Lifestyle Habits Associated with Weight Regain After Intentional Loss in Primary Care Patients Participating in a Randomized Trial

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BACKGROUND: Though long-term weight loss maintenance is the treatment goal for obesity, weight regain is typical and few studies have evaluated lifestyle habits associated with weight regain.

OBJECTIVE: To identify dietary and physical activity habits associated with 6- and 24-month weight regain among participants in a weight loss maintenance clinical trial.

DESIGN: Secondary analysis of randomized clinical trial data.

PARTICIPANTS: Adult primary care patients with recent, intentional weight loss of at least 5%.

MAIN MEASURES: Lifestyle habits included consumption of low-fat foods, fish, desserts, sugary beverages, fruits, and vegetables and eating at restaurants from the Connor Diet Habit Survey; moderate-vigorous physical activity by self-report; steps recorded by a pedometer; and sedentary behavior by self-report. The outcome variable was weight change at 6 and 24 months. Linear regression models estimated adjusted associations between changes in weight and changes in dietary and physical activity habits.

KEY RESULTS: Overall, participants (mean (SD): 53.4 (12.2) years old; 26% male; 88% white) maintained weight loss at 6 months ($n = 178$, mean (SD): -0.02 (5.70)% change) but began to regain weight by 24 months ($n = 157$, mean (SD): 4.22 (9.15)% increase). When considered all together, more eating at restaurants, reduced fish consumption, and less physical activity were most consistently associated with weight regain in fully adjusted models at both 6 and 24 months of follow-up. In addition, more sedentary behavior was associated with weight regain at 6 months while reduced consumption of low-fat foods, and more desserts and sugary beverages were associated with weight regain at 24 months.

CONCLUSIONS: Consuming less fish, fewer steps per day, and more frequent restaurant eating were most

consistently associated with weight regain in primary care patients. Primary care providers may consider addressing specific lifestyle behaviors when counseling patients after successful weight loss.

TRIAL REGISTRATION: ClinicalTrials.gov Identifier: NCT01946191

KEY WORDS: weight loss maintenance; diet; physical activity; primary care.

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INTRODUCTION

Healthy dietary habits and high physical activity levels are cornerstones of weight control.^{1–4} Though intentional weight loss of at least 5% has been associated with decreased morbidity and mortality and improved quality of life,⁵ long-term maintenance of weight loss remains especially challenging and most adults regain initial weight lost over time.⁶ To reduce the burden of obesity and related comorbidities, identification of effective strategies to prevent weight regain is critical.

Weight regain may be due, in part, to behavioral regression or shifts toward weight gain–promoting dietary and physical activity habits after initial weight loss. Specifically, automaticity of unhealthy habits developed prior to weight loss could be difficult to overcome long-term.⁷ Yet, developing healthy habits could counteract behavioral regression.^{8–13} A recent systematic review of 124 determinants of weight loss maintenance reported that regular weight monitoring and reduced caloric intake had the most evidence of benefit.¹³ Yet, less research has studied a contemporary, clinical population and evaluates specific dietary and physical activity habits that may be especially translatable when counseling patients.

Recently, the MAINTAIN-pc study reported that adding enhanced online coaching and communication with the primary care provider to tracking tools delivered through an electronic health record among primary care patients resulted in less weight regain at 24 months (-2.86 kg, $p < 0.001$).¹⁴ This study leveraged communication with coaches through the

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existing electronic patient portal and the primary care provider-patient relationships to encourage maintenance of weight loss through sustained healthy lifestyle behaviors (e.g., diet and physical activity). We have previously reported that certain lifestyle habits were associated with greater recent, intentional weight loss in MAINTAIN-pc participants at study enrollment.¹⁵ Habits associated with greater recent intentional weight loss included higher intake of fruits and vegetables, low-fat foods and recipes, and physical activity measured by self-report and a pedometer. As habits associated with weight loss may differ from those associated with weight regain,⁸ further analyses that identify habits associated with less weight regain across the 24-month follow-up would provide distinct and valuable information. These data could be clinically useful as the sample included primary care patients, with a range of comorbidities, and who had utilized a variety of behavioral methods to achieve weight loss prior to entering the study.

Thus, this secondary analysis aimed to identify dietary and physical activity habits associated with 6- and 24-month weight regain across participants with recent, intentional weight loss in the MAINTAIN-pc clinical trial. We hypothesized that greater weight regain would be associated with increased eating at restaurants, fried foods, desserts, sugary beverages, and sedentary time and would be inversely associated with consumption of low-fat foods and recipes, fish, fruits and vegetables, self-reported moderate-vigorous physical activity, and pedometer steps per day.

METHODS

Participants and Setting

This analysis used longitudinal data (baseline, 6-months follow-up, and 24-months follow-up) from the MAINTAIN-pc trial that was conducted in Pittsburgh, PA (from 2013 to 2017). As previously described,^{14,16} this trial randomized adult primary care patients with recent, intentional weight loss of $\geq 5\%$ into one of two 24-month intervention arms. All participants received access to study-developed, electronic health record-based lifestyle tracking tools and basic healthy lifestyle education for the 24-month study period. Half of the participants were randomized to receive additional individual health coaching delivered electronically through the same patient portal and by a study coach trained in nursing, nutrition, and exercise physiology. Participants were contacted weekly (month 1), bimonthly (months 2–6), and then quarterly over the 24-month intervention. The University of Pittsburgh Institutional Review Board approved the study, and all participants provided written informed consent.

For the current analysis, study arms were combined into a single cohort and only participants with follow-up data at 6 and 24 months, respectively, were included in analyses. Participants with follow-up outcome data at 6 months (92%) had similar baseline age, gender, body mass index, and education when compared with participants without follow-up data

(Supplemental Table 1). Participants with and without follow-up outcome data at 24 months (81%) were also similar by these characteristics, with the exception of education (higher in those with follow-up, $p = 0.005$).

Measurements

Demographic characteristics and medical conditions were self-reported at the baseline visit. Weight was measured by a calibrated Tanita WB-100 scale in light clothing and with shoes removed.

Dietary habits were measured by the Connor Diet Habit Survey.¹⁷ This instrument was developed and validated within a population-based, 5-year, low-fat/cholesterol dietary intervention study of coronary heart disease risk conducted in Portland, OR, beginning in 1978.¹⁸ The 57-item instrument queries usual dietary intake of specific foods or food groups (e.g., “How often do you eat desserts or baked goods” with six responses ranging from “once a day” to “never”) or habits (e.g., “How often do you eat dinner at a restaurant or cafeteria or eat ‘take out’” with six responses ranging from “more than 3 times a week” to “never”). The instrument is valid compared with 24-h dietary recall and was associated with 5-year changes in plasma cholesterol levels in the validation sample.¹⁷ We used specific questions chosen a priori from the survey to assess dietary habits that we hypothesized would be related to weight regain^{15,19}: fruits and vegetables, fish, sugary beverages, fried foods, desserts, eating at restaurants, and choosing low-fat foods and recipes. If the standardized survey answers were ranges, the midpoint of the range was used to estimate the dietary habits.

Physical activity was self-reported using questions from the Behavioral Risk Factor Surveillance Survey (BRFSS).²⁰ These queried the frequency and duration of moderate and vigorous intensity physical activity (e.g., “How many days per week do you do moderate activities for at least 10 minutes at a time?” and, then, “On days when you do moderate activity for at least 10 minutes at a time, how much total time do you spend doing these activities?”).²¹ Total minutes per week of moderate and vigorous activity per week were summed and divided by 7 to produce an estimate in minutes per day. These have been shown to accurately and reliably classify activity level in adults.²⁰

Sedentary behavior was assessed by the Sedentary Behavior Questionnaire (SBQ).²² This instrument asks participants to estimate time spent in nine sedentary behaviors on weekdays and weekends (e.g., “On a typical weekday, how much time do you spend doing the following?” for each of nine activities, e.g. television watching). Response options ranged from “none” to “6 or more hours”. A weighted average of total sitting time has good reliability in overweight adults with acceptable validity demonstrated in women.²²

Objective ambulation was captured as steps per day using a blinded Omron pedometer (HJ-720ITC) that did not provide feedback to the participant. Participants were asked to wear the

pedometer for 14 days during waking hours and return the monitor by mail. Steps were averaged across valid days, with any day registering a minimum of 500 steps considered valid.

Statistical Analyses

Participant characteristics and changes in weight, dietary, and physical activity habits were described using means with standard deviations or counts with percentages. Multiple linear regression models estimated associations between changes in dietary and physical activity habits (independent variables) with concurrent changes in weight (dependent variable), separately at 6 and 24 months. Initial models evaluated a single dietary or physical activity variable with adjustment for age, gender, randomized group, and primary care office strata. Final models evaluated independent associations by including all habits with a $p < 0.10$ from the initial single habit models, and then removing variables with $p < 0.05$ using a stepwise approach.

RESULTS

MAINTAIN-pc participants tended to be middle-aged, mostly white women, and the majority (76%) had a college degree or higher (Table 1). Though at the time of enrollment participants had an average body mass index (BMI) classified as obese, they had recently lost an average of 11.4% of their body weight within the 2 years prior to enrollment. This primary care population also had a high burden of comorbidities, with about half having high blood pressure and musculoskeletal disorders and lower (though notable) rates of dyslipidemia, diabetes/prediabetes, cardiovascular disease, and anxiety or depression.

When combining randomized groups, participants on average maintained pre-study weight losses at 6 months (-0.02% change (SD: 5.70%)) but had regained 4.22% (SD: 9.15%) by

24 months (Table 2). As previously reported,¹⁵ at baseline, participants infrequently consumed fried foods, desserts, and sugary beverages; frequently consumed fruits, vegetables, and low-fat foods; and ate at restaurants 2.50 (SD: 2.44) times per week. They reported moderate-vigorous physical activity levels at more than twice the minimum current guidelines,²³ took 6340 (SD: 3176) pedometer steps per day, and reported sitting 8.50 (SD: 3.56) hours per day.

Over follow-up, average dietary habits and physical activity levels were mostly stable at 6 months and differed only slightly by 24 months (Table 2). Yet, large standard deviations of the change variables at 6 and 24 months indicate that substantial individual-level changes in habits did occur.

Associations Between Changes in Dietary Habits and Weight

Associations between individual changes in dietary and physical activity habits with concurrent 6- and 24-month changes in weight were first evaluated in models including a single habit and adjusted for age, gender, randomized group, and primary care practice stratum (Supplemental Tables 2 and 3). In multivariable models (Table 3) considering all habits associated with $p < 0.10$ in the single habit models, retained variables associated with weight regain at 6 months included increased eating at restaurants and decreased fish consumption, as well as increased sedentary time and decreased moderate-vigorous physical activity. At 24 months, weight regain was again associated with increased eating at restaurants and decreased fish, but also reduced low-fat foods and recipes and increased desserts and sugary beverages. At 24 months, decreased steps per day were associated with weight regain. Consumption of fruits and vegetables and fried foods did not meet criteria for inclusion in the stepwise models.

DISCUSSION

In this study, we report lifestyle habits that were associated with weight regain in a group of primary care patients enrolled in the MAINTAIN-pc trial over 24 months. The three habits most consistently associated with weight regain (at both 6 and 24 months) were increased eating at restaurants, decreased fish consumption, and decreased physical activity. Increased sedentary behavior was associated with weight regain at 6 months and decreased low-fat foods and increased in sugary beverages and desserts were associated with weight regain at 24 months. Taken together, we summarize the key habits associated with weight regain among MAINTAIN-pc participants that could be useful behavioral targets for primary care providers and their patients seeking to maintain recent weight loss success (Table 4).

Measurable health and quality of life benefits are realized with weight losses of 5–10%, and these are sustained if weight lost is not regained.^{5,7} Thus, long-term weight loss

Table 1 Baseline Participant Characteristics (n = 194)

	Overall
Age (years)	53.4 (12.2)
Male, n (%)	51 (26%)
Race	
White	171 (88%)
Black	20 (10%)
Asian	3 (2%)
Education	
High school	9 (5%)
Some college	37 (19%)
College	63 (32%)
Graduate degree	85 (44%)
Body mass index (kg/m ²)	30.4 (5.9)
Recent weight loss (%)	−11.4% (6.5%)
Comorbid conditions	
High blood pressure	96 (49%)
Dyslipidemia	83 (43%)
Diabetes and prediabetes	42 (22%)
Cardiovascular disease	20 (10%)
Musculoskeletal disorder	100 (52%)
Anxiety or depression	53 (27%)

Data presented as mean (SD) or n (%)

Table 2 Mean (SD) Baseline and Change in Weight, Dietary Habits, and Physical Activity at 6 and 24 Months

	N	Baseline	N	6-month change	N	24-month change
Weight (kg)	194	85.77 (19.08)	178	−0.09 (4.96)	157	3.39 (7.69)
Weight (%)	—	—	178	−0.02 (5.70)	157	4.22 (9.15)
Low-fat foods and recipes (times/week)	194	3.23 (2.56)	169	−0.18 (2.21)	144	−0.38 (2.27)
Eating at restaurant (times/week)	194	2.50 (2.43)	169	0.15 (1.75)	144	0.01 (1.92)
Fish (servings/week)	194	1.28 (1.00)	169	0.02 (0.92)	144	−0.16 (0.92)
Desserts (servings/week)	194	2.02 (1.84)	170	0.04 (1.88)	145	0.20 (1.87)
Fried foods (servings/week)	194	1.42 (2.28)	170	−0.01 (2.20)	145	0.19 (2.78)
Sugary beverages (servings/week)	194	0.46 (1.09)	169	−0.05 (0.96)	144	0.11 (1.09)
Fruits + vegetables (servings/day)	194	5.13 (2.85)	169	−0.45 (2.76)	144	−0.47 (2.70)
Sedentary time (h/day)	193	8.50 (3.56)	168	0.49 (3.66)	140	0.07 (3.71)
MVPA (min/day)	194	45.89 (40.06)	172	−0.08 (41.65)	145	0.07 (45.86)
Steps (per day)	167	6340 (3176)	135	56 (2247)	114	−609 (2767)

Data are presented as mean (SD). MVPA moderate-vigorous physical activity

maintenance is the treatment goal for obesity. With further consideration that the 1- to 5-year period following initial weight loss is when most weight is regained,^{5,6} a focus on strategies to maintain weight loss in the first few years is key. Moreover, some studies suggest initial weight loss vs. weight loss maintenance behavioral strategies might differ.⁸ This concept is reinforced when synthesizing findings of this current weight regain analysis with our previous research associating lifestyle habits with recent intentional weight loss in MAINTAIN-pc.¹⁵ Though physical activity associated with both recent weight loss and reduced weight regain, greater fruits, vegetables, and low-fat foods were most associated with recent weight loss¹⁵ while greater fish consumption and less eating at restaurants were most consistently associated with reduced weight regain.

Varkevisser and colleagues recently systematically reviewed 124 demographic, behavioral, psychological, and environmental factors associated with weight loss maintenance.¹³ Specifically for the factors most consistently associ-

ated with reduced weight regain in our study, this review graded the evidence as “strong” for reduced restaurant eating and higher physical activity and “moderate” for increased fish consumption. The evidence for other behavioral factors that we identified as potentially important for attenuating weight regain were graded as “strong” (less sugary beverages) or “insufficient” (desserts, sitting time; more low-fat foods or recipes). Of interest for the habits that we found were not associated with weight regain in multivariable models, this review graded the evidence that fruit and vegetable intake was associated with less weight regain as “strong” while fried food intake was graded as “insufficient”.¹³

Several large survey or observational cohorts have investigated lifestyle habits associated with weight regain. In an analysis from the National Weight Control Registry ($N=2886$), a survey study that remotely enrolled volunteers who self-reported weight losses of ≥ 30 lbs. that had been maintained for ≥ 1 year, participants who decreased physical activity and increased dietary fat intake were more likely to regain

Table 3 Estimated Weight Change (kg) Associated with 1-Unit Change in Multiple Dietary Habits and Physical Activity Metrics at 6 and 24 Months

	6 months		24 months	
	Beta (95% CI)	p	Beta (95% CI)	p
Lifestyle habits				
Low-fat foods (times/week)			−0.65 (−1.16, −0.13)	0.014
Restaurants (times/week)	0.75 (0.30, 1.20)	0.001	0.61 (0.05, 1.18)	0.034
Fish (servings/week)	−0.85 (−1.64, −0.06)	0.036	−1.69 (−2.82, −0.55)	0.004
Desserts (servings/week)	—		0.71 (0.09, 1.33)	0.025
Fried foods (servings/week)	—		—	
Sugary beverages (12 oz./week)	—		1.50 (0.51, 2.48)	0.003
Fruits + vegetables (servings/day)	—		—	
Sedentary behavior (per h/day)	0.22 (0.004, 0.44)	0.0463	—	
Moderate-vigorous physical activity (per 10 min/day)	−0.35 (−0.53, −0.16)	0.0003	—	
Steps (per 1000 steps/day)	—		−0.89 (−1.29, −0.50)	<0.001
Covariates				
Age (years)	−0.10 (−0.16, −0.04)	0.0013	−0.10 (−0.19, −0.01)	0.0339
Gender	−0.33 (−2.09, 1.43)	0.7094	−1.79 (−4.21, 0.64)	0.1465
Randomized group	−1.35 (−2.87, 0.18)	0.0839	−1.12 (−3.35, 1.11)	0.3211
Stratum (GIMO/non-GIMO)	1.45 (−0.07, 2.96)	0.0607	0.76 (−1.48, 3.01)	0.5010
R ²	0.324		0.471	

Stepwise regression used $p < 0.1$ as entry criteria for single-variable models and retained variables with $p < 0.05$. Habit variables that did not meet criteria for retention in stepwise model are labeled with a dash (—). Beta coefficients are adjusted for all other covariates in the table and age, gender, randomized group, and stratum

Table 4 Key Strategies Associated with Weight Regain in MAINTAIN-pc Primary Care Patients

<div> <div>More Robust</div> <div>←</div> <div>→</div> <div>Less Robust</div> </div>		
<ul style="list-style-type: none"> • More eating at restaurants • Decreased fish consumption • Decreased physical activity (self-report/steps per day) 	<ul style="list-style-type: none"> • Decreased low-fat foods • Increased sugary beverages • Increased desserts • Increased sitting (self-report) 	<ul style="list-style-type: none"> • Decreased fruits and vegetables • Increased fried foods

weight lost over 10 years.⁹ Though consistent with our findings regarding physical activity and low-fat foods, our findings among MAINTAIN-pc participants recruited through primary care offices, and often with more recent (within last 2 years) and modest ($\geq 5\%$) weight losses, could be more translatable when treating patients during the most vulnerable period for weight regain. Another survey⁸ conducted on a random sample of 1165 US adults identified several lifestyle habits associated with weight loss maintenance that were consistent with our study, including higher consumption of low-fat proteins (potentially comparable with our fish intake) and consistent engagement in exercise. In contrast to our findings, this survey study additionally identified higher consumption of fruits and vegetables as a weight loss maintenance strategy. In the Coronary Artery Risk Development (CARDIA) observational cohort,¹⁰ lifestyle habits associated with weight loss maintenance in mid-life among 534 participants included increasing physical activity and decreased sugar-sweetened beverages, though changes in overall Healthy Eating Index were not associated. Taken together, higher participation in physical activity appears to be most consistently associated with weight regain, while dietary habits are more variable.

Like this current study, habits associated with weight regain have also been evaluated within clinical trials. In the Weight Loss Maintenance (WLM) trial,¹² participants ($n = 1685$) losing at least 4 kg during an initial 6-month intensive phase were randomized to three interventions for weight loss maintenance. Lifestyle habits associated with maintaining weight lost in the WLM included increases in the Healthy Eating Index and moderate-vigorous physical activity.¹² Among participants ($n = 105$) recruited from primary care offices in Poland in a diabetes prevention lifestyle intervention study,¹¹ only decreased fat consumption predicted weight loss maintenance at 3 years; changes in physical activity, fruit and vegetable intake, saturated vs. unsaturated fat intake, and alcohol consumption were not related. However, compared with these studies, our data may be more relevant to a typical, clinical population. Our participants had achieved weight loss through a variety of self-guided behavioral methods (rather than as part of an initial trial), our study assessed specific dietary habits (e.g., restaurant eating, fish consumption), and we included objective assessment physical activity.

Overall, despite differences in study populations and the exact habits evaluated, our results are largely consistent with the previous literature¹³ and, moreover, conventional wisdom that advocates an active lifestyle and eating meals at home that include fish, are low in fat, and have limited added sugars. Of note, greater intake of fish in this study may reflect the recommended dietary pattern that replaces less healthy proteins with leaner, healthier proteins²⁴; we were unable to assess other proteins separately with the dietary questionnaire used. That fruit and vegetable intake was not consistently protective of weight regain in the multiply adjusted models is our most unexpected result.^{10,25} One possibility is that increases in the consumption of fruits and vegetables during the weight loss maintenance phase could reflect an overall increase in dietary intake rather than a less calorically dense dietary pattern that may have contributed to initial weight loss.^{15,26}

Our study has several limitations. Lifestyle variables (dietary habits, moderate-vigorous physical activity, and sedentary behavior) are self-reported and may have been subject to recall or social desirability biases. We were limited in dietary habits and other data that we could extract from the Diet Habit Survey; for example, total caloric intake, consumption of lean proteins, or method of fish preparation were not available. Our evaluation of lifestyle behaviors without accounting for total caloric intake, physiological factors, or chronic conditions could have impacted associations. Also, the study was powered to detect a weight change between two randomized groups and may have had limited power to detect smaller associations in this secondary analysis that combined randomized groups. Thus, caution should be used when interpreting these hypothesis-generating associations that do not reflect an experimental test of the effect of altering these specific habits. Though we did not adjust the family-wise error rate for the multiple habits considered within each model, consideration of 10 habits could have inflated type I error. Lastly, as is typical in weight interventions, the population in MAINTAIN-pc was mostly female, white, and educated, which reduces generalizability. These limitations are balanced by strengths, which include prospectively assessed changes in habits that readily translate into potential strategies within a relevant, contemporary cohort of primary care patients, with a high prevalence of comorbidities, and who achieved intentional weight loss through a variety of behavioral methods.

The findings of this study could be useful for primary care practice. Despite the 2018 US Preventative Task Force recommendation to offer or refer adults with obesity to behavior-based weight loss maintenance interventions (moderate certainty, grade B),²⁷ weight control counseling in primary care remains underutilized.²⁸ Numerous barriers to such counseling include high workload, lack of patient interest, or lack of training or referral resources.^{28,29} Our data suggest referring patients with recent, intentional weight loss to coaching helps them stay committed to their weight-controlling behaviors. Staying active; sustaining or increasing dietary behaviors such as consumption of fish and low-fat foods; and maintaining or reducing eating at restaurants, sugary beverages, and desserts may all help prevent weight regain. Though beyond the scope of this manuscript, providers could consider counseling through methods including shared decision-making or motivational interviewing to patients with recent intentional weight loss, or referral to behavioral specialists.³⁰ Future research could evaluate whether counseling from members of the primary care team (e.g., providers, staff) that focuses on behavioral strategies to maintain physical activity and dietary habits could reduce weight regain with the ultimate goal of improving obesity treatment outcomes.

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Data Availability: Data are available to interested readers by contacting Dr. Conroy at molly.conroy@hsc.utah.edu.

Compliance with Ethical Standards:

The University of Pittsburgh Institutional Review Board approved the study, and all participants provided written informed consent.

Conflict of Interest: Dr. Barone Gibbs reports grants from AHRQ, during the conduct of the study, grants from the American Heart Association, grants from the National Institutes of Health, and grants from the Tomayko Foundation, outside the submitted work. Dr. Fischer reports grants from AHRQ, during the conduct of the study, grants from PCORI, and grants from NIH, outside the submitted work. Dr. Hess reports personal fees from Astelles, outside the submitted work. Dr. McTigue reports grants from the University of Pittsburgh, during the conduct of the study. The other authors declare that they have no conflict of interest.

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