus, there is uncertainty in the literature regarding the determinants of post-cessation weight concern. Inconsistencies may be related, in part, to a lack of uniformity in how weight concern is measured and a failure to examine weight concern as a potentially multi-dimensional construct. Discrepancies may also relate to the types of samples studied, such as convenience samples of smokers not undergoing cessation, as few studies (Borrelli et al., 1998; Clark et al., 2006; Meyers et al., 1997) have been conducted with community-based samples of smokers who are interested in quitting. Improving our understanding of the determinants of post-cessation weight concern may help to improve targeted cessation interventions for weight concerned smokers who want to quit – an important sub-population for clinical and public health efforts.

The purpose of this study is to describe baseline determinants of post-cessation weight concern in a population of adult smokers participating in a community-based smoking cessation randomized controlled trial (RCT). The associations of two distinct measures of post-cessation weight concern: 1) Smoking behaviors related to weight control (Weekley et al., 1992) and 2) Tolerated post-cessation weight gain before relapse (Meyers et al., 1997) with several potential determinants were assessed.

While it is expected that women will express greater weight concerns than men, this descriptive analysis explores if, and the degree to which, post-cessation weight concern is correlated with a constellation of healthy and unhealthy factors including BMI, PA levels, enjoyment of and barriers to PA, alcohol use, saturated fat intake, motivation to quit, confidence to stay quit, and scores on measures of depressive symptoms and other psychosocial measures. Previous studies have found inconsistent determinants of weight concerns, but most have used only a single scale and often these scales have not been validated. Thus, it is unclear if determinants of weight concerns differ according to the dimension of weight concerns that is assessed. This analysis will assess two dimensions in an exploratory fashion. It will further assess if either measure of weight concern better predicts the associated correlates in a community sample of treatment seeking smokers, in which these factors have not been adequately studied.

Methods

Data Set

Data used for this study are from the Lifestyle Enhancement Program (LEAP) smoking cessation two group randomized controlled trial, which compared adjunctive physical activity counseling to general wellness counseling with standard smoking behavioral/pharmacologic

cessation treatment (Vander Weg et al., 2018). The analysis used baseline (pre-randomization) data from 392 participants collected between 2004-2007. Inclusion criteria consisted of smoking for at least one year, smoking five or more cigarettes per day, being relatively sedentary, and interested in quitting smoking. Participants actively sought inclusion into the study and were willing to take part in PA or wellness counseling to assist quitting smoking.

Measures

Measures are briefly described below. An expanded description is contained in Appendix A.

Dependent Variables

Smoking to Control Weight. The “control” variable is a measure of weight concern using the Smoking Situations Questionnaire (Weekley et al., 1992), which queries about smoking behaviors that are used as strategies to control body weight including to prevent and control weight, in lieu of snacking, at the end of a meal, and to suppress appetite. The 6 items are measured on a 6-point Likert scale from “strongly disagree” to “strongly agree.”; these items had adequate internal consistency in our data (Cronbach Alpha=0.87). The mean of the individual items comprises the “control” score.

Intolerance of Post-cessation Weight Gain. The “intolerance” variable assesses whether the respondent would tolerate post-cessation weight gain without relapsing, using the validated Weight Concerns Scale (Meyers et al., 1997). Modified from previous studies, the original 2-pound increment, 10 question scale was changed to a 5-pound increment, six question scale. For each of six post-cessation weight gain ranges (1-5 lbs to 26-30 lbs) participants indicated the likelihood they would return to smoking on a 4-point scale from “somewhat unlikely” to “very likely.” Consistent with previous work (Clark et al., 2006; Landrau-Cribbs et

al., 2015; Meyers et al., 1997), participants were dichotomized as “weight concerned” if they endorsed being either “somewhat” or “very” likely to return to smoking at any threshold of weight gain, or not “weight concerned”.

Independent Variables

Sociodemographic / body composition variables. Variables included: age, sex, race, marital / relationship status, employment status, and body mass index (kg/m²). Because only 2.6% of the sample responded to race as “other,” with all other respondents reporting White or Black, race was dichotomized into two groups, White or non-White. Marital and relationship status was dichotomized into partnered (married or living with domestic partner) or not partnered. Employment status was dichotomized into employed or unemployed.

General psychosocial variables. Variables included: perceived stress (Perceived Stress Scale; Cohen et al., 1983), perceived social support (Perceived Social Support Scale; Blumenthal et al., 1987), depressive symptoms (CES-d; Radloff, 1977), and mood states: depressed, anger, confusion, vigor, fatigue, and tension (Profile of Mood States; McNair et al., 1977) using multi-item scales.

Smoking related variables. Variables included: number of years smoking, number of prior 24-hour quit attempts, level of nicotine dependence (Fagerström Test for Nicotine Dependence; Heatherton et al., 1991), severity of nicotine withdrawal symptoms (Minnesota Withdrawal Scale; Hughes et al., 1991), self-efficacy (Self-efficacy for Quitting Smoking / Temptation to Smoke Form; Velicer et al., 1990) and social support for quitting (Partner Interaction Questionnaire; Cohen & Lichtenstein, 1990), and motivation, confidence, and decisional balance to quit (Decisional Balance to Quit Smoking; (Velicer et al., 1990), using single or multi-item scales.

Physical activity (PA) related variables. Variables included: environmental and personal barriers to PA (Barriers to Physical Activity Scale; Salmon et al., 2003), perceived barriers to exercise (Perceived Barriers to Exercise Scale; Castro et al., 1999), enjoyment of various types of PA (Enjoyment of Types of Physical Activity; Salmon et al., 2003), overall enjoyment of PA (Physical Activity Enjoyment Scale; Kendzierski & DeCarlo, 1991), self-efficacy for PA (Exercise Self-efficacy Scale; Marcus et al., 1992), weekly minutes of moderate and vigorous PA, strength, and flexibility activity (7-day Physical Activity Recall; Salis et al., 1985; and Compendium of Physical Activities; Ainsworth et al., 2011) using multi-items scales.

Dietary intake and alcohol variables. Variables included: saturated fat intake, as a percentage of total energy intake, measured by the National Cancer Institute's Diet History Questionnaire, and alcohol use, measured by the question, "on average, how many alcoholic drinks do you have each week?".

Analytic Approach

This is a cross sectional, secondary analysis aimed to identify determinants of post-cessation weight concern in a sample of treatment-seeking smokers. For each dependent variable ("control" and "intolerance") an analysis of bivariable associations of all independent variables described above was performed. Variables that were correlated at a p-value of .10 or less were retained for inclusion in the final regression models.

As females consistently have greater weight concern than males in the literature (French et al., 1995; Jeffery et al., 2000; Landrau-Cribbs et al., 2015; Perkins et al., 2001; Pomerleau & Kurth, 1996; Rosenthal et al., 2013; Tuovinen et al., 2015), and it is unclear if there are sex differences in many determinants of weight concern, each independent variable was modeled

with sex as a potential effect modifier. Associations with a p-value of less than .05 were included in final regression models.

To determine which variables most strongly correlated with post-cessation weight concern, a multiple linear regression analysis was performed to predict “control” and a multiple logistic regression analysis was performed to predict “intolerance” as the dependent variables using SAS 9.4. Variance inflation factors for all variables modeled were assessed for collinearity with values below 5 considered acceptable.

Across all independent and dependent variables, missing data rates ranged from 0% to 22% of cases. Only 4 of 42 variables had missing values of 5% or more of cases (Table 2). To address this, multiple imputation using PROC MI in SAS 9.4 was performed prior to running the regression models to impute missing values. Consistent with recommendations (Rubin, 1987), five imputations were run and then combined using PROC MIANALYZE in SAS 9.4 to estimate the missing values.

Results

Descriptive Statistics

Participants (n = 392) were between 18-65 years of age, 62% female, 67% White, 51% were married or living with a domestic partner, and 75% were employed. The average BMI was 28 (standard deviation (SD) = 5.8). On the “intolerance” outcome, 56% of participants were considered “weight concerned,” indicating that they believed they were likely to relapse if some threshold of weight gain occurred. On the “control” outcome, the average score was 1.78 (SD = 1.13) on a scale from 0 to 5, with higher scores indicating greater weight concern (Table 1).

Correlates of “Control”

In the bivariable correlation analysis, variables positively correlated with “control” (at $\alpha \leq .10$) included BMI, perceived stress, depressive symptoms, confusion mood state, nicotine withdrawal symptoms, temptation to smoke in negative affect situations, temptation to smoke in positive affect/social situations, personal barriers to PA, environmental barriers to PA, perceived barriers to exercise, enjoyment of unorganized PA, and enjoyment of walking. Female and White smokers had higher “control” scores than male and non-white smokers, respectively (at $\alpha \leq .10$). In addition, vigor mood state, motivation to quit smoking, confidence in quitting smoking, total minutes of moderate PA per week, and total minutes of vigorous PA per week were negatively correlated with “control” (Table 2).

Variables that interacted significantly with sex in their association with weight control included greater depressed mood among males ($p=.0484$), less perceived total social support among males ($p=.012$), less enjoyment of organized PA among males ($p=.048$), and greater temptation to smoke in positive social situations ($p=.0074$) among females. While initially included in the regression model, these interaction terms became non-significant and were ultimately removed from the final model.

Results from the final regression model indicated that smokers who are female, White, have a higher BMI, have less motivation to quit, and participate in less weekly moderate PA have greater weight concern (Table 3).

Correlates of “Intolerance” for Post-cessation Weight Gain

In the bivariable correlation analysis, variables positively correlated with unwillingness to tolerate post-cessation weight gain (i.e., anticipating relapse if weight gain occurred) (at $\alpha \leq .10$) included higher BMI, and greater temptation to smoke in negative social situations, personal barriers to PA, perceived barriers to exercise, and saturated fat intake. Female and

White smokers had higher “intolerance” scores than male and non-white smokers, respectively (at $\alpha \leq .10$). In addition, motivation to quit smoking, confidence in quitting smoking, negative social support for quitting smoking, enjoyment of organized PA, enjoyment of PA overall, and minutes of moderate PA per week were negatively correlated with “intolerance” (at $\alpha \leq .10$; Table 2).

Variables that interacted significantly with sex in their association with weight gain intolerance included less perceived total social support among males ($p=0.004$), greater perceived stress among males ($p=0.04$), greater BMI among males ($p=0.0003$), less anger mood state among females ($p=0.04$) and less depressed mood among females ($p=0.01$). These interaction terms were initially included in the logistic regression model. All but BMI became non-significant in the multivariable model and were removed.

Results from the logistic regression model indicate that smokers who are female, White, and endorsed less motivation to quit have greater odds of anticipating relapse if weight gain occurred (Table 4). A significant interaction indicated that men with higher BMI anticipated relapsing if weight gain occurred, but no such association was found for women. A further decomposition of this interaction was performed by calculating the difference in least square means of BMI between males and females using unimputed data in SAS 9.4. Due to missing data, 88 observations were excluded from this analysis, but the interaction remained significant. This analysis indicates that at lower levels of BMI (16-32) males had significantly lower odds of weight concern compared to females. Yet at very higher levels of BMI (37-50), male odds of weight concern were significantly greater than female. As shown in Figure 1, the association of weight gain intolerance and BMI was “less steep” for women than for men indicating that across the full BMI range the likelihood of being weight concerned does not vary much for women. In

contrast, weight gain is likely to be a concern for men only at relatively high BMIs). In this sample of smokers there were two observations with a BMI below 17 (undernourished) with heights and weights of 177.1 cm; 53.3 kgs, and 169cm; 46.5 kgs respectively. Likewise, there was one extreme BMI of 50 with height and weight of 170.5 cm, 145 kgs. Results were essentially unchanged when these outliers were removed.

Discussion

This study adds to the literature by comprehensively examining the determinants of two distinct measures of post-cessation weight concern in a community sample of smokers participating in a cessation program. Results indicate that several key variables are significantly associated with both measures of weight concern, supporting previous studies. This analysis also examined PA and psychosocial variables, which have not, to our knowledge, been previously examined in a community sample with regard to weight concern. The findings make a novel contribution to the literature by showing that, with the exception of motivation to quit and participation in modest physical activity, there was a lack of significant association between weight concerns and any other PA variables (barriers, enjoyment, self-efficacy etc.), and psychosocial variables (depressive symptoms, mood states, confidence, perceived social support, etc.).

Our results are generally consistent with previous literature, showing that women are more likely to have smoking-related weight concerns than men (French et al., 1995; Jeffery et al., 2000; Landrau-Cribbs et al., 2015; Perkins et al., 2001; Pomerleau & Kurth, 1996; Rosenthal et al., 2013; Tuovinen et al., 2015). In the present study, women were more likely to use smoking to control weight and less willing to tolerate post-cessation weight gain compared to men.

While BMI for both men and women was generally positively related to weight concerns – whether defined as control or intolerance, consistent with previous research (Aubin et al., 2009; Beebe & Bush 2015; Levine et al., 2013; Luostarinen et al., 2013; Pinsker et al., 2017), an important caveat is that BMI modified the association of sex and intolerance of weight gain. At lower levels of BMI men were more tolerant of weight gain than women; this association flipped however at higher BMI, such that at high levels of obesity (e.g., above 40) men were less tolerant of weight gain than women. These findings suggest that while weight concerns should be considered as a barrier to cessation among women at all body weights, obese men may require targeted assistance to address two risk factors simultaneously. Similar findings of obese men being more weight concerned were documented in previous research (Levine et al., 2013; Pánková, et al., 2017). Results of a qualitative study exploring weight concern among obese male and female smokers identified cessation barriers related to several key themes including current body dissatisfaction, the relationship between cessation and weight gain, and past cessation experiences managing stress and other chronic diseases (Bush et al., 2014). Further studies with obese males could help identify specific barriers to and motivators of cessation among this subpopulation of smokers. Since obese male smokers are at substantially increased risk of early death (Freedman et al., 2006; Ma et al., 2013), and risk of post-cessation weight gain is greatest among smokers who are already obese (Lycette et al., 2011; Scherr et al., 2015; Veldheer et al., 2015) interventions for this population that simultaneously target smoking cessation and weight gain prevention may be beneficial.

Previous studies found that confidence in one's ability to quit smoking is inversely related to weight concerns (Glasgow et al., 1999; Jeffrey et al., 2000). Our study found this expected relationship in bivariable models but not in multivariable models, indicating that the

association is confounded by other factors such as sociodemographic characteristics. In contrast, motivation to quit was inversely and independently related, in multivariable models, to both using smoking to control weight and anticipating relapse if weight gain occurred. These findings indicate that motivation to quit is a robust correlate of concerns about post-cessation weight gain, although the cross-sectional nature of our data preclude determining temporality of the association. Regardless however, in the context of seeking treatment for cessation, this finding indicates that the challenge for weight concerned individuals is not so much “Can I quit?” as “Do I want to quit?”

These results suggest that cessation interventions aimed at reducing weight concern specifically may increase motivation to quit. In fact, two RCTs that evaluated interventions to reduce weight concern found promising results. Perkins et al. (2001) found that a cognitive behavioral smoking cessation intervention focused on acceptance of modest weight gain improved cessation outcomes (21% biochemically confirmed continuous abstinence at 12 months) compared to standard behavioral cessation counseling (9% biochemically confirmed continuous abstinence at 12-month) and to a weight control intervention (13% biochemically confirmed continuous abstinence at 12-month) among a sample of 219 weight concerned women. Another RCT (N=349) looking at the combined effect of bupropion and cognitive behavioral therapy to accept modest weight gain among women found that individuals receiving this combination had improved smoking cessation outcomes at short term follow up (6 months) but not long-term (12 months), compared to standard cessation treatment (Levine et al., 2010). These promising efficacy trials warrant more research.

While it is conceivable that weight concerned individuals may engage in more PA and enjoy PA more because they use it to control weight, the results did not support this. There was a

significant association between smoking to control weight and engaging in less weekly minutes of moderate physical activity, but no other PA variables were significant. Little attention has been given to the relationship between weight concern and PA behavior among individuals in a community sample making a cessation attempt in the literature. One study by Pinto et al. (1999) found a positive association between reported “pros” to exercise and weight concerns in a cessation program, but the sample was limited to women. A later study examining weight concern among ever-smokers included PA as a potential confounder, but it did not significantly affect the association between smoking status with weight concern (Luostarinen et al., 2013), suggesting that PA does not mediate the association.

The strengths of this study include the relatively large community-based sample of smokers who planned to quit and the use of two distinct measures of weight concerns related to cigarette smoking and quitting. Our results contribute to the literature by demonstrating in a clinical sample that the major determinants of weight concerns are sex (female), race (White), and motivation to quit are similar to previous studies of non-clinical samples (e.g., college students, adults not planning to quit) and are similar regardless of whether weight concerns are measured as engaging in smoking to control weight or anticipating relapse if weight gain occurs. However, the sex interaction with BMI resulting in odds of relapse being more pronounced among obese men is a novel finding that should be further explored. Further, while smoking for weight control was associated with lower levels of PA, overall, there was little evidence that behavioral and psychosocial factors (e.g., attitudes towards PA, depression, and mood) were determinants of weight concerns.

A limitation to this analysis is the cross-sectional design, as temporality cannot be established between the dependent and independent variables. In addition, findings are limited

in scope to a population of healthy, sedentary smokers seeking cessation treatment in a community setting and who are willing to participate in adjunctive PA or wellness support. This study is also limited in that it assessed only two distinct measures of weight concern and could not evaluate whether other dimensions of the construct such as dieting behavior and perceptions of being overweight regardless of weight status have distinct determinants (French and Jeffrey, 1995).

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Tables

Table 1: Sample Descriptive Statistics

Categorical Variables	Males n, (%)	Females n, (%)	Total n=392 (%)	
<i>Race</i>				
White	100 (67%)	161 (66%)	261 (67%)	
Non-White*	49 (33%)	82 (34%)	131 (33%)	
<i>Marital status</i>				
Married / partnered	80 (54%)	118 (49%)	198 (50%)	
Unmarried / unpartnered	69 (46%)	125 (51%)	194 (50%)	
<i>Employment status</i>				
Employed	123 (83%)	172 (71%)	295 (75%)	
Not employed	26 (17%)	71 (29%)	97 (25%)	
<i>Weight Concerned (“intolerance”)</i>				
Weight Concerned	57 (38%)	161 (66%)	218 (56%)	
Non-Weight Concerned	92 (62%)	82 (34%)	174 (44%)	
Continuous Variables				
	Male, mean (SD)	Female, mean (SD)	Total, mean (SD)	Range
Age	45.1 (10.0)	44.3 (10.1)	44.6 (10.16)	18-64
BMI	27.7 (5.1)	28.2 (6.3)	27.97 (5.84)	16.26-50
Weight Concerned (“control”)	1.32 (.98)	2.05 (1.13)	1.78 (1.13)	0-5
<i>General psychosocial variables</i>				
Perceived stress	21.72 (8.22)	22.59 (8.23)	22.26 (8.22)	4-50
Total social support	65.79 (13.02)	66.58 (15.47)	66.28 (14.58)	12-84
Depressed mood (CES-D)	11.70 (9.51)	12.23 (10.17)	12.03 (9.9)	0-50
Profile of Moods States: Tension	7.80 (6.43)	7.99 (6.47)	7.91(6.44)	0-35
Profile of Moods States: Depression	7.04 (9.78)	7.33 (10.47)	7.22 (10.20)	0-54

Table 1 (continued)

Continuous Variables	Males Mean, SD	Females Mean, SD	Total Mean, SD	Range
Profile of Moods States: Anger	6.06 (6.87)	5.41 (6.55)	5.66 (6.68)	0-42
Profile of Moods States: Fatigue	6.22 (5.67)	6.61 (5.83)	6.46 (5.76)	0-26
Profile of Moods States: Confusion	5.67 (4.60)	5.53 (4.61)	5.59 (4.60)	0-24
Profile of Mood States: Vigor	16.67 (6.04)	16.34 (6.68)	16.47 (6.44)	0-32
<i>Smoking related variables</i>				
Total years smoking	24.99 (10.09)	23.12 (11.09)	23.83 (10.74)	2-50
Number of prior quit attempts	2.42 (1.11)	2.54 (1.14)	2.49 (1.13)	1-5
Number of cigarettes per day	23.40 (9.80)	19.47 (9.04)	20.99 (9.51)	4-80
Fagerström Test for Nicotine Dependence	5.24 (2.3)	4.74 (2.33)	4.93 (2.31)	0-10
Nicotine withdrawal symptoms	.90 (.64)	1.02 (.71)	.98 (.68)	0-3.4
Temptation to smoke in negative affect/social situations	4.15 (.85)	4.41 (.65)	4.31 (.74)	1-5
Temptation to smoke in positive affect/social situation	3.68 (.82)	3.90 (.83)	3.88 (.83)	1.66-5
Temptation to smoke habit	3.60 (.80)	3.54 (.93)	3.56 (.88)	1-5
Motivation to quit smoking	8.50 (1.6)	8.94 (1.27)	8.78 (1.42)	1-10
Confidence in quitting smoking	8.12 (1.96)	8.07 (2.12)	8.09 (2.06)	0-10
Decisional balance to quit smoking	-1.59 (4.03)	-2.30 (4.55)	-2.03 (4.37)	-12-12
Social support (positive) to quit smoking	14.4 (11.25)	13.63 (10.93)	13.92 (11.04)	0-40
Social support (negative) to quit smoking	15.86 (10.87)	13.06 (10.99)	14.13 (11.01)	0-40
<i>Dietary variables</i>				
Saturated fat intake	12.18 (3.04)	11.65 (2.75)	11.86 (2.87)	3.94- 20.08
Alcohol use	3.65 (4.63)	1.97 (3.65)	2.29 (4.11)	0-21
<i>Physical Activity (PA) Variables</i>				
Environmental barriers to PA	3.77 (3.16)	4.99 (.37)	4.53 (3.34)	0-16.8
Personal barriers to PA	6.52 (4.65)	7.24 (3.72)	6.97 (4.11)	0-19.43
Perceived barriers to exercise	1.81 (.54)	2.06 (.58)	1.97 (.58)	1-3.75
Enjoyment of PA	3.76 (.81)	3.81 (.81)	3.80 (.81)	1-5
Enjoyment of organized PA	2.89 (.82)	2.92 (.79)	2.91 (.80)	1-5
Enjoyment of unorganized PA	2.72 (1.03)	2.95 (1.08)	2.86 (1.07)	1-5

Table 1 (continued)				
Continuous Variables	<i>Males Mean, SD</i>	<i>Females Mean, SD</i>	<i>Total Mean, SD</i>	Range
Self-efficacy for exercise	18.1 (6.11)	18.37 (5.68)	18.27 (5.84)	6-30
Enjoyment of walking	2.56 (1.04)	3.11 (.97)	2.9 (1.03)	0-4
Moderate PA / minutes per week	217.5 (475.63)	113.30 (183.65)	152.69 (329.6)	0-2475
Vigorous PA / minutes per week	66.46 (198.93)	47.97 (150.16)	54.96 (170.22)	0-1800
Strength training minutes per week	6.83 (25.13)	5.93 (22.64)	6.27 (23.58)	0-240
Flexibility training minutes per week	7.94 (25.85)	9.44 (28.05)	8.87 (27.87)	0-180

*non-White: 31% (n=121) Black, 2.5% (n=10) other (American Indian, n=6; Asian, n=1; “Other”, n=3)

Table 2: Pearson Correlation with “Control” and “Intolerance” measures of Weight Concern

Variables	n	Control		Intolerance	
		R	P	R	P
<i>Sociodemographic / body composition variables</i>					
Age	392	-.047	.35	.01	.81
Sex (male vs female)	392	-.31	<.0001	-.27	<.0001
Race (non-White vs White)	392	-.10	.04	-.23	<.0001
Married / Partnered	392	-.002	.96	.04	.43
Employed	392	-.02	.70	-.07	.15
BMI	391	.23	<.0001	.19	<.0001
<i>General psychosocial variables</i>					
Perceived stress	384	.13	.01	.05	.31
Total social support	386	-.01	.79	.009	.86
Depressive symptoms (CES-D)	377	.13	.01	-.01	.79
Profile of Moods States: Tension	386	.08	.14	.03	.49
Profile of Moods States: Depression	385	.07	.19	.007	.89
Profile of Moods States: Anger	385	.07	.18	.07	.18
Profile of Moods States: Fatigue	384	.08	.12	.08	.12
Profile of Moods States: Confusion	386	.14	.01	-.05	.33
Profile of Mood States: Vigor	387	-.09	.08	-.04	.42
<i>Smoking related variables</i>					
Total years smoking	390	-.01	.85	.03	.52
Number of prior quit attempts	390	-.08	.13	.03	.52
Number of cigarettes per day	392	-.06	.25	-.04	.44
Fagerström Test got Nicotine Dependence	384	-.003	.96	-.02	.67

Table 2 (continued)

Variables	n	Control		Tolerance	
		R	P	R	P
Nicotine withdrawal symptoms	387	.17	.001	.08	.13
Temptation to smoke in negative affect/social situations	392	.14	.01	.12	.02
Temptation to smoke in positive affect/social situations	388	.08	.10	.06	.25
Temptation to smoke habit	388	.093	.11	.01	.84
Motivation to quit smoking	392	-.12	.02	-.10	.05
Confidence in quitting smoking	389	-.13	.01	-.15	.003
Decisional balance to quit smoking	386	.04	.41	.06	.26
Social support (positive) to quit smoking	368	.04	.42	.05	.33
Social support (negative) to quit smoking	369	-.03	.53	-.12	.02
<i>Dietary variables</i>					
Saturated fat intake	381	.04	.45	.11	.03
Alcohol use	306	-.02	.67	.01	.86
<i>Physical Activity (PA) Variables</i>					
Environmental barriers to PA	392	.11	.03	.02	.70
Personal barriers to PA	392	.09	.07	.10	.06
Perceived barriers to exercise	386	.25	<.0001	.18	.0003
Enjoyment of PA	391	-.04	.44	-.12	.02
Enjoyment of organized PA	382	-.003	.95	-.10	.04
Enjoyment of unorganized PA	390	.08	.10	.009	.86
Self-efficacy for exercise	392	-.04	.39	-.004	.93
Enjoyment of walking	392	.13	.01	.08	.12
Moderate PA / minutes per week	381	-.14	.01	-.12	.02
Vigorous PA/ minutes per week	381	-.12	.02	-.03	.61
Strength training minutes per week	381	.07	.15	.002	.97
Flexibility training minutes per week	381	-.002	.96	.04	.44

* $p \leq .10$ considered significant and added to regression models

Table 3: Linear Regression – Predictors of Weight Concern (Control)

Variables	B (standardized)	SE	P
<i>Sociodemographic /body composition</i>			
Sex (male=1/female=0)	-.52	.10	<.0001
Race (non-White=1 White=0)	-.12	.05	.02
BMI	.21	.05	<.0001
<i>General psychosocial variables</i>			

Table 3 (continued)

Variables	<i>B</i> (standardized)	<i>SE</i>	<i>P</i>
Perceived stress	-.02	.07	.83
Depressive symptoms (CES-D)	.02	.08	.82
<i>Profile of mood states</i>			
Confusion	.09	.08	.30
Vigor	.08	.06	.23
<i>Smoking related variables</i>			
Nicotine withdrawal symptoms	.05	.08	.54
Temptation to smoke in negative affect situations	.05	.05	.35
Temptation to smoke in positive affect/social situations	.02	.05	.74
Motivation to quit smoking	-.14	.05	.006
Confidence to stay quit	-.03	.05	.62
<i>Physical activity (PA) related variables</i>			
Personal barriers to PA	-.07	.06	.23
Environmental barriers to exercise	-.02	.06	.71
Perceived barriers to exercise	.11	.06	.07
Enjoyment of unorganized PA	.06	.05	.28
Enjoyment of walking	.03	.05	.58
Total weekly moderate PA	-.10	.05	.03
Total weekly vigorous PA	-.07	.05	.11

Table 4: Logistic Regression – Predictors of Weight Concern (Intolerance)

Variables	<i>Odds Ratio</i>	<i>95% CI</i>	<i>P</i>
<i>Sociodemographic / body composition</i>			
Sex (male =1 vs female = 0)	.29	.17 - .49	<.0001
Race (nonwhite = 1 vs white = 0)	.39	.23 - .66	.0004
BMI	1.24	.93 - 1.64	.14
<i>Smoking related variables</i>			
Temptation to smoke in negative affect situations	1.19	.93 - 1.53	.16
Motivation to quit smoking	.77	.59 - 1.00	.05
Confidence to stay quit	.91	.70 - 1.19	.50
Negative social support for quitting smoking	.91	.71 - 1.18	.48
<i>Physical activity related variables</i>			
Perceived barriers to exercise	1.28	.95 - 1.73	.11
Personal barriers to exercise	.89	.67 - 1.18	.42
Enjoyment of PA	.92	.71 - 1.19	.52
Enjoyment of organized PA	.95	.73 - 1.24	.71
Total weekly moderate PA	.79	.59 - 1.06	.11
<i>Diet and Alcohol Variables</i>			
Saturated fat intake	1.20	.94 - 1.52	.14
BMI*SEX (Male=1/female=0)	2.54	1.42 - 4.56	.002

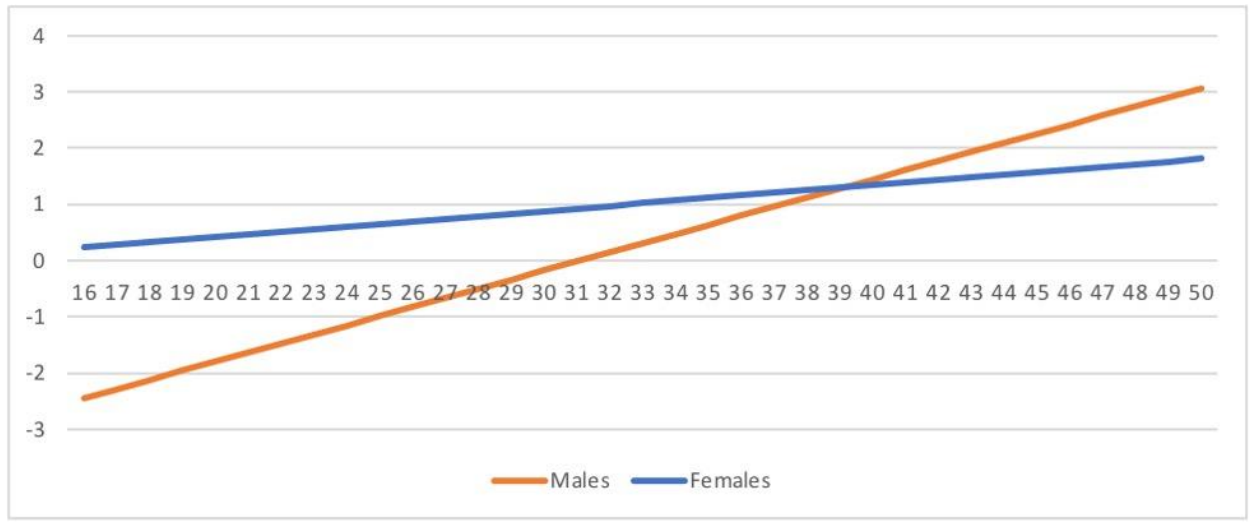


Figure 1: Weight Concerned – “Intolerance” BMI * Sex Interaction
 X axis: Log odds Y axis: BMI

CHAPTER III

Weight concerns as a predictor of weight gain in smokers participating in a community-based cessation program

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Abstract

Background: Concern about weight gain is a barrier to smoking cessation, but it is unclear if weight concerns are predictive of weight gain in the context of community-based cessation programs.

Methods: Using linear mixed modeling, data from baseline and three follow up periods were analyzed from a cessation trial of 392 adults, randomized to physical activity (PA) or general wellness counseling as adjunctive treatment for cigarette smoking. The dependent variable was weight gain over the three follow up time periods calculated as current weight minus baseline weight. Independent variables included two measures of weight concern 1) Use of smoking to control weight (“control”) and 2) Willingness to tolerate weight gain without returning to smoking (“intolerance”), using validated instruments. The intolerance measure was operationalized and analyzed as a dichotomous, continuous, and categorical variable to assess predictive utility for weight gain. Covariables included BMI, nicotine dependence, age, smoking status, and time. As no sex difference in weight gain was found, the sample was stratified by sex with variables entered into a linear mixed repeated measures model to identify if weight concerns were predictive of weight gain. Covariables were modeled as effect modifiers with weight concern and removed if insignificant.

Results: Weight concern for the “control” measure significantly predicted weight gain among males ($B=1.24$; $p=0.05$). There was also an interaction between this measure of weight concern and nicotine dependence with males with higher levels of weight concern but lower levels of nicotine dependence gaining more weight. No other measure of weight concern was a significant predictor of weight gain among males or females. Variables that consistently predicted weight

gain in most models included race (white for males, non-white for females), greater nicotine dependence, and greater abstinence from smoking.

Conclusions: Within this community sample of smokers attempting to quit, with the exception of males with lower nicotine dependence, weight concerns are not predictive of weight gain during a cessation attempt, and therefore, likely do not need to be specifically addressed during a cessation intervention for most individuals. However, for males, high levels of concern about weight related to behaviors to control weight may put one at risk for weight gain. Incorporating strategies for weight management as part of the cessation intervention may be beneficial to this subset of the population.

Introduction

Weight gain is common after quitting smoking and thus, concern about gaining weight is common among smokers (Aubin et al., 2012; Germeroth and Levine, 2018; Klesges & Klesges, 1998; Pankova et al., 2017; Weekley et al., 1992). Weight concern has been identified in previous studies as a barrier to cessation (Clark et al., 2006; Meyers et al., 1997; Schauer et al., 2013; Weekley et al.; 1992) and a cause for relapse (Jefferey et al., 2000; Pisinger & Jorgeson, 2007). Understanding the association between weight concerns and weight gain is important for at least two reasons. First, given the adverse health consequences of post-cessation weight gain (Chinn et al., 2005; Janzon et al., 2004; Yeh et al., 2010) a positive association between concerns and weight gain would suggest the importance of targeting weight concerned smokers to weight gain prevention efforts. Second, lack of such an association could help assuage fear that weight gain is inevitable for smokers who have weight concerns. However, there has been little attention in the literature specifically examining post-cessation weight concern as a predictor of

weight gain following cessation. Among the studies that do exist, findings have been mixed, sample characteristics have varied, and measurements have been inconsistent.

Some studies have found a positive association between post-cessation weight concern and weight gain. Borelli et al. (1998) examined the role of post-cessation weight concerns using a 6-item scale focused on general weight concerns, cessation related weight gain concerns, and weight gain expectancy in a community-based cessation program. In this study increased weight concern predicted weight gain at the end of treatment, after controlling covariables such as smoking status (7-day point prevalent, biochemically verified abstinence vs. not quit), nicotine dependence, age, and BMI. However, the follow up period was relatively short (3 months) which didn't allow for an analysis of longer-term effects of weight concerns.

In another study of post-menopausal weight concerned women, Copeland et al. (2015) found that weight gain among abstainers continued through 16 weeks post-treatment but post-cessation weight concerns predicted weight gain among smoking abstainers only at 8 weeks post-treatment and not at 16 weeks. Similar results were obtained defining smoking abstinence as either 7-week point prevalent or continuous abstinence (both biochemically verified) and controlling for nicotine dependence. Thus, the weight concerns instrument used may not be useful to predict long-term post-cessation weight gain and had some noteworthy limitations. Although individuals had to endorse one of two statements of being weight concerned to be included in the study, an additional multi-item measure of concern was administered to all study participants, which included a single question focused on concern about weight gain (9-point scale), and other items about weight loss history, highest and lowest adult weights, and ideal weight. It was not specified if all of these items combined to result in a weight concern score or if the score was based on the single 9-point item about weight concerns. Although single item

questions limit the reliability of a measure, this finding is noteworthy as the study sample was already considered “weight concerned,” minimizing the effect size.

A study of young women enrolled in a cessation program through Planned Parenthood found that weight concerns were a significant predictor of self-reported post-cessation weight gain among both quitters and continuing smokers controlling for nicotine dependence, but specific results by smoking status were not provided (Glasgow et al., 1999). In this study, weight concern was measured using the validated Smoking Situation Questionnaire (Weekley et al., 1992), which focuses on smoking behaviors to control weight. A limitation of this study was that it included only young women (mean age 24) and had a relatively short follow up period (6 months). Although previous studies have found that most weight gain usually occurs in the first three months following cessation (Aubin et al., 2012; Perkins, 1993), it may continue for protracted periods after cessation (Aubin et al., 2012; Tian et al., 2015); as such, a longer follow up period would help to assess trajectories of weight gain among weight concerned versus non-concerned individuals to determine if weight gain happens more quickly or is more extended in those that are weight concerned. This can have clinical implications, as weight gain is a common cause for relapse (Pisinger & Jorgeson, 2007).

While most studies have been conducted among white smokers, a study of 342 male and female treatment-seeking Black smokers found that weight concerns moderated the effect of cessation on weight gain (Tan et al., 2018). Among those with weight concerns (dichotomized, based on a single item question: “if you stopped smoking cigarettes today, how concerned would you be that you might start smoking again because of any weight gain?”) the rate of weight gain was highest among weight concerned smokers who had greater periods of abstinence (biochemically confirmed) over a 12-month period. However, weight concerns were measured

using a single item question, which limits reliability. Also, the sample was limited to Black smokers, so comparisons by racial group were not possible. Thus, several studies consistently show that weight concerns are related to weight gain among white smokers, but there are little data on Black smokers.

Results contradicting the positive association between weight concerns and weight gain during a cessation attempt were found in two other studies. One study comparing the timing of interventions for smoking and weight control among 315 women in a cessation attempt found that individual differences in baseline weight concern, measured by the Smoking Situations Questionnaire (Weekley et al., 1992), were not predictive of weight change at the end of treatment or through 9-month follow up (Spring et al., 2004). While this study controlled for smoking status (biochemically verified, 7-day point prevalence), nicotine dependence, and baseline weight, limitations are that this sample only examined female smokers, and recruitment materials emphasized quitting smoking and minimizing weight gain. This may have resulted in a study sample that was relatively weight concerned at baseline, reducing the range of scores and making an effect more difficult to detect.

Another study of 2,388 men and women using telephone quit lines found that weight concern, measured with a single-item instrument, was positively associated with baseline weight but did not predict weight gain during the cessation attempt (Tan et al., 2020). While quit status was controlled for in the analysis, limitations of this study include that it relied on self-report for weight and quit status (24-hour point prevalence), was limited to a 6-month follow up period and used a crude (single item) measure of weight concerns. In addition, while obesity was controlled for, it was not clear if nicotine dependence was controlled for, which is important as greater

nicotine dependence has been linked to more weight post-cessation weight gain (Williamson et al., 1991).

In light of these inconsistencies, additional longitudinal analyses on the relationship between weight concerns and weight gain during a cessation attempt are needed. Because discrepant findings could be due to variations in the way post-cessation weight concerns are defined and measured (French & Jeffery, 1995; Germeroth & Levine, 2018), this analysis uses two multi-item, validated measures of post-cessation weight concern previously used in the literature. In addition, tobacco abstinence is biochemically verified and controlled for along with baseline BMI and smoking status in this analysis. This is important as magnitude of weight gain is related to how cessation is defined with greater weight gain observed for more stringent definitions of abstinence (e.g., continuous vs. point prevalent; verified biochemically vs. self-report only; length of follow up period; Klesges et al., 1997). The proposed study also uses a community based representative sample with White and non-White (primarily Black) treatment seeking smokers including both males and females, as some evidence suggests that weight gain predicts relapse in men rather than women (Borelli et al., 2001). Finally, the proposed analysis includes 12-month follow up period to determine differences in weight gain by time in weight concerned versus non-weight concerned individuals.

Methods

Data set

This is a secondary analysis of data collected for the Lifestyle Enhancement Program (LEAP) smoking cessation and physical activity randomized controlled trial (Vander Weg et al., 2017). Four waves of data collected between June 2004 and May 2007 were used. The dataset includes 392 participants, all meeting inclusion criteria of smoking for at least one year, smoking five cigarettes per day, leading a mainly sedentary lifestyle, and wanting to quit smoking.

Participants agreed to receive combined behavioral/pharmacologic treatment for smoking cessation along with random assignment to either physical activity or wellness counseling as adjunctive treatment. Participants were between 18-65 years of age, 62% female and 33% non-White.

Measures

Dependent Variable

Weight Change. The dependent variable of interest for this analysis is weight change in kilograms, collected over three time periods after baseline during the cessation intervention (7-weeks, 6-months and 12-months post quit-date). This will be calculated by subtracting the baseline weight from the weight at each follow up period.

Independent Variables

Control: Smoking to Control Weight. The first measure of weight concern was assessed using the Smoking Situations Questionnaire (SSQ; Weekley et al., 1992). This instrument consists of 6 items administered at baseline assessing reasons why respondents may smoke for weight control reasons. Each item has a 6-point scale from strongly disagree (0), disagree (1) slightly disagree (2) slightly agree (3) agree (4) strongly agree (5). The mean of the responses results in the “control” score. The range of scores is from 0-5. Psychometric evaluation of the SSQ in this study showed that the items load on one factor (unidimensional), and it has good internal consistency (Cronbach alpha = .76) and test-retest reliability ($r=.95$, $p < .001$). It also showed evidence of predictive validity for smoking status (Weekley et al., 1992). In the LEAP dataset, internal consistency was adequate (Cronbach alpha= 0.87).

It consists of the following items:

1. I continue to smoke so that I don't gain weight.

2. I started to smoke to control my weight.
3. If I stop smoking, I will gain weight.
4. I often smoke to kill my appetite when I get hungry.
5. I smoke at the end of a meal so I won't eat too much.
6. I smoke instead of snacking when I am bored.

Intolerance: Intolerance to amount of weight gain before relapse. The Weight Concerns Scale (WCS) was modeled after Bandura's assessment of self-efficacy (Bandura & Adams, 1977) and measures if a respondent perceives they will return to smoking at incremental amounts of post-cessation weight gain (Meyers et al., 1997). This scale was modified from the original 2-pound, 10 question scale used in previous studies (Clark et al., 2006; Landrau-Cribbs et al., 2015) to a 5-pound increment, six question scale. For each of six post-cessation weight gain ranges, from 1-5 lbs to 26-30 lbs, participants indicated the likelihood that they would start smoking again, on a 4-point scale: somewhat unlikely (0), unlikely (1), likely (2) very likely (3). This scale was validated to predict smoking cessation in prior research in that participants categorized as weight concerned were less likely to be quit after a smoking intervention at 1-, 6- and 12-month follow-up periods (Meyers et al., 1997).

It consists of the following items:

1. If, after quitting smoking, you gained 26-30 pounds, how likely are you to start smoking again?
2. If, after quitting smoking, you gained 21-25 pounds, how likely are you to start smoking again?
3. If, after quitting smoking, you gained 16-20 pounds, how likely are you to start smoking again?

4. If, after quitting smoking, you gained 11-15 pounds, how likely are you to start smoking again?
5. If, after quitting smoking, you gained 6-10 pounds, how likely are you to start smoking again?
6. If, after quitting smoking, you gained 1-5 pounds, how likely are you to start smoking again?

For this analysis, the WCS measure was operationalized in three ways. First, it was assessed as a dichotomous variable consistent with previous work (Clark et al., 2006; Landrau-Cribbs et al. 2015; Meyers et al., 1997). Participants were classified as weight concerned if he or she reported being either “somewhat” or “very” likely to return to smoking at any level of weight gain. Second, it was assessed as a multilevel categorical variable as follows:

Level 0: respondents answer “very” or “somewhat” unlikely to start smoking again to all questions;

Level 1: Respondents answer very or somewhat likely beginning with questions 1 and 2;

Level 2: Respondents answer very or somewhat likely beginning with question 3 and 4;

Level 3: Respondents answer very or somewhat likely beginning with question 5 and 6;

Third, it was assessed as a quantitative sum score by quantifying the response options 0-3 with very unlikely as 0 and very likely as 3. Then a sum of questions 1-6 were calculated for a total score ranging from 0-18.

Since most previous studies have scored the WCS as a dichotomous variable (Clark et al., 2006; Landrua-Cribbs et al. 2015; Pankova et al., 2017), this expanded approach of using dichotomous, multi-level categorical, and continuous scoring was used to determine if more sensitive scoring of the questionnaire results in more useful information.

Other Variables

Smoking Status. Smoking status was measured at each follow up period using 7-day point prevalent, based on a self-report of not having smoked, not even a puff, in the last 7-days, verified with a CO of <10. Quitting smoking often results in weight gain (Aubin et al., 2012), therefore quit status was included as a covariable as to not conflate the weight concern/weight gain association in this analysis. It was also examined as a potential effect modifier.

Nicotine Dependence. Because of its association with weight concern (Glasgow et al., 1999; Jeffery et al., 2000) and its inclusion as a covariable in previous studies (Borelli et al., 1998) nicotine dependence was included in the analysis as a covariable and effect modifier. Nicotine Dependence was measured by the Fagerstrom Test of Nicotine Dependence (FTND) (Heatherton et al., 1991). The FTND is a commonly used scale consisting of 6 items that assess subjective nicotine dependence. Scores range from zero to 10 with higher scores indicating greater dependence. The FTND predicts smoking abstinence and correlates with biochemical measures of tobacco use (Kozlowski et al., 1994). In psychometric evaluation, it is considered highly reliable with acceptable internal consistency (Cronbach alpha .64) and test-retest reliability with no significant difference between first and second administration. It also strongly correlates to cotinine levels (0.39, $p < .05$) and years smoked (0.52, $p < .001$) (Pomerleau et al., 1994). In the LEAP dataset, internal consistency was adequate (Cronbach alpha = .63)

Demographic / Body composition. Because studies have found significant differences in post-cessation weight gain among White and Black smokers (Tan et al., 2020; Williamson et al., 1991), race was included as a covariable and effect modifier. Also, as females tend to be more weight concerned than males (Landrau-Cribbs et al., 2015; Perkins et al., 2001; Rosenthal et al., 2013; Tuovinen et al., 2015) sex was included as an initial covariable and then the sample was

stratified by sex for further analysis. Finally, consistent with previous studies, (Borelli et al., 1998) baseline age and body mass index (BMI) were included as covariables. Baseline weight was not included as a covariable to avoid collinearity, as baseline weight is a component of the BMI calculation. BMI is a more sensitive measure of overweight and obesity than baseline weight.

All covariables were formally tested for confounding by running models to measure the association between the dependent and independent variables both with and without the potential confounder. A 10% change in the estimated measure of association indicated confounding (Greenland et al., 1989).

Analytic Approach

A factor analysis on the SSQ in the current study was performed generating a single factor, consistent with other studies (Weekley et al., 1992). Internal consistency was assessed by calculating the Cronbach alpha which was considered adequate ($\alpha = 0.87$). The SSQ scores were normally distributed.

A linear mixed method repeated measures analysis, using PROC MIXED in SAS 9.4, was used to determine the effect of weight concern on weight change over time for participants in the smoking cessation program. The analysis examined two measures of weight concerns, “control” and “intolerance” in separate models. As previously described, the “intolerance” scale was operationalized using three different methods – as a dichotomized variable, a continuous variable, and a categorical variable. Therefore, four models were tested. To account for random effects within individuals’ repeated weight measures, Toeplitz, compound symmetry, auto regressive and unstructured covariance structures were tested with unstructured selected as the best model fit based on lowest BIC and AIC values. Data were analyzed both overall and

stratified by sex. Several effect moderators were examined to determine if the effect of weight concerns interact with other key variables related to weight gain including time, nicotine dependence, smoking quit status, race, and sex. A p-value of .05 determined significance for this analysis.

Hypotheses

It is hypothesized that, after controlling for covariables, weight concerns will predict weight gain over the course of the cessation attempt. Since the “control” weight concern variable focuses on smoking behaviors to avoid weight gain, it is hypothesized that this measure will more strongly predict weight gain during cessation compared to the “intolerance” weight concern measures, related to relapse. If people’s perceptions on the “intolerance” measure truly reflects whether they are likely to relapse if they gain weight, then when they do relapse, this would attenuate the magnitude of weight gain, thereby obscuring the weight concern/weight gain effect.

For the “control” weight concern variable, it is also hypothesized that there will be a sex by weight concern interaction with a stronger positive association between weight concern and weight gain for women. For males, there is not expected to be a significant association between weight concern and weight gain. This is supported by with the literature that females tend to be more weight concerned than males and gain more weight than males during a cessation attempt (French et al., 1995; Jeffery et al., 2000; Landrau-Cribbs et al., 2015; Williamson et al., 1991).

For both weight concern measures, it is expected that weight concerned Black smokers will gain more weight than weight concerned White smokers. This is supported by the literature that Black smokers tend to gain more weight than White smokers after cessation (Williamson et al., 1991) but findings are mixed as to whether Black smokers are more weight concerned than White smokers (Clark et al., 2006; Pomerleau et al., 2001; Sanchez et al., 2005). It is also

expected, based on previous literature, that smokers with greater weight concerns and greater nicotine dependence will gain more weight than those with less weight concerns. Finally, it is hypothesized that quit status will interact with weight concerns in that weight concerned smokers that have not quit will have less weight gain, assuming they have returned to smoking to mitigate weight gain.

Results

Descriptive Statistics

Participants ($n = 392$) were between 18-65 years of age, 62% female, 67% White, had an average BMI of 28 (standard deviation (SD) = 5.8) and an average nicotine dependence score of 4.9 (SD=2.3) on a scale of 0-10. Using the “control” weight concern measure, the average weight concern score on a scale from 0-5 was 1.8 (SD = 1.3). Using the “intolerance” dichotomized measure of weight concern, 56% of participants were considered weight concerned, indicating that they believed they were likely to relapse if some threshold of weight gain occurred. Using this same scale but analyzed categorically, 44% were in the lowest category for weight concern indicating that they are unlikely to return to smoking at any amount of weight gain, 10% were in the next level indicating that they are likely to return to smoking only after gaining 20 or more pounds, 34% were in the third level indicating that they would return to smoking after gaining 11 to 20 pounds, and 17% were in the highest level for weight concern indicating that they would return to smoking after gaining 1 to 10 pounds (Table 1). Average weight gain for all participants was 1.6 kgs (SD=2.5) at 7-weeks, 1.2 kgs (SD=4.1) at 6-months and 1.4 kgs (SD=6.2) at 12-month follow up. Mean weight gain over the three follow up points was greater in quitters than non-quitters (all p -values $>.05$). There was one extreme weight gain score of -50kgs at one year follow up among a 30-year-old woman with a baseline BMI of 50. This outlier was retained in the analysis.

All covariables were formally tested for confounding, with sex, BMI, and nicotine dependence meeting the threshold of confounding the relationship between weight concerns (control) and weight gain; sex and smoking status meeting the threshold of confounding the relationship between weight concerns (intolerance – dichotomized) and weight gain; sex and BMI meeting the threshold of confounding the relationship between weight concerns (intolerance – continuous) and weight gain; and sex, smoking status, and nicotine dependence confounding the relationship between weight concerns (intolerance – levels) and weight gain. All models included these confounders as well as age and time. After controlling for confounders and covariables initial linear regression models for all four weight concern measures did not show a significant difference between males and females with regard to weight gain, or an interaction between sex and weight concern measures on weight gain. However, females in this sample of smokers have a significantly higher weight concern (control) score ($p < .0001$) and weight concern (intolerance – dichotomized) score ($p < .0001$) than males. Therefore, the sample was stratified by males and females with regression models run separately to examine potential effect moderators of weight concerns on weight gain within each strata.

Predictors of weight gain for females

When modeling the effect of weight concern on weight gain among female smokers, not one of the four measures of weight concerns (control, intolerance – dichotomized, intolerance – continuous, or intolerance – levels) was significant in predicting weight gain, opposite to the expected results. However, other covariables emerged as significant predictors of weight gain in females. In the control and intolerance – continuous models, non-White females gained significantly more weight than White ($B = .83, p = .04$ and $B = .87, p = .03$ respectively). This relationship was nearly significant when modeling the other two measures of weight concerns

(intolerance – dichotomized ($B = .74$, $p=.06$) and intolerance – levels ($B=.74$, $p=.07$). This was also modeled with Black only women (ten “others” removed) with little change in results. In addition, greater abstinence from smoking, (i.e. being abstinent at more follow up visits), significantly predicted weight gain in most models (control model $B=.62$, $p=.04$; intolerance – dichotomized model $B=.64$, $p=.05$; intolerance – levels model $B=.66$, $p=.04$). Smoking status was also nearly significant in the intolerance – continuous model ($B=.60$, $p=.065$) (Tables 2-4). Nicotine dependence did not emerge as a significant predictor of weight gain when included in the weight concern control model, but it did significantly predict weight gain in the three models for intolerance (intolerance – dichotomized, $B=.22$, $p=.01$; intolerance – continuous, $B=.23$, $p=.01$ and intolerance – levels, $B=.22$, $p=.01$). Age, BMI, and time did not significantly predict weight gain in females in any of the four models tested.

Predictors of weight gain for males

The weight concern control measure was a significant predictor of weight gain in males ($B=1.24$, $p=.05$) and the model showed a significant interaction between nicotine dependence and weight concern control ($B= -.28$, $p=.02$). When examining the main effect of nicotine dependence, it too is nearly significant ($B= .38$, $p=.056$). At higher levels of both nicotine dependence and weight concerns, “control” males gained more weight. A decomposition of this interaction (Figure 1) shows that when weight concern “control” scores are high, weight gain is higher in participants with low nicotine dependence. When weight concern “control” increases, weight gain decreases in the higher nicotine dependence group. What this indicates is that when both nicotine dependence and weight concern “control” scores are high, there is a dampening effect. Weight still increases but the growth is decelerating. Therefore, nicotine dependence may

moderate the effect of weight concerns on weight gain. The “intolerance” measures of weight concerns were not significant predictors of weight gain among males.

Similar to the female models, other covariables consistently predicted weight gain. Race was a significant predictor of weight gain in males in three of the four models and nearly significant in the fourth model. However, this relationship is in the opposite direction of the female model with White males gaining significantly more weight than non-White males (control model, $B=1.02$, $p=.05$; intolerance – dichotomized model, $B=1.1$, $p=.04$; intolerance – continuous model $B=1.0$, $p=.066$; and intolerance – levels model $B= 1.1$, $p=.05$). This was also modeled with all Black males (ten “others” removed) with little change in results. Consistent with females, greater abstinence from smoking predicted weight gain in males in all four models (control, $B = 1.54$, $p=.0002$; intolerance – dichotomized, $B= 1.6$, $p=.0001$; intolerance – continuous, $B= 1.56$, $p=.0002$; and intolerance – levels, $B= 1.62$, $p=.0001$). Lastly, nicotine dependence nearly emerged as a significant predictor of weight gain in just the control model for males ($B= .38$, $p=.056$) but not in the weight concern intolerance models. Age, BMI, and time were not significant predictors of weight gain in these smokers.

Discussion

This study adds to the literature by examining whether two measures of weight concern predict weight gain over the course of a cessation attempt among a community sample of smokers. In addition, the weight concern measure related to intolerance to weight gain was operationalized three different ways to determine if one method was more sensitive than others in predicting weight gain. The findings did not support the hypothesis, in that none of the four measures of weight concerns predicted weight gain in females and only one predicted weight gain in males. This contradicts previous studies that found a predictive relationship between

weight concerns and weight gain during a cessation attempt in a mixed population of men and women (Borelli et al., 1998) and populations of women only (Copeland et al., 2015, Glasgow et al., 2019) but supports other research finding no predictive relationship (Spring et al., 2004; Tan et al., 2021; Weekley, et al, 1992). However, one measure of weight concerns in this analysis, “control”, did predict weight gain in males but not females. This was the opposite to what was hypothesized, as females in this sample had significantly greater weight concerns than males in both “intolerance” and “control” measures. This might indicate that while weight concerns are more pervasive among females, as widely documented in previous studies (French et al., 1995; Jeffery et al., 2000; Landrau-Cribbs et al., 2015; Perkins et al., 2001; Pomerleau & Kurth, 1996; Rosenthal et al., 2013; Tuovinen et al., 2015), weight concerned females might be more conscious about maintaining weight compared to males and therefore weight concerns did not significantly impact weight gain in this sample. There was an interaction in males between weight concerns “control” and nicotine dependence in that at higher levels of weight concern, weight gain was higher among those with lower nicotine dependence. At high levels of weight concern, and high levels of nicotine dependence, weight gain was lower. The combination of these two factors at a high level has a dampening effect on weight gain. A possible explanation is that since nicotine dependence is associated with greater smoking (i.e., nicotine intake) this serves to control weight, so in combination with engaging in weight “control” behaviors, the net effect may be to attenuate weight gain. The measures of weight concern related to intolerance of weight gain were not significantly associated with weight gain in this population of smokers.

Several other variables did significantly predict weight gain in males and in females in this analysis. Race was a consistent significant or nearly significant predictor in all models, however in opposite directions in males and females. Consistent with other studies (Kleges et al.,

1998; Swan & Carmelli, 1995; Williamson et al., 1991), among females, being non-White, and predominately Black in this sample, significantly predicted weight gain. However, in this analysis the opposite was true among males in that being White compared to non-White significantly predicted weight gain. This is inconsistent with most literature on race and weight concerns. Given the limited literature on weight concerns among Black men, this finding warrants further examination. Consistent with the literature, greater abstinence from smoking also significantly or nearly significantly predicted weight gain in all models for both males and females which is expected (Aubin et al., 2012; Veldheer et al., 2015). Finally, nicotine dependence was a predictor of weight gain for males and females in some but not all models. This is consistent with the literature linking nicotine dependence with greater post-cessation weight gain (Killi et al., 2019; Komiyama et al., 2013; Williamson et al., 1991).

Implications of these findings are that, except for males with lower nicotine dependence, weight concerns are not predictive of weight gain during a cessation attempt, and therefore, likely do not need to be specifically addressed during a cessation intervention for most individuals. However, for males, high levels of concern about weight related to behaviors to control weight may put one at risk for post-cessation weight gain. Future qualitative studies could look more specifically at this population of male smokers to determine specific needs related to weight control during cessation. Perhaps males, being less concerned about weight in general, need support for weight maintenance outside of smoking than females during a cessation attempt.

The strengths of this study include a large community-based sample of smokers who planned to quit. This study also used validated instruments for weight concerns and nicotine dependence. BMI and weight change were calculated objectively, using height and weight

measurements, not self-report. Smoking status was biochemically verified at each follow up. While the predictive ability of weight concerns on weight gain was not as expected, the other variables related to weight gain are consistent with a large body of literature and add confidence in these findings.

There are limitations to this analysis. While this is a prospective repeated measures design, the findings are limited in scope to a population of relatively healthy, sedentary smokers that are seeking cessation treatment in a community setting and are willing to participate in a physical activity program. This analysis specifically looked at two dimensions of weight concern including smoking behaviors to maintain weight and intolerance to various levels of weight gain. Other dimensions of weight concern such as dieting behavior and perceptions of being overweight were not included.

In conclusion, this study adds important information to the current literature on weight concerns and its impact on weight gain during a smoking cessation attempt, as it uses validated measures in a community-based sample of smokers. This study does not support previous studies that having greater weight concerns predict greater weight gain during cessation in females. However, among males, one measure of weight concerns did predict greater weight gain. Future studies could explore this relationship further to confirm if males that smoke to control weight require additional intervention strategies to prevent excessive weight gain during a cessation attempt. In addition, other dimensions of weight concern, such as dieting behavior and perceptions of being overweight should be examined for their impact on cessation related weight gain.

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Tables

Table 1: Sample Descriptive Statistics

Categorical Variables			N=392, 100%
	Male, n (%)	Female, n (%)	Total, n (%)
<i>Race</i>			
White	100 (67%)	161 (66%)	261 (67%)
Non-white*	49 (33%)	82 (34%)	131 (33%)
Total	149 (100%)	243 (100%)	392 (100%)
<i>Weight Concern (intolerance – dichotomized)</i>			
Weight Concerned	57 (38%)	161 (66%)	218 (56%)
Non-Weight Concerned	92 (62%)	82 (34%)	174 (44%)
Total	149 (100%)	243 (100%)	392 (100%)
<i>Weight Concern (intolerance – levels)</i>			
Level 0 (least weight concerned)	91 (61%)	80 (33%)	171 (44%)
Level 1	14 (9%)	27 (11%)	41 (10%)
Level 2	32 (21%)	80 (33%)	112 (34%)
Level 3 (most weight concerned)	12 (8%)	56 (23%)	68 (17%)
Total	149 (100%)	243 (100%)	392 (100%)
<i>Smoking Status (7-day point prevalence)</i>			
<i>Time 1 (7 weeks)</i>			
Quit	53 (54%)	63 (41%)	116 (46%)
Smoking	45 (46%)	91 (59%)	136 (54%)
Missing	51	89	140
<i>Time 2 (6 months)</i>			
Quit	32 (44%)	50 (37%)	82 (39%)
Smoking	41 (56%)	85 (63%)	126 (61%)
Missing	76	108	184

Table 1 (continued)

Categorical Variables				
Time 3 (1 year)				
Quit	34 (29%)	56 (28%)	90 (28%)	
Smoking	85 (71%)	145 (72%)	230 (72%)	
Missing	30	42	72	
Continuous Variables				
	<i>Male, mean (SD)</i>	<i>Female, mean (SD)</i>	<i>Total, mean (SD)</i>	Range
Age (years)	45.1 (10.0)	44.3 (10.1)	44.6 (10.1)	18-64
BMI	27.7 (5.1)	28.2 (6.3)	27.97 (5.8)	16-50
Weight Concern (control)	1.32 (.98)	2.05 (1.13)	1.78 (1.13)	0-6
Weight Concern (intolerance – continuous)	4.3 (4.6)	7.4 (5.2)	6.22 (5.24)	0-18
Fagerström Test for Nicotine Dependence	5.24 (2.3)	4.73 (2.3)	4.93 (2.31)	0-10
Weight gain (kgs) –				
Time 1	2.1 (2.5)	1.3 (2.4)	1.6 (2.5)	-6-10.6
Time 2	2.6 (4.01)	1.6 (4.1)	1.2 (4.1)	-13.2-15.4
Time 3	1.9 (5.4)	1.1 (6.6)	1.4 (6.2)	-50.5-24.1

*non-White: 31% (n=121) Black, 2.5% (n=10) other (American Indian, n=6; Asian, n=1; “Other”, n=3)

Table 2: Linear Mixed Model Regression – Predictors of weight gain in smokers – weight concern (control)

Variable		<i>B</i>	<i>SE</i>	<i>P</i>
weight concern (control)	Male	1.24	.63	.05
	Female	-.18	.36	.61
Race (non-White=1 White=0)	Male	-1.02	.52	.05
	Female	.83	.39	.04
BMI	Male	-.05	.05	.33
	Female	.004	.03	.86
Smoking Status, 7- day point prevalence over 3 time points	Male	1.54	.40	.0002
	Female	.62	.32	.05
Fagerström Test for nicotine dependence	Male	.38	.20	.056
	Female	.10	.15	.52
Age	Male	-.04	.02	.07
	Female	.01	.02	.53

Table 2 (continued)

Variables		<i>B</i>	<i>SE</i>	<i>P</i>
Time 6 months (compared to 7 weeks)	Male	.29	.37	.44
	Female	.12	.30	.70
Time 1 year (compared to 7 weeks)	Male	.43	.43	.32
	Female	-.16	.46	.73
Fagerström Test for nicotine dependence*weight concern (control)	Male	-.28	.11	.02
	Female	.06	.07	.34

Table 3: Linear Mixed Model Regression – Predictors of weight gain in smokers – weight concern (intolerance – dichotomized)

Variable		<i>B</i>	<i>SE</i>	<i>P</i>
weight concern (intolerance – dichotomized)	Male	-.20	.53	.71
	Female	-.33	.39	.40
Race (non-White=1 White=0)	Male	-1.1	.53	.04
	Female	.74	.40	.06
BMI	Male	-.07	.05	.20
	Female	.01	.03	.73
Smoking Status, 7- day point prevalence over 3 time points	Male	1.6	4.0	.0001
	Female	.64	.32	.05
Fagerström Test for nicotine dependence	Male	-.02	.11	.88
	Female	.22	.09	.01
Age	Male	-.04	.02	.11
	Female	.01	.02	.45
Time 6 months (compared to 7 weeks)	Male	.26	.37	.47
	Female	.11	.30	.71
Time 1 year (compared to 7 weeks)	Male	.38	.43	.39
	Female	-.16	.46	.73

Table 4: Linear Mixed Model Regression – Predictors of weight gain in smokers – weight concern (intolerance – continuous)

Variable		<i>B</i>	<i>SE</i>	<i>P</i>
weight concern (intolerance – continuous)	Male	.02	.06	.72
	Female	.001	.04	.97

Table 4 (continued)				
Variable		<i>B</i>	<i>SE</i>	<i>P</i>
Race (non-White=1 White=0)	Male	-1.00	.54	.066
	Female	.87	.40	.03
BMI	Male	-.08	.05	.14
	Female	.01	.03	.71
Smoking Status, 7- day point prevalence over 3 time points	Male	1.56	.41	.0002
	Female	.60	.32	.065
Fagerström Test for nicotine dependence	Male	-.02	.11	.84
	Female	.23	.09	.01
Age	Male	-.04	.02	.10
	Female	.01	.02	.54
Time 6 months (compared to 7 weeks)	Male	.26	.37	.49
	Female	.04	.30	.88
Time 1 year (compared to 7 weeks)	Male	.40	.44	.37
	Female	-.22	.46	.64

Table 5: Linear Mixed Model Regression – Predictors of weight gain in smokers – weight concern (intolerance – levels)

Variables		<i>B</i>	<i>SE</i>	<i>P</i>
weight concern (intolerance – levels) Level 1 compared to zero	Male	-.10	.92	.92
	Female	-.58	.69	.40
weight concern (intolerance – levels) Level 2 compared to zero	Male	-.23	.62	.71
	Female	-.14	.46	.75
weight concerned (intolerance – levels) Level 3 compared to zero	Male	-.23	.97	.81
	Female	-.15	.50	.77
Race (non-White=1 White=0)	Male	-1.1	.54	.05
	Female	.74	.40	.07
BMI	Male	-.07	.05	.21
	Female	.005	.03	.88
Smoking Status, 7- day point prevalence over 3 time points	Male	1.62	.41	.0001
	Female	.66	.32	.04

Table 5 (continued)

Variables		<i>B</i>	<i>SE</i>	<i>P</i>
Fagerström Test for nicotine dependence	Male	-.02	.11	.87
	Female	.22	.09	.01
Age	Male	-.03	.02	.13
	Female	.01	.02	.46
Time 6 months (compared to 7 weeks)	Male	.26	.37	.47
	Female	.12	.30	.69
Time 1 year (compared to 7 weeks)	Male	.38	.43	.38
	Female	-.15	.46	.74

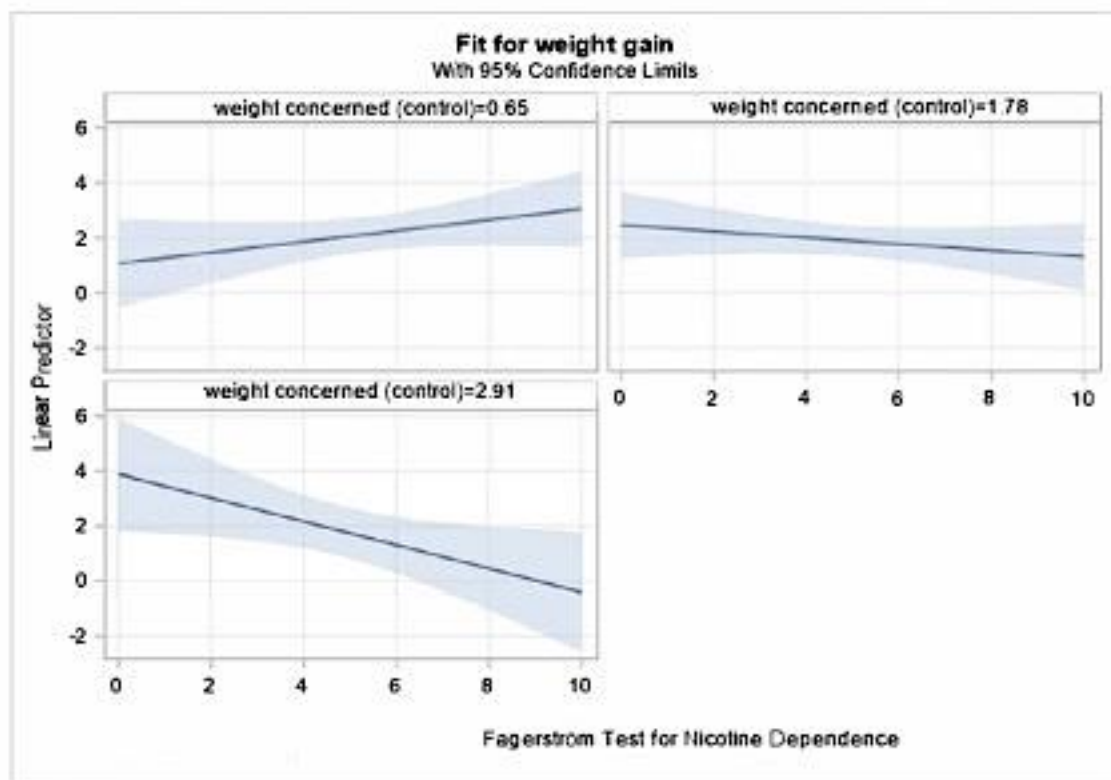


Figure 1: Interaction decomposition of nicotine dependence and weight concern (control) on weight gain.

X axis: nicotine dependence, Y axis: weight gain

CHAPTER VI

Weight concerns as a predictor for smoking cessation in smokers participating in a community-based cessation program

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Abstract

Background: Concern about weight gain is a barrier to smoking cessation, but it is unclear if weight concerns are predictive of cessation success rates in the context of community-based cessation programs.

Methods: Using logistic regression mixed modeling, data from baseline and three follow up periods were analyzed from a cessation trial of 392 adults, randomized to physical activity (PA) or general wellness counseling as adjunctive treatment for cigarette smoking. The dependent variable was smoking status (quit or smoking) measured as biochemically verified 7-day point prevalence at each follow up time period. Independent variables included two measures of weight concern: 1) Use of smoking to control weight (“control”) and 2) Willingness to tolerate weight gain without returning to smoking (“intolerance”), using validated instruments. The intolerance measure was operationalized and analyzed as a dichotomous, continuous, and categorical variable to assess predictive utility for smoking status. Covariables included body mass index (BMI), nicotine dependence, age, and time. As no sex difference in the outcome variables were found, the sample was stratified by sex so that potential effect moderators could be examined with weight concerns within each sex. Variables were entered into a logistic mixed repeated measures model to identify if weight concerns are predictive of weight gain. Covariables modeled as effect moderators with weight concern (nicotine dependence, time, and race) were removed if insignificant.

Results: Measures of weight concern did not significantly predict cessation for any measure of the construct or in either sex. Covariables that consistently predicted smoking cessation in most models included nicotine dependence, older age, and time since quit day.

Conclusions: Within this community sample of smokers attempting to quit, weight concerns are not predictive of successful cessation during a cessation attempt, and therefore, likely do not need to be specifically addressed to increase successful cessation rates. However, this analysis did not include weight concerns as a barrier to initiate a cessation attempt as the sample had volunteered for a cessation program, which may be significant consideration.

Introduction

Concern about post-cessation weight gain has been cited in multiple studies as a barrier to cessation and a predictor of cessation outcomes (Clark et al., 2006; Meyers et al., 1997; Schauer et al., 2013; Weekley et al., 1992). Weight gain has also been identified in studies as a cause for relapse (Jefferey et al., 2000; Pisinger & Jorgeson, 2007). However, results examining the impact of post-cessation weight concerns on cessation have been inconsistent, and the findings vary based on how weight concerns are measured, the cessation outcome being assessed (i.e. smoking reduction, quit attempts, short-term abstinence, long-term abstinence), sample characteristics (e.g., smokers tracked longitudinally during a quit attempt vs. cross-sectional or prospective population-based studies using self-reported smoking status), and the covariables included as confounders (Germeroth & Levine, 2018). Despite discrepancies, a predictive association between weight concerns and cessation outcomes supports the idea that interventions addressing concerns about gaining weight should positively affect quit outcomes. Therefore, clarifying if there is a predictive association in a clinical sample of smokers attempting to quit smoking remains important.

Several studies have found a significant association between weight concerns and cessation, with smokers who have greater weight concerns being less likely to successfully quit. In a cross-sectional study of 221 current and former smokers, Weekley, et al. (1992) found that

current smokers had greater weight concerns than former smokers; in addition, among current smokers, those with greater weight concerns were less likely to intend to quit smoking. The measure used in this study was the multi-item Smoking Situations Questionnaire (SSQ), which focuses on smoking behavior as a strategy to control weight. Weekley et al. (1992) controlled for several covariables including age, sex, race, and nicotine dependence but it was not prospective and did not use a clinical sample of smokers undergoing a quit attempt.

In a prospective study of 1,700 smokers in a cessation trial, Clark et al. (2006) found that being weight concerned was associated with lower short-term (12 weeks) smoking abstinence rates (7-day point prevalence, biochemically confirmed), after adjusting for age, race, nicotine dependence, and other characteristics. In this study, weight concerns were measured using the Weight Concerns Scale (WCS), modeled after Bandura's assessment of self-efficacy (Bandura & Adams, 1977), and measures if a respondent perceives they will return to smoking at incremental amounts of post-cessation weight gain (Meyers et al., 1997). A longer-term follow-up was not included and other dimensions of weight concern, such as smoking to control weight, were not assessed.

A study of 746 weight concerned female smokers entering two different cessation programs found that higher weight concern levels predicted whether participants remained in the study long enough to enter the treatment phase (Copeland et al., 2006). Although this study controlled for BMI and nicotine dependence, it used a single item 9-point question to measure weight concerns that asked participants to rate the degree to which they were concerned about weight gain following smoking cessation. However, using a sample of weight concerned individuals would reduce the range of scores and therefore, the effect size, making this finding

notable. The participants in this study were recruited from two smoking cessation clinical trials specifically for weight concerned women.

Contrary to these findings, several studies have found no association between weight concerns and short-term (6 months or less) smoking cessation outcomes. In a clinic-based cessation study of 122 participants, weight concerns did not predict cessation (7-day point prevalence, biochemically verified) at the end of treatment or 3-month follow-up after controlling for smoking rate, BMI, and sex (Borelli et al., 1998). This study measured weight concerns using a 6-item scale that focused on general weight concerns, post-cessation weight gain concerns, and weight gain expectancy. A strength of this study is that it comprised individuals in a quit attempt, however, men were relatively underrepresented, and the follow-up period was limited.

Few prospective studies that assessed longer term follow up periods (greater than 6 months) have found significant association between weight concerns and cessation. In a study of diabetic smokers using quit lines for cessation, Schauer et al. (2013) found a significant association between higher weight concerns and lower likelihood of tobacco abstinence (7-day and 30-day point prevalence) measured at 7-months post-treatment. However, in this study, the measure used for weight concerns was not specified, quit status was not biochemically verified, and it is unclear whether the results are generalizable to non-diabetics, or the vast majority of smokers interested in quitting who do not avail themselves of Quit Line services. Demographic and tobacco use characteristics, though not specified, were controlled.

In a prospective study of 580 smokers recruited from the general community to participate in a smoking cessation program, Meyers et al. (1997) found that participants who were not weight concerned, assessed with the WCS, were 56% more likely to be quit at the end

of treatment and approximately two times more likely to be quit during short-term (1-month and 6-month) and long-term (12-month) follow up periods (continuous abstinence since quit date, biochemically verified). A strength of this study is its use of the validated WCS for assessing weight concerns but as with Clark et al. (2006) it was limited to weight gain tolerated before relapse as opposed to other dimensions of weight concern such as weight gain expectancy and smoking to control weight. It also appears that sex was controlled for and tested for an interaction with weight concerns, but no other covariables were specified.

In another prospective study of 417 treatment seeking weight concerned female smokers, French et al. (1992) found that while “restrained eating”, defined as consciously controlling or restricting food intake (Savage et al., 2009), marginally predicted greater smoking abstinence at 6-months (“are you currently smoking one or more cigarettes per day?” – self-report not biochemically verified), smoking-specific weight concerns did not predict smoking cessation at 4-week or 6-month follow-ups, and were not associated with previous cessation attempts after controlling for nicotine dependence, BMI, and other covariables. However, this study only used a single-item question to measure smoking specific weight concerns, with unknown reliability and validity. Additionally, since all individuals reported weight concerns at baseline, range restriction in scores may have made an effect more difficult to detect.

Glasgow et al. (1999) examined weight concern in a prospective study of 506 young women (average age 24 years) in a Planned Parenthood smoking cessation program and found that weight concern, as measured by the Smoking Situations Questionnaire (Weekley et al., 1992), did not predict abstinence (not smoking for minimum of 30 days – biochemically verified), number of quit attempts at 6-months follow-up, or reduction in the number of

cigarettes at 6-months follow up. While this study controlled for age, nicotine dependence, and confidence to quit, it included only young female smokers, limiting generalizability.

A study of 92 post-menopausal weight concerned females who recently quit smoking found that weight concerns did not emerge as a predictor of relapse (biochemically verified 7-day point prevalence and continuous abstinence) at 2 or 4 months follow up (Copeland et al., 2015) after controlling for covariables including age, race, BMI, nicotine dependence. Although individuals had to endorse one of two statements of being weight concerned to be included in the study, an additional multi-item measure of concern about post-cessation was administered to all study participants. This measure consisted of a single question focused on concern about weight gain (9-point scale), and other items about weight loss history, highest and lowest adult weight, and ideal weight. It was not specified if all of these items were combined to create a weight concern score or if the score was based on the single 9-point item about weight concerns. Single item questions limit the reliability of a measure and using a population that is already considered “weight concerned,” increases the likelihood of Type 2 error.

Prospective studies of smokers in a cessation attempt with longer term follow up periods also found no association between weight concerns and cessation. A population-based study of nearly 5,000 adult men and women enrolled in a work-site intervention for smoking and weight loss found no association between weight concerns and smoking cessation among baseline smokers (self-report – no occasional or daily smoking reported, not biochemically verified) or relapse among baseline former smokers (no occasional and no daily smoking reported, not biochemically verified) at two years follow up after controlling for age, BMI, and number of baseline cigarettes. (French et al., 1995). In this study, males and females were analyzed separately and interactions (BMI, age) were assessed but not significant. However, weight

concerns were measured indirectly using reported history of dieting, desired weight loss, and personal weight preferences as the measure of weight concerns. Similarly, in a population-based lifestyle intervention study, Pisinger & Jorgeson (2007) examined the effect of baseline weight concerns on one-year cessation outcomes (self-report – “do you smoke?”; biochemically verified at follow up) in sample of 1,387 daily smokers in a cessation intervention. While concerns about weight gain were reported as a reason for relapse by more than a third of the sample, weight concerns at baseline did not predict smoking cessation at one-year follow up after controlling for age, sex, socio-economic status, and BMI, but not nicotine dependence. It is important to note that in this study, weight concerns were measured by a one question scale, with known validity and reliability.

Another prospective study of 315 women in a cessation attempt found that baseline weight concern, measured by the Smoking Situations Questionnaire (Weekley et al., 1992) was not predictive of smoking status (7-day point prevalence, biochemically verified) at the end of treatment or through 9-month follow up (Spring et al., 2004). This study was again limited to women, and recruitment materials emphasized quitting smoking and minimizing weight gain. This may have resulted in a study sample that was relatively weight concerned at baseline, reducing the range of scores, and making an effect more difficult to detect.

In another longitudinal population-based study of 355 adult making a quit attempt, Tuovinen et al. (2018) found that more nicotine dependent smokers had greater weight concerns, using the Borelli et al. (1998) scale. Yet among smokers with low, rather than high nicotine dependence, greater weight concerns predicted a lower likelihood of quitting (self-report using a series of smoking frequency questions, not biochemically verified) and smoking reduction at 7-years follow up, controlling for covariables such as sex, age, motivation to quit, and nicotine

dependence. This interaction highlights that exploring nicotine dependence as a potential effect modifier is important to understanding the significance of weight concerns in a community sample of smokers.

In a study of 593 smokers enrolled in a cessation program (Pankova et al., 2017), weight concerns were associated with a delay in setting a quit date but did not predict abstinence (continuous, biochemically confirmed) at 12-months post-cessation. This study used the WCS instrument to assess perceived intolerance to post-cessation weight gain before relapse (Meyer et al., 1997) to measure weight concerns and did not assess other dimensions of weight concern such as smoking to control weight gain.

A handful of studies have been conducted in special populations. Martin et al. (2016), examined barriers to cessation in a sample of 184 substance dependent patients in a smoking cessation program, found that higher weight concerns predict greater smoking frequency at 1-month but not 3-months follow up. There was no association between weight concerns and cessation (7-day point prevalence, biochemically confirmed) at either follow up. This study used a three-question scale as part of a larger scale (Barrier to Quitting Smoking in Substance Abuse Treatment; Asher et al., 2003) and defines weight concerns as agreeing with weight gain, hunger, and eating more as barriers to cessation. It does not appear that this study controlled for sex or nicotine dependence.

A study using the same measure of weight concern as Borelli et al. (1998) assessed 540 Black, light smokers participating in a cessation trial and found a null association between weight concerns and cessation (7-day point prevalence, biochemically verified) at 7-week and 26-week follow-up (Faseru et al., 2013), controlling for treatment. However, these findings are

limited to Black smokers that smoke no more than 10 cigarettes a day. The follow up period was also limited.

A study of 345 light and intermittent Hispanic smokers participating in a brief cessation intervention, Landrau-Cribbs et al. (2015) found no association between smoking cessation at 3-months follow up and weight concerns, using a scale focused on intolerance to levels of weight gain before relapse. Covariables included: age, weight, smoking frequency, and amount and general weight concerns. In this study, tobacco use (30-day abstinence) was self-reported, not biochemically verified.

Finally, one study found a positive association with greater cessation outcomes (7-day point prevalence, biochemically verified) among weight concerned smokers, but this study only assessed smoking abstinence at 1-month follow-up, and only in a population of light smokers (Baha & Le Faou, 2013). In addition, weight concerns were conceptualized and measured differently than previous studies using an open-ended thematic question: “What are you afraid of while trying to stop smoking?” A response of anything weight related was considered “weight concerned.” This analysis did adjust for significant baseline covariables and analyzed sex separately.

As previously discussed, these discrepancies in the literature are likely due to the various ways that weight concerns are defined and measured, key differences in the samples, inconsistencies in covariables included in models, and varying cessation related outcomes being evaluated. Therefore, examining the relationship between baseline weight concerns and abstinence from tobacco over several time points in this community-based sample of smokers will be useful in understanding if weight concern is predictive of cessation outcomes for individuals who are interested in quitting and amenable to treatment, which substantially boosts

quit rates (Fiore et al., 2008). To comprehensively and accurately assess smoking-related weight concern, this analysis will use two validated measures widely reported in the literature, and evaluate several operationalizations of weight concern defined as intolerance of post-cessation weight gain. Further, the analysis will include both men and women, and Whites and Blacks to assess important effect moderators. Lastly, we will include a longer follow up period (12 months) and will test and control for several key covariables: sex, race, age, nicotine dependence and BMI.

Methods

Data set

This will be a secondary analysis of data collected for the Lifestyle Enhancement Program (LEAP) smoking cessation and physical activity randomized controlled trial (Vander Weg et al., 2018). Baseline data plus 3 follow up waves collected between June 2004 and May 2007 were used. The dataset includes 392 participants, all meeting inclusion criteria of smoking for at least one year, smoking five cigarettes per day, leading a mainly sedentary lifestyle, and wanting to quit smoking. Participants agreed to receive combined behavioral/pharmacologic treatment for smoking cessation along with random assignment to either physical activity or wellness counseling as adjunctive treatment. Participants were between 18-65 years of age, 62% female and 67% White.

Measures

Dependent Variable

Smoking Abstinence. The dependent variable of interest for this analysis is quit status (yes or no) using 7-day point prevalence, based on a self-report of not having smoked, not even a puff, in the last 7 days, verified with an expired carbon monoxide (CO) of <10 ppm, collected

over three time periods from baseline during the cessation intervention (7-weeks, 6-months, and 12-months).

Independent Variables

Control: Smoking to Control Weight. Weight concerns was measured using the Smoking Situations Questionnaire (SSQ; Weekley et al., 1992). See description in Chapter III.

Intolerance: Intolerance to amount of weight gain before relapse. Weight concerns was measured using the Weight Concerns Scale (WCS; Meyers et al., 1997). See description in Chapter III.

Other Variables

Demographic. Since females tend to be more weight concerned than males (Landrau-Cribbs et al., 2015; Perkins et al., 2001; Rosenthal et al., 2013; Tuovinen et al., 2015) sex was included in this analysis as an initial covariable and then the sample was stratified by sex to examine potential effect moderators with weight concerns within each sex. Consistent with previous studies (Borrelli et al., 1998, Tan, 2020) baseline BMI and age were included in the model as covariables. Race was also included as a covariable and potential effect moderator.

Nicotine dependence. Because of its association with weight concern and its inclusion as a covariable in previous studies (Borrelli et al., 1998, Tan, 2020), nicotine dependence as measured by the Fagerstrom Test of Nicotine Dependence score (see description in Chapter III; (Heatherton et al., 1991), was included in the analysis as a covariable and potential effect moderator.

All covariables were formally tested for confounding by running models to measure the association between the dependent and independent variables with and without the potential confounder. A 10% change in the estimated measure of association indicated confounding.

Analytic Approach

A factor analysis on the SSQ in the current study was performed generating a single factor, consistent with other studies (Weekley et al., 1992). Internal consistency was assessed by calculating the Cronbach alpha which was considered adequate ($\alpha = 0.87$). The SSQ scores were normally distributed.

All covariables were formally tested for confounding with race, age, sex, and nicotine dependence meeting the threshold of confounding the relationship between of weight concerns (control) and smoking status; and race, time, age, BMI, nicotine dependence and sex meeting the threshold of confounding the relationship between all other measures of weight concerns (intolerance – dichotomized, intolerance – continuous, intolerance – levels) and smoking status. All models included these confounders. After controlling for confounders and covariables, initial logistic regression models, using the GEE procedure in SAS 9.4, for all four weight concern models did not show a significant difference between males and females with regard to quit status, or an interaction between sex and weight concern measures on quit status. However, females in this sample of smokers have a significantly higher weight concern (control) score ($p < .0001$) and weight concern (intolerance – dichotomized) score ($p < .0001$) than males. Therefore, the sample was stratified by males and females with regression models run separately to examine the effect of weight concerns in each strata and to examine potential effect moderators of weight concerns on quit status.

For the smoking status dependent variable, a repeated measures logistic regression analysis was used to determine the effect of weight concern on quit status over three time points. Separate analyses examined two measures of weight concerns, “control” and “intolerance.” In addition, the “intolerance” scale was operationalized in three different methods – as a

dichotomized variable, a continuous variable, and a categorical variable. Therefore, four models were tested. To account for random effects within individuals' repeated weight measures, Toeplitz, compound symmetry, auto regressive and unstructured covariance structures were tested with unstructured selected as the best model fit based on lowest BIC and AIC values. Data were analyzed both overall and stratified by sex to examine potential effect moderators with weight concerns within each sex (nicotine dependence, race, and time). Covariables of age and BMI were also included in the models. A p-value of .05 determined significance for this analysis.

Hypotheses

It was hypothesized that, after controlling for covariables, weight concern would predict cessation outcomes with lower point prevalence abstinence among weight concerned individuals over time.

Comparing the two weight concern measures, it was hypothesized that the weight concern “intolerance” measure would more strongly predict cessation. Because the weight concern “control” measure assesses behaviors related to smoking to prevent gain, it is hypothesized that a high “control” score would predict a delay in cessation attempt rather than a relapse. It was also hypothesized that there would be a sex by weight concern interaction with a strong positive association between weight concern and smoking (not quit) for females. For males, there is not expected to be a significant association between weight concern and smoking. This is supported by the literature that females tend to be more weight concerned than males (French et al., 1995; Jeffery et al., 2000; Landrau-Cribbs et al., 2015) and weight concerned smokers have poorer cessation outcomes in treatment (Clark et al., 2006; Meyers et al., 1997; Schauer et al., 2013).

Results

Descriptive Statistics

Participants ($n = 392$) were between 18-65 years of age, 62% female, 67% White, had an average BMI was 28 (standard deviation (SD) = 5.8) and an average nicotine dependence score of 4.9 (SD=2.3) on a scale of 0-10. Using the “control” weight concern measure, the average score on a scale from 0-5 was 1.8 (SD = 1.3). Using the “intolerance” dichotomized measure of weight concern, 56% of participants were considered “weight concerned,” indicating that they believed they were likely to relapse if some threshold of weight gain occurred. Using this same scale but analyzed categorically, 44% were in the lowest category for weight concern indicating that they are unlikely to return to smoking at any amount of weight gain, 10% in the next level indicating that they are likely to return to smoking only after gaining 20 or more pounds, 34% were in the third level indicating that they would return to smoking after gaining 11 to 20 pounds, and 17% were in the highest level for weight concern indicating that they would return to smoking after gaining 1 to 10 pounds (Table 1). Among participants measured at each follow up period, the biochemically verified 7-day point prevalence rate was 46% at 7 weeks, 39% at 6 months, and 28% at one year.

Predictors of quit status in females

In all four models tested, measures of weight concerns (control, intolerance – dichotomized, intolerance – continuous, intolerance – levels) did not significantly predict quitting smoking in females. However, variables that did consistently emerge as predictors for smoking status among females include nicotine dependence, age, and time. Although the effect sizes are small, in all models, greater nicotine dependence predicted significantly lower odds of being quit. Likewise, greater age predicted significant higher odds of being quit. At one year

follow up, females were significantly less likely to be quit compared to 7-week follow up in all models. In the “intolerance – levels” model, they were also significantly less likely to be quit at 6 months follow up compared to 7-weeks. Race and baseline BMI did not significantly predict quit status. (Tables 2-5).

Predictors of quit status in men

With the exception of one measure, weight concerns did not have a significant effect on quit status in men. The one significant result was in the “intolerance – levels” measure, where individuals in Level 1 (would relapse if experienced weight gain of over 20 pounds) had significantly lower odds of being quit compared to level 0 (would likely not relapse at any level of weight gain). However, this effect was not significant or in the same direction at Level 2 (would relapse if gained 11-20 pounds) or Level 3 (would relapse is gained 1-10 pounds). There was a weight concern “intolerance – levels” by time interaction in this model between participants in weight concern Level 1 and Time 3. However, this interaction was not significant in the other levels or Time 2.

Variables that consistently predicted odds of quitting in all four models include nicotine dependence and time. At both 6 months compared to 7-weeks and one year compared to 7-weeks, males had lower odds of being quit. Males with greater nicotine dependence also had lower odds of being quit in all four models. Higher age was a significant predictor of greater odds of being quit in the weight concern “control” and “intolerance – dichotomized” models. It was barely significant in the “intolerance – continuous” model ($p=.068$). Race and BMI did not significantly predict odds of quit status in any model.

Discussion

This study adds to the literature by examining two measures of weight concern as a construct and whether it can predict smoking cessation over the course of a cessation attempt among a community sample of smokers. In addition, the weight concern measure related to intolerance to weight gain was operationalized three different ways to determine if one method was more sensitive than others in predicting cessation. The findings did not support the hypothesis, in that none of the four measures of weight concerns predicted cessation in females and only one predicted cessation in males, but only among those with low weight concern compared to no weight concern. This contradicts previous studies that found a predictive relationship between greater weight concerns and lower odds of cessation (Clark et al., 2006; Meyers et al., 1997; Schauer et al., 2013; Weekley et al., 1992) but supports other research that did not find a predictive relationship between weight concerns and cessation (Borelli et al., 1998; Copeland et al., 2015; French et al., 1992; French et al., 1995; Glasgow et al., 1999; Pisinger & Jorgeson, 2007; Spring et al., 2004). The one measure that did show a significant effect of weight concerns on cessation was the intolerance measure of weight concerns where the respondents were categorized in weight concern levels from zero (not weight concerned) to 3 (very weight concerned). In this model, only the level one group in males had lower odds of cessation compared to the Level zero group. However, this was not significant for Levels 2 or 3 which one would expect if there were truly a relationship between weight concerns and cessation. One would think that at higher levels of the attribute, the effect on cessation would be greater and significant. In the absence of such a graded association it is possible that the lone significant association is spurious. In addition, in this model there was a time by weight concern interaction in that individuals in Level 1 and at follow up Time 3 (12-months) had significantly

greater odds of cessation. Again, this is likely a spurious finding as the other levels of weight concern do not show a similar pattern or significant impact on cessation. Level 1 does not represent a strong level of weight concern as individuals in this level reported that they would be likely or very likely to return to smoking after gaining 20 pounds or more. Levels 2 (return to smoking after gaining 11-20 pounds) and 3 (return to smoking after gaining 1-10 pounds) represent higher weight concerns.

Several other variables did significantly predict cessation in males and in females in this analysis. Greater nicotine dependence significantly predicted lower odds of cessation in both males and females, and in all four models. This is consistent with the literature on cessation in that those with greater nicotine dependence are less likely to successfully quit smoking (Hymowitz et al., 1997, Transdisciplinary Tobacco Use Research Center (TTURC) Tobacco Dependence et al., 2007; Ussher et al., 2016). In addition, follow up time significantly predicted cessation in that at 12-months compared to 7-weeks, both males and females has lower odds of being quit, consistent with the well-known shape of the “relapse curve” after a quit attempt (Hughes et al., 2004; Ward et al., 1997). For males, this was also significant at the 6-month follow up period. This indicates that there is significant relapse during cessation, which is consistent with the literature, but these data show that earlier relapse was more likely to occur in males and not females. A study examining sex differences in an unaided cessation attempt found that women were at greater risk of relapse than men (Ward, et al., 1997) and a systematic review looking at sex differences found that in most studies, females are less likely to quit than males and have more difficulty maintaining long term abstinence (Smith, et al, 2016). While this data did not show a sex difference in cessation when examining males and females together, the stratified model did indicate significantly lower odds of cessation among males at 6-months

compared to 7-weeks, which was not found in the female model. This indicates that females were more successful at maintaining abstinence from 7-weeks to 6-months than males. Reasons for this are unclear and may warrant further analysis. Finally, age was a significant predictor of cessation in all four female models and in two of the four male models with older age predicting greater cessation which is supported in the literature (Hymowitz et al., 1997; Kaleta et al., 2012; Monsó et al., 2001; Osler & Prescott, 1998; Yang et al., 2015).

Implications of these findings are that neither dimension of weight concerns (control or intolerance) in this population of community smokers appears to predict cessation success and therefore, weight concerns likely do not need to be specifically addressed during a cessation intervention for most individuals in a community cessation program.

The strengths of this study include a large community-based sample of smokers who planned to quit. This study also used validated instruments for weight concerns and nicotine dependence. BMI was calculated objectively using height and weight measurements. Smoking status was biochemically verified at each follow up. While the predictive ability of weight concerns on cessation was not as hypothesized, the other variables related to weight gain have been mainly consistent with a large body of literature and add confidence to these findings.

While this prospective, repeated measures design had many strengths, there were limitations. Findings are limited to a population of relatively healthy, sedentary, treatment seeking smokers in a community setting that are willing to participate in a physical activity program. It is possible that weight concerned smokers self-selected not to participate in the program. However, sociodemographic characteristics of the sample were similar to other community-based cessation trials (Borelli & Mermelstein, 1998; Levine et al., 2013; Meyers et al., 1997) and the distribution of scores for both weight control instruments indicated that the

sample was very heterogenous on this construct. Second, this analysis extends previous research by examining two dimensions of weight concern (control and intolerance) but other dimensions of weight concern such as dieting behavior and perceptions of being overweight were not included. Third, the impact of weight concerns on initiating a cessation attempt were also not included in this analysis as this population was a community sample that volunteered for a cessation program.

In conclusion, this study makes an important contribution to the current body of literature on weight concerns and smoking cessation as it uses validated measures in a community-based sample of smokers undergoing a cessation attempt. Our findings do not support the hypothesis that greater weight concerns predict cessation outcomes and therefore, likely do not need to be specifically addressed in a cessation intervention. However, weight concerns still may be an important factor for those not making a cessation attempt and contemplating cessation, which was not examined in this study. Further research using validated measures of weight concern are warranted for these populations to encourage cessation among smokers. In addition, other dimensions of weight concern, such as dieting behavior and perceptions of being overweight should be examined for their impact on contemplating cessation and cessation outcomes.

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Tables

Table 1: Sample Descriptive Statistics

Categorical Variables			<i>N=392, 100%</i>
	Male, n (%)	Female, n (%)	Total, n (%)
<i>Race</i>			
White	100 (67%)	161 (66%)	261 (67%)
Non-white*	49 (33%)	82 (34%)	131 (33%)
Total	149 (100%)	243 (100%)	392 (100%)
<i>Weight Concern (intolerance – dichotomized)</i>			
Weight Concerned	57 (38%)	161 (66%)	218 (56%)
Non-Weight Concerned	92 (62%)	82 (34%)	174 (44%)
Total	149 (100%)	243 (100%)	392 (100%)

Table 1 (continued)

Categorical Variables	Male, n (%)	Female, n (%)	Total, n (%)	
Weight Concern (intolerance – levels)				
Level 0 (least weight concerned)	91 (61%)	80 (33%)	171 (44%)	
Level 1	14 (9%)	27 (11%)	41 (10%)	
Level 2	32 (21%)	80 (33%)	112 (34%)	
Level 3 (most weight concerned)	12 (8%)	56 (23%)	68 (17%)	
Total	149 (100%)	243 (100%)	392 (100%)	
Smoking Status 7-day point				
<i>Time 1 (7 weeks)</i>				
Quit	53 (54%)	63 (41%)	116 (46%)	
Smoking	45 (46%)	90 (59%)	136 (54%)	
Missing	51	89	140	
<i>Time 2 (6 months)</i>				
Quit	32 (44%)	50 (37%)	82 (39%)	
Smoking	41 (56%)	85 (63%)	126 (61%)	
Missing	76	108	184	
<i>Time 3 (1 year)</i>				
Quit	34 (29%)	56 (28%)	90 (28%)	
Smoking	85 (71%)	145 (72%)	230 (72%)	
Missing	30	42	72	
Continuous Variables				
	<i>Male, mean (SD)</i>	<i>Female, mean (SD)</i>	<i>Total, mean (SD)</i>	<i>Range</i>
Age (years)	45.1 (10.0)	44.3 (10.1)	44.6 (10.1)	18-64
BMI	27.7 (5.1)	28.2 (6.3)	27.97 (5.8)	16-50
Weight Concern (control)	1.32 (.98)	2.05 (1.13)	1.78 (1.13)	0-6
Weight Concern (intolerance – continuous)	4.3 (4.6)	7.4 (5.2)	6.22 (5.24)	0-18
Fagerström Test for Nicotine Dependence	5.24 (2.3)	4.73 (2.3)	4.93 (2.31)	0-10

*non-White: 31% (n=121) Black, 2.5% (n=10) other (American Indian, n=6; Asian, n=1; “Other”, n=3)

Table 2: Logistic Mixed Model Regression – Predictors of cessation – weight concern (control)

Variables		Odds Ratio	95% CI	P
Weight concern (control)	Male	.98	.92-1.06	.67
	Female	1.03	.99-1.08	.18

Table 2 (continued)

Variables		Odds Ratio	95% CI	P
Race (non-White=1 White=0)	Male	.91	.78-1.06	.23
	Female	1.08	.96-1.22	.21
BMI	Male	1.00	.99-1.02	.84
	Female	1.01	.996-1.02	.29
Fagerström Test for nicotine dependence	Male	.96	.93-.99	.01
	Female	.97	.95-.996	.02
Age	Male	1.01	1.00-1.01	.05
	Female	1.01	1.00-1.01	.01
Time 6 months (compared to 7 weeks)	Male	.85	.77-.94	.002
	Female	.96	.90-1.03	.29
Time 1 year (compared to 7 weeks)	Male	.82	.75-.89	<.0001
	Female	.91	.85-.99	.02

Table 3: Logistic Mixed Model Regression – Predictors of cessation in smokers – weight concern (intolerance – dichotomized)

Variables		Odds Ratio	95% CI	P
Weight concern (intolerance – dichotomized)	Male	1.004	.85-1.18	.97
	Female	.998	.89-1.12	.97
Race (non-White=1 White=0)	Male	.91	.78-1.07	.26
	Female	1.07	.95-1.21	.28
BMI	Male	1.00	.99-1.02	.96
	Female	1.01	.997-1.02	.18
Fagerström Test for nicotine dependence	Male	.96	.93-.99	.01
	Female	.97	.95-.997	.03
Age	Male	1.01	1.00-1.01	.05
	Female	1.01	1.002-1.01	.01
Time 6 months (compared to 7 weeks)	Male	.85	.77-.94	.002
	Female	.96	.89-1.03	.28
Time 1 year (compared to 7 weeks)	Male	.81	.75-.89	<.0001
	Female	.91	.85-.99	.02

Table 4: Logistic Mixed Model Regression – Predictors of cessation in smokers – weight concern (intolerance – continuous)

Variables		Odds Ratio	95% CI	P
weight concern (intolerance – continuous)	Male	1.01	.99-1.03	.31
	Female	1.002	.99-1.01	.68
Race (non-White=1 White=0)	Male	.94	.8-1.1	.45
	Female	1.09	.96-1.23	.18
BMI	Male	.998	.98-1.11	.78
	Female	1.01	.997-1.02	.20
Fagerström Test for nicotine dependence	Male	.96	.93-.99	.01
	Female	.97	.95-.998	.03
Age	Male	1.01	1.00-1.01	.068
	Female	1.01	1.01-1.01	.017
Time 6 months (compared to 7 weeks)	Male	.86	.78-.95	.003
	Female	.96	.89-1.03	.28
Time 1 year (compared to 7 weeks)	Male	.82	.75-.99	<.0001
	Female	.92	.85-.99	.03

Table 5: Logistic Mixed Model Regression – Predictors of cessation in smokers – weight concern (intolerance – levels)

Variable		Odds Ratio	95% CI	P
weight concern (intolerance – levels) Level 1 compared to zero	Male	.72	.58-.88	.002
	Female	.99	.73-1.36	.97
weight concern (intolerance – levels) Level 2 compared to zero	Male	1.11	.89-1.39	.35
	Female	.93	.78-1.11	.40
weight concern (intolerance – levels) Level 3 compared to zero	Male	1.04	.70-1.55	.86
	Female	.93	.76-1.14	.47
Race (non-White=1 White=0)	Male	.92	.78-1.08	.30
	Female	1.09	.96-1.24	.18
BMI	Male	1.003	.989-1.02	.72
	Female	1.01	.997-1.02	.15
Fagerström Test for nicotine dependence	Male	.96	.94-.99	.01
	Female	.98	.95-1.00	.05

Table 5 (continued)

Variables		Odds Ratio	95% CI	P
Age	Male	1.004	.998-1.01	.21
	Female	1.01	1.002-1.01	.01
Time 6 months (compared to 7 weeks)	Male	.85	.73-1.002	.05
	Female	.87	.78-.98	.03
Time 1 year (compared to 7 weeks)	Male	.83	.73-.95	.001
	Female	.84	.75-.95	.004
Time (2)*Weight concern (level 1)	Male	1.17	.998-1.38	.05
	Female	1.21	.87-1.67	.26
Time (2)*weight concern (level 2)	Male	1.02	.81-1.28	.88
	Female	1.13	.98-1.30	.10
Time (2) * weight concern (level 3)	Male	.99	.69-1.4	.91
	Female	1.18	.96-1.46	.12
Time (3) * weight concern (level 1)	Male	1.2	1.1-1.4	.008
	Female	1.16	.80-1.66	.44
Time (3) * weight concern (level 2)	Male	.92	.73-1.15	.46
	Female	1.15	.96-1.38	.12
Time (3) * weight concern (level 3)	Male	1.02	.73-1.4	.93
	Female	1.09	.91-1.30	.35

CHAPTER V

Conclusion and Implications for Public Health

Smoking related weight concern has historically been a complex construct to understand as it is highly prevalent among smokers, but the literature is unclear as to whether it interferes with successful cessation and/or leads to excessive weight gain during cessation. Inconsistent findings are likely due to numerous methods of measuring weight concerns and potential confounding. This study adds important information to the literature as it comprehensively examines smoking related weight concerns, both cross sectionally and longitudinally, using two validated measures of weight concern in a relatively large community-based sample of smokers undergoing a cessation attempt. It also controls for several confounders using valid and reliable instruments. Results of this study uncovered several determinants of weight concern and the predictive ability of weight concern measures on cessation outcomes and weight gain in this sample of smokers.

Using a cross sectional design, examining baseline data of 392 smokers participating in a cessation attempt, the first study found that the major determinants of weight concerns are sex (female), race (White), and motivation to quit, and are similar for both measures of weight concern: “control” and “intolerance”. While these findings are consistent with previous literature, a novel finding that warrants further examination concerns obese males. A sex interaction with BMI indicates that the odds of anticipating relapse are more pronounced in this group. Another important contribution that, to our knowledge, had not been previously examined was that, while smoking for weight control was associated with lower levels of physical activity, behavioral and psychosocial factors (e.g., attitudes towards physical activity, depression, and mood) were not found to be determinants of weight concerns.

The second study examined this data longitudinally to determine if either measure of weight concern could predict weight gain over three follow up time points (7-weeks, 6-months, 12-months) during a cessation attempt. In this analysis, the two validated measures of weight concern used in the cross-sectional study were again used. The second, “intolerance” measure was operationalized three ways (dichotomous, categorical, and continuous) to determine if more sensitive scoring of responses would better predict weight gain. Important confounders and covariables were controlled for in each model including quit status, race, time, BMI, nicotine dependence, and age. While findings did not support previous studies that greater weight concerns predict greater weight gain during cessation in females, they did reveal that among males, greater “control” scores (i.e. engaging in smoking to control weight) did predict greater weight gain. It could be conceived that males, being less concerned about weight in general, need additional support for weight maintenance during cessation. This finding warrants further investigation.

The third study examined this data longitudinally again to determine if either measure of weight concerns could predict cessation outcomes — i.e. greater tobacco abstinence over three follow up time periods (7-weeks, 6-months and 12-months). The two validated measures from the cross-sectional study were again used, and similar to the second study, the “intolerance” measure was operationalized and assessed as a dichotomous, categorical, and continuous variable. Key confounders and covariables from the literature were controlled for including race, age, time, nicotine dependence and BMI. Findings do not support the hypothesis that greater weight concerns predict cessation outcomes in this community-based sample of smokers participating in cessation program. However, this construct should be further examined in other

populations such as individuals still contemplating cessation. Weight concerns could be an important determinant of not making a cessation attempt.

These findings have important implications for public health practice. Most importantly, this study used a diverse clinical sample of smokers undergoing a quit attempt. Many previous studies used population-based samples of smokers not attempting to quit. While these data are older, more recent studies of smokers undergoing quit attempts show similar demographic characteristics (Dunsiger et al., 2021; Oncken et al., 2020; Williams et al., 2021) suggesting that determinants of weight concerns from this study, and factors that emerged as predictors of cessation and weight gain are generalizable to present day smokers. From a practical perspective, weight concerns do not seem to be very important in terms of impeding cessation or predicting excessive weight gain. Because of this, it seems that for highly weight concerned smokers, additional intervention strategies to address weight concerns will not result in greater cessation or less weight gain. The exception to this is perhaps obese males, who may be at greater risk for relapse if weight gain occurs. While weight concerns were lower in males overall, it was in males that weight concerns predicted weight gain and was associated with greater odds of anticipating relapse. In these individuals, strategies to maintain weight while undergoing cessation may attenuate weight gain and reduce weight concerns overall. Two randomized controlled trials evaluating cognitive behavioral cessation interventions aimed at acceptance of a modest amount of weight gain found this approach led to greater cessation rates compared to standard cessation treatment (Levine et al., 2010b, Perkins et al., 2001). However, these efficacy trials warrant more research, specifically in obese men. Studies indicate that acceptance of a modest amount of weight gain is a positive health trade off compared to the

continuance of smoking in terms of cardiovascular disease risk (Hasegawa et al., 2019; Hu et al., 2018; Prugger et al., 2015).

While previous studies found that confidence in one's ability to quit smoking is inversely related to weight concerns (Glasgow et al., 1999; Jeffrey et al., 2000), our multivariable analysis did not show an association between weight concerns and confidence to quit. However, our multivariable analysis showed that motivation to quit was inversely and independently related to both weight concern measures – smoking to control weight and anticipating relapse due to weight gain. This important correlate of postcessation weight concern indicates that the challenge for weight concerned individuals is not so much “Can I quit?” as “Do I want to quit?” Therefore, while weight concerns may not be a key factor for individuals undergoing a quit attempt, it may still be a very important construct to consider for smokers that are in the contemplative stage, not yet making a quit attempt. Studies of individuals that do not intend to quit smoking in the immediate future could further elucidate the importance of weight concerns among smokers.

This three-study approach had strengths and limitations. Strengths include using data from a relatively large community-based sample of smokers who planned to quit, and the use of two distinct, validated measures of weight concerns related to cigarette smoking and quitting. The first study included a comprehensive examination of several determinants of weight concerns using objective and validated scales and measures (Appendix A). In the second and third study, dependent variables were objective and biochemically confirmed, and the analytic approach controlled for important covariables supported by previous literature. However, the first study was a cross-sectional design so it is important to note that temporality could not be established between the independent and dependent variables. In addition, findings of all three

studies are limited in scope to a population of healthy, sedentary smokers seeking cessation treatment in a community setting, and who are willing to participate in adjunctive physical activity or wellness support. Further studies of other populations, such as those contemplating rather than attempting cessation are warranted to determine if weight concerns inhibit cessation initiation. These studies are also limited in that they assessed only two distinct measures of weight concern and could not evaluate whether other dimensions of the construct, such as dieting behavior and perceptions of being overweight regardless of weight status, have other distinct determinants and/or can predict cessation related weight gain or cessation outcomes. Finally, these data are dated and may not be broadly generalizable to current day smokers.

APPENDIX A

Supplementary Table 1: Self-Reported Independent Variable Measures

Measure	Description	Calculation	Cronbach Alpha (α)
<i>Weight Concern Variables</i>			
Smoking Situations Questionnaire (Weekley et al., 1992)	Assesses behaviors to control body weight including smoking to prevent and control weight, in lieu of snacking, at the end of a meal, and to suppress appetite. (6 items)	The 6 items were measured on a 6-point Likert scale from strongly disagree to strongly agree. The mean resulting in the “control” score.	$\alpha = 0.87$
Weight Concerns Scale (Meyers et al., 1997)	Assesses intolerance to post-cessation weight gain and anticipating smoking relapse if weight gain occurs. (6 items)	For each of the six post-cessation weight gain ranges, from 1-5 lbs to 26-30 lbs respondents indicated the likelihood that they would relapse, on a 4-point scale from “somewhat unlikely” to “very likely.” Dichotomized scoring with respondents being classified as “weight concerned” if they reported being either “somewhat” or “very” likely to return to smoking at any level of weight gain.	n/a
<i>General psychosocial variables</i>			
Perceived Stress Scale (Cohen et al., 1983)	Assesses the respondent’s perceived level of stress. (14 item).	Respondents rated feelings using a 5-point Likert-type scale – 0 (never) to 4 – (very often). Scores were summed. Lower scores suggest lower levels of stress.	positive items $\alpha = 0.83$; negative items $\alpha = 0.69$

Supplementary Table 1 (continued)

Measure	Description	Calculation	Cronbach Alpha (α)
<p>Perceived Social Support Scale (Blumenthal et al., 1987)</p>	<p>Assesses general social support. (12 items).</p>	<p>Respondents rated their agreement for each situation on a Likert-type scale ranging from 0 (very strongly disagree) to 6 (very strongly agree). Scores were summed. Higher scores indicated greater social support.</p>	<p>$\alpha = 0.93$</p>
<p>Center for Epidemiologic Studies-Depressed Mood (CES-D) (Radloff, 1977)</p>	<p>Assesses symptoms of depressed mood. (20 items).</p>	<p>Respondents rated their endorsement of 20 items on a Likert-type scale ranging from 1 (rarely or none of the time) to 4 (most of the time). Four of the items were reverse scored. The questionnaire was summed. Lower scores were associated with less depressive symptomology.</p>	<p>negative items $\alpha = .89$; positive items $\alpha = .79$</p>
<p>Profile of Mood States (POMS) (McNair et al., 1977)</p>	<p>Assessment of distinctive mood types: depression, anger, confusion, fatigue, tension, and vigor. (65 items).</p>	<p>Respondents rated how often they felt each of 65 items on a Likert type scale ranging from 0 to 4 in the past week. Two of the items were reverse scored. The subscales of the questionnaire were summed to create a score of each mood state. Higher scores were associated with greater degree of each mood state.</p>	<p>depressed ($\alpha = .95$) anger ($\alpha = .90$) confusion ($\alpha = .86$) vigor ($\alpha = .90$) fatigue ($\alpha = .89$) tension ($\alpha = .92$)</p>

Supplementary Table 1 (continued)

Measure	Description	Calculation	Cronbach Alpha (α)
<i>Smoking related variables</i>			
Fagerstrom Test of Nicotine Dependence (Heatherton et al., 1991)	Assessment of the degree of nicotine dependence. (6 items).	The 6-items are coded and totaled. Scores range from 0-10. Higher totals indicate greater dependence.	($\alpha = .63$)
Minnesota Withdrawal Scale (Hughes et al., 1991)	Assessment of nicotine withdrawal symptoms. (9 items).	Respondents rated the degree to which they experienced the 9 symptoms on a scale from 0 (none) to 4 (severe). A mean is extracted. Higher numbers indicate greater symptomology.	($\alpha = .83$)
Self-efficacy for Quitting Smoking / Temptation to Smoke form (Velicer et al., 1990)	Assesses temptation to smoke in 3 distinct areas (habit, positive, and negative social situations). (9 items).	Respondents rated the degree they are tempted to smoke on the 9 items (3 items for each category). Scores range from 0 (not tempted at all) to 4 (extremely tempted). Scores are summed. Higher scores indicate a higher level of temptation.	($\alpha = .78$);
Motivation to quit smoking	Assesses motivation to quit smoking. (1 item).	Motivation levels were rated on a 10-point Likert-type scale with 0 indicating not at all motivated and 10 indicating extremely motivated. A higher score is associated with greater motivation.	n/a
Confidence to quit smoking	Assesses the level of confidence that the	Confidence levels were rated on a 10-	n/a

	respondent has in remaining free from smoking. (1 item).	point Likert-type scale with 0 indicating not at all confident and 10 indicating extremely confident. A higher score is associated with greater confidence.	
Partner Interaction Questionnaire (Cohen & Lichtenstein, 1990)	Assesses the degree of positive or negative support for respondent's smoking cessation efforts from a spouse, partner or other. (20 items).	Respondents rated their agreement for each item on a Likert-type scale ranging from 0 (never) to very often (4). Scores were summed for each subscale (positive/negative). Higher scores are associated with greater positive/negative social support.	negative items $\alpha = .91$; positive items $\alpha = .92$
Decisional Balance to Quit smoking (Velicer et al., 1985)	Measures the importance of the decision to smoke in terms of pros and cons. (6 items).	Respondents rated how important their decision to smoke is on a scale from 0 (not at all important) to 4 (extremely important) for each of the 6 pro and con statements. Scores for each subscale (pros/cons) were summed. Decisional balance score was calculated by subtracting the con score from the pro score. This score correlates to stage of change.	Pro scale $\alpha = .74$; cons scale $\alpha = .70$

Supplementary Table 1 (continued)

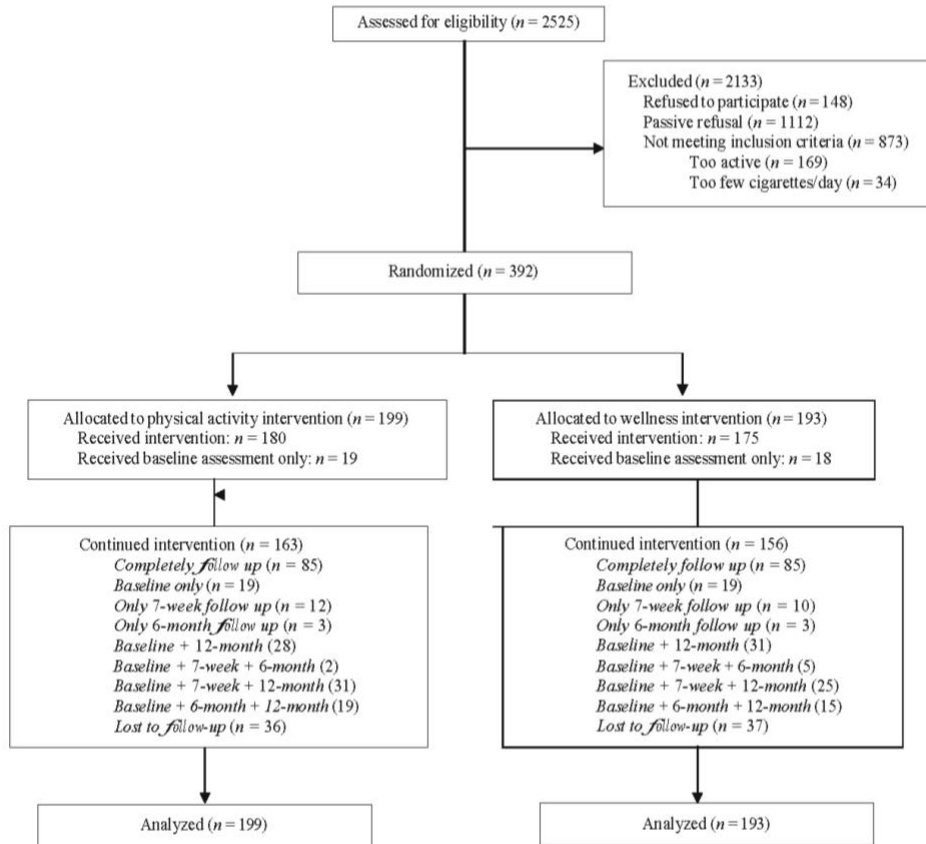
Measure	Description	Calculation	Cronbach Alpha (α)
<i>Physical activity (PA) related variables</i>			
Barriers to Physical Activity scale (Salmon et al., 2003)	Assesses environmental and personal barriers to engaging in physical activity (12 items).	Respondents rated how much of a barrier various personal and environmental factors were to being physically active on a Likert-type scale of 0 (not a barrier) to 4 (very much a barrier). Scores were summed overall and for each subscale (environmental / personal).	($\alpha = .72$)
Perceived Barriers to Exercise Scale (Castro et al., 1999)	Assesses barriers to engage in exercise (8 items).	Respondents rated how often barriers would prevent them from exercising on a Likert-type scale from 1 (never) to 5 (very often). Items were summed for analysis. Higher scores indicate a greater impact of barriers on maintaining an exercise routine.	($\alpha = .64$)

Supplementary Table 1 (continued)

Measure	Description	Calculation	Cronbach Alpha (α)
Enjoyment of types of physical activity (Salmon et al., 2003).	Assesses level of enjoyment from physical activity (PA) including organized PA, unorganized PA, and walking. (12 items).	Respondents rated much they enjoy they various forms of organized activities, unorganized activities and walking on a scale from 0 to 4. Scores were summed in total and over three subscales (organized, unorganized, and walking). Higher scored indicate greater enjoyment.	($\alpha = .76$)
Physical Activity Enjoyment Scale (Kendzierski & DeCarlo, 1991)	Assesses overall enjoyment of physical activity (5 items).	Respondents rated how they feel while using a Likert-type scale from 1-5. A mean score is extracted. Higher scores indicate greater enjoyment.	positive items $\alpha = .84$; negative items $\alpha = .78$
Exercise Self-Efficacy Scale (Marcus et al., 1992)	Assesses confidence in continuing to engage in exercise when life events (e.g. rain) intrude. (6 items).	Respondents rated how confident they were to continuing exercising on a Likert-type scale from 1 (not at all confident) to 5 (completely confident). A mean score was extracted. Higher scores suggested greater self-efficacy.	($\alpha = .85$)
7 day Physical Activity Recall (Sallis et al., 1985) and Compendium of Physical Activities (Ainsworth et al., 2011).	Semi-structured interview that estimates an individual's time spent in physical activity, as well as strength and flexibility activities, in the past seven days.	Time was summed and the Compendium of Physical Activities was used to code intensity values (i.e. moderate, vigorous) for activities reported by participants.	n/a

APPENDIX B

Flow Chart of Enrollment and retention of the Lifestyle Enhancement Program (LEAP) smoking cessation two group randomized controlled trial (Stockton, et al., 2023).



Stockton, M.B., Ward K.D., McClanahan B.S., Vander Weg, M.W., Coday, M., Wilson, N.,

Relyea, G., Read, M.C., Connelly, S., Johnson, K.C. (2023). The Efficacy of Individualized, Community-Based Physical Activity to Aid Smoking Cessation: A Randomized Controlled Trial, *Journal of Smoking Cessation*, 2023.

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