Predictors Associated With Changes of Weight and Total Cholesterol Among Two Occupational Cohorts Over 10 Years

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Objective: To ascertain worker health characteristics and psychosocial factors associated with changes in body weight and total cholesterol (TC) among two production operation populations. **Methods:** We performed descriptive and predictive analysis of questionnaire data and biomedical measurements from two prospective cohort studies. Our key outcomes were changes in weight, and TC over 5 to 10 years between baseline and exit assessments. **Results:** A total of 146 subjects were analyzed. Increases in weight were associated with belief in being overweight and baseline overweight and obesity. Increases in TC levels were associated with female sex, belief that TC levels were "not good," and feeling depressed. **Conclusions:** Most of the reported associations with increases in weight and TC levels are amenable to interventions and may be a target for workplace intervention programs.

One in every six adults (16.3%) has high total cholesterol (TC) ($\geq$240 mg/dL) and 35.5% of US adults are obese (body mass index [BMI] $\geq$30.0 kg/m^2).[1,2] Both elevated cholesterol and BMI have been associated with workplace absenteeism and health care costs.[3] Henke et al[4] estimated that cholesterol, weight, blood pressure and glucose had the greatest impact on total health care costs among workers in a manufacturing plant.

The Center for Disease Control and Prevention estimates that overall medical costs related to obesity for US adults were $147 billion in 2008.[5] The US economic productivity losses because of obesity are projected to be between $48 billion and $66 billion per year by 2030.[6] In addition to cardiovascular health concerns, obesity has also been associated with musculoskeletal or joint-related pain in the feet,[7] knees,[8–12] back,[13–17] shoulders,[18–23] and hands.[24,25] In addition, obesity has been associated with an increased risk of occupational injuries.[26–28]

An individual's perceived risk of developing a certain health condition is likely essential in motivating behavior.[29,30] Adults with elevated TC or BMI may be more motivated to alter their lifestyle because of health concerns. Therefore, it seems necessary that adults have an understanding of key health indicators as well as recommended target levels. A study to assess whether better knowledge improves adherence to lifestyle changes in patients with coronary heart disease concluded that "patient education must be formalized and acknowledged as an official part of the health care system."[31] This suggests that people who are aware of their TC levels may be more likely to reduce their blood cholesterol levels.

To the best of our knowledge, no prior research has been conducted assessing the changes in TC and weight over time among production workers. Therefore, the goal of this study was to ascertain characteristics associated with changes in weight and TC from baseline enrollments to study completion. We were particularly interested in assessing whether knowledge of TC and BMI levels was associated with changes.

METHODS

This research study was nested within the Utah populations of two prospective cohorts (the WISTAH distal upper extremity [DUE] cohort and the BackWorks low back pain [LBP] cohort).[32,33] Both cohorts were approved by the University of Utah's Institutional Review Board (Nos. 00010930 and 00011889). Baseline data for these cohorts were collected during worksite enrollments conducted between 2002 and 2007. Additional data were collected during study completion visits in the spring of 2012 and analyzed in 2013. The parent cohort studies have detailed methods in articles published.[32,33] Thus, a brief summary of the methods follows.

Subjects

Subjects were at least 18 years of age at enrollment and employed at one of the eight participating companies in Utah. Participants were excluded if they could not give informed consent, did not speak either English or Spanish, and were planning to retire within 4 years of study enrollment. Subjects for this nested study were recruited from five different employment settings in Utah, which included airbag manufacturing, sewing facility, office work, red meat processing, and printing operations.[32,33] Only a subset of both cohorts had TC measured at baseline, and this subset was eligible for the present analysis.

Baseline Measures

At baseline enrollments, workers completed a laptop-administered questionnaire under the supervision of a research assistant. Data quantified at baseline included demographics (age, sex, race, marital status, and education level), leisure-time physical activity, tobacco use, psychosocial factors (eg, depression, job satisfaction, and family problems), and health status (eg, "Have you even been told by a physician that you have high cholesterol [laboratory test result over 200 mg/dL]").

Questions addressed 21 leisure-time physical activities (eg, walking, baseball, and basketball) and could include additional activities beyond those 21. Each of those activities was further queried for the number of months per year, the average number of times per week, and the average number of minutes each activity was performed. A composite of all these activities was calculated, and the total reported leisure-time physical activity in minutes per week was determined.

Height and weight were measured in stocking feet to calculate BMI. Height was assumed to have not changed appreciably during

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the study. If weight exceeded 200 kg, two scales were used simultaneously and the sum was recorded. A BMI of less than 18.5 kg/m^2 was classified as underweight, between 18.5 and 24.9 kg/m^2 was classified as normal weight, 25 to 29.9 kg/m^2 was classified as overweight, and more than 30 kg/m^2 was classified as obese.

Serum nonfasting TC, low-density lipoprotein, high-density lipoprotein, triglycerides, C-reactive protein, and hemoglobin A1c levels were measured in blood collected by venipuncture and analyzed at ARUP Labs in Salt Lake City or by finger-stick and analyzed using Alere Cholestech LDX system (Alere Inc, Waltham, MA).

Blood pressure was measured in a seated position after a minimum of 5 minutes of rest using automated cuffs (Omron HEM-780).

Study participants were informed of their weight and blood pressure results upon completion of baseline enrollments by a trained researcher. Immediate feedback regarding those results was provided in writing indicating desired ranges for each of those measures. A handout was given to each participant that listed the measured systolic and diastolic blood pressure. Recommendations for normal, prehypertension, stage 1 hypertension, and stage 2 hypertension were also listed, indicating whether a lifestyle modification is encouraged or not. Blood test results were mailed to the participants upon receipt of the blood results from the laboratory. The mailer contained the current classifications and recommendations for adult TC, low-density lipoprotein, high-density lipoprotein, triglycerides, C-reactive protein, and hemoglobin A1c. Participants were advised to consult with their health care provider if any of the reported values were out of range.

Study Completion Measures

Age at study completion was recalculated. Participants completed another laptop-administered questionnaire. Survey items quantified leisure-time physical activity outside work, and psychosocial factors (eg, depression, job satisfaction, and family problems) with the same questions as in the baseline questionnaire. It also included items regarding knowledge of BMI, knowledge of TC levels, and fruit and vegetable intake.

Dietary intake questions were included that have been previously developed.[34] Fruit and vegetable intake was assessed by asking "How many times do you typically eat a serving of fruit in 1 day?" and "How many times do you typically eat a serving of vegetables in 1 day?" Binary dummy variables were created for both of these variables (<5 vs ≥ 5).

Breakfast and fast food consumptions were assessed by asking "How many times do you eat restaurant or fast food in a typical week?" and "How many times do you typically eat breakfast in 1 week (7 days)?" Dummy variables reporting tertiles were created for both breakfast and fast food consumption.

Participants were asked whether they could recall their current TC and BMI (*yes/no*). Questions on how study participants perceive their weight and TC were also included. Subjects were asked "Do you think your total cholesterol is good, not good, unsure?" and "Do you believe you are underweight, normal weight, overweight, obese, unsure?" Intake of cholesterol-lowering medication was also assessed.

Having received any education (eg, doctor, the Internet, and magazines) in weight management, diet, nutrition, or physical fitness throughout the study duration was also assessed.

Outcome Variables

Changes in weight were determined by comparing the measured weight at the study completion visit with the weight at the baseline visit.

Blood samples were drawn at study completion via finger-stick method using the Alere Cholestech LDX system (Alere Inc, Waltham, MA). These data enabled the assessment of changes in TC levels throughout the course of the study.

Data Analysis

All analyses were performed using SAS 9.3 (SAS Institute, Cary, NC). Outliers and missing data were verified by pulling individual charts for each participant. Imputation using the study population mean was used when missing data could not be verified. Less than 0.3% of all data were imputed.

Variables were analyzed for normality and skewness. Mean differences for weight and TC changes between baseline enrollments and study completion visits were determined by using a paired *t* tests (normal distribution) and Wilcoxon signed rank sum test (not normally distributed).

Statistical significance was determined using an α level of 0.05. Frequencies, means, and standard deviations (SDs) were used to describe the population.

We assessed the data for attrition bias because a large proportion of our population exited the study. We aimed to determine whether those workers who exited the study had different characteristics from those who completed the study and would have therefore introduced attrition bias. Differences were assessed for demographics (age, sex, race, education, and marital status) by using chi-square test analyses. In addition, we assessed differences for our main continuous health outcomes (weight and TC) by using the Wilcoxon-Mann-Whitney test.

Multivariate linear regression was conducted to identify which factors were independently associated with the main outcomes. Factors for the multivariate model were selected on the basis of evidence published in other research articles and biological plausibility. Stepwise backwards regression analyses were performed separately for each outcome.

To investigate whether the relationships between participant characteristics, BMI, and TC would differ between the cohorts, we ran linear regression models including interaction terms between the cohort status (DUE or LBP) and the predictor variables. We used an a-priori *P* value of 0.1 for significance of each interaction term.

RESULTS

A total of 366 subjects met the baseline inclusion criteria. More than half exited the study for various reasons unrelated to the study, which are detailed in Fig. 1 (eg, leaving employment to take another job, retirement, and termination). Another 38 were lost to follow-up at study completion visits. A total of 146 subjects remained

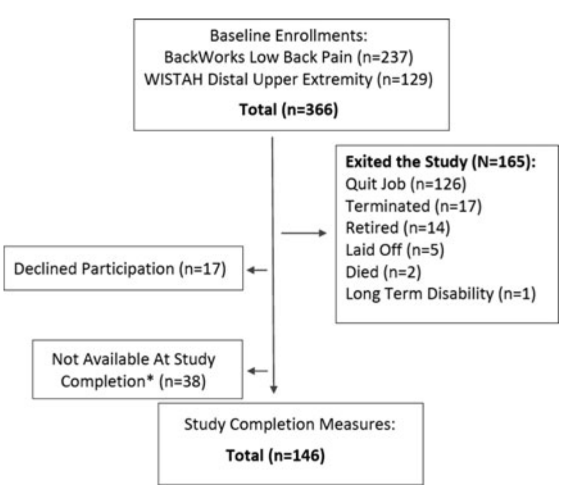

FIGURE 1. Flowchart of study participants from baseline enrollments to study completion measures.

in the cohort through study completion and participated in the end of study visits.

At study completion, participants were between ages 35 and 55 years ($n = 86$; 58.9%) with a mean age of 49.6 (SD = 10.6) years. The majority were female ($n = 74$; 50.7%) and white ($n = 98$; 67.1%). Most ($n = 106$; 72.6%) were married and 46.6% ($n = 68$) had a high school degree or General Educational Development (GED). More than half of the population was obese ($n = 84$; 57.5%), with a mean BMI of 31.7 (SD = 7.4) kg/m^2. Only 4.8% ($n = 7$) of the subjects at exit reported knowing their BMI, although 58.9% ($n = 86$) believed themselves to be overweight. Less than 10% reported knowing their TC. Only 57.5% ($n = 84$) of workers consumed five or more servings of fruits and vegetables combined per day (Table 1).

A plurality of the participants ($n = 65$; 45%) had abnormal TC levels (≥ 200 mg/dL) at baseline enrollments. Nevertheless, 57% ($n = 37$) with abnormal baseline TC levels reported not having been informed about those abnormal levels by a health professional.

Table 2 shows the mean weight and TC comparing baseline measures and study completion measures. The mean TC became significantly lower (194.4 ± 36.3 vs 182.1 ± 37.8; $P < 0.0001$). In contrast, mean weight was significantly higher at study completion (86.9 ± 23.6 vs 90.5 ± 24.5; $P = 0.003$).

Attrition bias analyses indicated that only age significantly differed between those who exited the study and those who completed it ($P < 0.0001$). Statistical differences between groups were not found for sex ($P = 0.3$), race ($P = 0.2$), marital status ($P = 0.2$), education ($P = 0.3$), weight ($P = 0.1$), and TC levels ($P = 0.6$).

Associations with weight changes among production workers are shown in Table 3. Workers who believed they were overweight or obese at study completion gained significantly more weight (increase of 6.7 kg vs 14.4) compared with those who believed they were of normal weight.

Those who consumed breakfast less than six times per week (the lowest tertile of breakfast consumption) lost 4.4 kg ($P = 0.058$) as compared with those eating breakfast daily. Nevertheless that association was only borderline significant. No significant associations were found between fast food consumption and weight changes. Reported physical activity at baseline was not associated with weight changes.

Associations with TC changes are reported in Table 4. TC level changes for workers who indicated "always" feeling depressed were significantly higher (112.4 mg/dL; $P = 0.009$) than those who indicated "never." Nevertheless, only two workers indicated "always" feeling depressed. Workers who indicated "often" having family problems experienced lower TC levels (−36.5 mg/dl; $P = 0.002$) as compared with those who indicated "never." Workers who believed their TC levels to be "no good" increased their TC levels (17.6 mg/dL; $P = 0.02$) compared with those who indicated "good." TC levels among female workers increased more so than among males throughout the course of the study (16.0 mg/dL; $P = 0.007$). Eating breakfast less than six times per week (the lowest tertile of breakfast consumption) was associated with reduced TC levels as compared with eating breakfast every day (−16.9 mg/dl, $P = 0.005$).

DISCUSSION

This study found that the sole characteristic associated with weight gain over the study duration is a belief they are overweight or obese. A characteristic associated with weight reduction was being overweight or obese at baseline. Characteristics associated with increases in TC levels over the study duration included female sex, belief their TC levels were "not good," and feeling depressed. Characteristics associated with TC reductions included having family problems and consuming breakfast less than six times per week. To

TABLE 1. Population Demographic Characteristics With Self-Reported Health Indicators at Study Completion ($N = 146$)

Variables	n (%)
Age, yrs	
<35	29 (19.9)
≥35 to ≤55	86 (58.9)
>55	31 (21.2)
Sex*	
Female	74 (50.7)
Male	72 (49.3)
Race*	
White	98 (67.1)
African American or Black	2 (1.4)
Asian	2 (1.4)
Pacific Islander or Native Hawaiian	15 (10.2)
Hispanic or Latino	29 (19.9)
Marital status*	
Never married (single)	23 (15.8)
Married	106 (72.6)
Divorced	13 (8.9)
Separated	4 (2.7)
Education level*	
Some high school	7 (4.8)
High school graduated or GED	68 (46.6)
Some college	57 (39.0)
College graduate (bachelor's degree or higher)	14 (9.6)
Measured BMI status, kg/m^2	
Underweight (BMI <18.5)	2 (1.4)
Normal (BMI 18.5–24.9)	19 (13.0)
Overweight (BMI 25–29.9)	41 (28.1)
Obese (BMI ≥30)	84 (57.5)
Do you know what your BMI is?	
Yes	7 (4.8)
No	139 (95.2)
Do you believe you are	
Underweight	9 (6.2)
Normal weight	31 (21.2)
Overweight	86 (58.9)
Obese	18 (12.3)
Unsure	2 (1.4)
Do you know what your current total blood cholesterol is?	
Yes	12 (8.2)
No	134 (91.8)
Do you think your total cholesterol is	
Good	67 (45.9)
Not good	26 (17.8)
Unsure	53 (36.3)
Do you currently take cholesterol-lowering medication?	
Yes	29 (19.9)
No	117 (80.1)
Restaurant or fast food consumption (per week)	
≤1	92 (63.0)
2	23 (15.8)
≥3	31 (21.2)

(*continues*)

TABLE 1. (*Continued*)

Variables	*n* (%)
Breakfast consumption (per week)	
<6	51 (34.9)
6	10 (6.9)
≥7	85 (58.2)
Fruit and vegetables combined (servings/d)	
<5	62 (42.5)
≥5	84 (57.5)
How often do you have family problems that irritate or bother you?	
Never	28 (19.2)
Sometimes	101 (69.2)
Often	14 (9.6)
Always	3 (2.0)
How often do you feel down, blue, or depressed?	
Never	54 (37.0)
Sometimes	77 (52.7)
Often	13 (8.9)
Always	2 (1.4)
How often do you feel nervous?	
Never	37 (25.4)
Sometimes	90 (61.6)
Often	18 (12.3)
Always	1 (0.7)
How satisfied are you with your job?	
Very satisfied	72 (49.3)
Somewhat satisfied	58 (39.7)
A little satisfied	13 (8.9)
Not at all satisfied	3 (2.1)
	Mean ± SD
Age, yrs	49.6 ± 10.6
BMI, kg/m^2	31.6 ± 7.4
Leisure-time physical activity, min/wk*	282.6 ± 314.3
Leisure-time physical activity, min/wk	119.6 ± 173.1

*Assessed at baseline.
BMI, body mass index; GED, General Educational Development; SD, standard deviation.

our surprise, fast food consumption was not associated with weight or TC level changes, except for breakfast consumption.

Surprisingly, baseline leisure-time physical activity was not associated with TC changes. Workers reported baseline leisure-time physical activity that met exercise guidelines[35] (mean 282.6 ± 314.3), but not at study completion (119.6 ± 173.1). A meta-analysis of 95 studies assessing exercise effects on serum lipid and lipoprotein levels found that exercise lowered cholesterol levels by 7 to 13 mg/dL compared with controls,[36,37] with larger reductions among those losing weight. Nevertheless, questionnaires assessing physical activity levels are subject to recall errors and biases. We suspect that most workers overreported their leisure-time physical activity levels.

We were also surprised that fat intake and fast food consumption were not significantly associated with TC or weight changes. Reductions in saturated fat, dietary cholesterol, and weight are considered to offer the most effective dietary strategies for reducing TC.[38,39] Nevertheless, controlled studies have reported only modest long-term reductions in TC.[37] Short-term decreases in TC of 10% to 20% have resulted from a controlled low-fat diet.[37] This study's finding may be partially due to a single assessment of dietary intake at exit among the workers.

We found significant associations between depression and increasing TC levels. These findings are somewhat concurrent with other research studies. Symptoms of depression and anxiety have been associated with decreased levels of high-density lipoprotein cholesterol and increased abdominal obesity.[40] Researchers found that anxiety is a proxy risk factor for depression severity in aggravating dyslipidemia.[40]

Less than 10% of workers reported knowing their TC levels at study exit, although all had received results from this study many years previously. Most workers (53.9%) who believed their TC was "not good" actually had normal TC levels (<200 mg/dL). Yet, considering only 57% of workers with abnormal baseline TC levels recalled having been informed of their TC levels by a physician, suggests a need for more intensive interventions.

These results also showed no significant associations between health education and changes in TC and weight. It is widely believed that awareness and knowledge of factors associated with negative health outcomes is necessary before health promotion programs can be successfully implemented.[31,41–44]

The prevalence of obesity in this working population (57.5%) was greater than the US adult population (35.7%).[1] This is also greater than the reported obesity prevalence among the general population in Utah (22.5%),[45] and is twice as high as a recently reported prevalence for US workers (27.7%).[46]

Given the impacts of BMI and TC on health care and occupational costs,[3–7] this research analyzed a target population that should

TABLE 2. Comparison of Weight and Total Cholesterol at Baseline and Study Completion ($N = 146$)

	Baseline Measures Mean ± SD	Study Completion Measures Mean ± SD	*P*
Weight, kg	86.9 ± 23.6	90.5 ± 24.5	0.003
Total cholesterol, mg/dL	194.4 ± 36.3	182.1 ± 37.8	<0.0001
	n (%)*	*n* (%)*	
<200 mg/dL	81 (55.5)	102 (69.9)	
≥200 mg/dL	65 (44.5)	44 (30.1)	

*We categorized TC based on the ATP III Classification: desirable (<200 mg/dL) and borderline high/high (≥200 mg/dL).[35]
SD, standard deviation.

TABLE 3. Multivariate Linear Regression Analyses of Associations With Weight Change* From Baseline to Study Completion

	Change in Weight (kg) From Baseline	Standard Error	*P*
Baseline age, yrs	− 0.1	0.1	0.56
Baseline BMI, kg/m^2			
Underweight	1.1	7.8	0.89
Normal weight		Reference	
Overweight	− 7.5	3.0	0.01
Obese	− 11.2	3.1	0.0003
Baseline leisure-time total physical activity, min/wk			
0–240		Reference	
240–480	3.9	2.9	0.16
>480	0.9	2.9	0.75
Sex			
Female	− 1.4	2.3	0.53
Male		Reference	
Breakfast consumed, times/wk			
<6	− 4.4	2.3	0.06
6	− 5.3	4.3	0.21
7		Reference	
Nutrition/diet education†			
Yes		Reference	
No	− 0.3	2.9	0.92
Physical fitness education†			
Yes		Reference	
No	− 0.5	2.5	0.83
Weight management education†			
Yes		Reference	
No	4.1	2.7	0.13
Do you know what your BMI is?			
Yes		Reference	
No	5.7	4.7	0.23
Do you believe you are			
Underweight	− 4.0	5.1	0.43
Normal weight		Reference	
Overweight	6.7	2.7	0.02
Obese	14.4	3.9	0.0004
Not sure or do not know	− 2.6	9.0	0.77
Do you think your total cholesterol is			
Good		Reference	
Not good	− 0.4	2.8	0.9
Unsure	1.2	2.4	0.6
Fast food consumed/wk‡			
≤1		Reference	
2	0.7	2.9	0.8
≥3	1.3	2.6	0.6
Cohort			
DUE		Reference	
LBP	− 0.4	2.3	0.9

*Weight changes = weight study completion (kg) − weight baseline (kg).
†Throughout the duration of this study, have you received any education (your doctor, the Internet, magazines, etc.)?
‡How many times do you eat restaurant or fast food in a typical week (eg, Chili's™, McDonald's™, Burger King™, or your local diner; take home leftovers count twice)?
BMI, body mass index; DUE, distal upper extremity; LBP, low back pain.

TABLE 4. Multivariate Linear Regression Analyses of Associations With TC Changes* From Baseline to Study Completion

	Change in TC (mg/dL) From Baseline	Standard Error	*P*
Baseline age, yrs	-0.7	0.3	0.04
Baseline BMI, kg/m^2			
Underweight	12.6	19.1	0.51
Normal weight		Reference	
Overweight	– 7.3	7.2	0.31
Obese	– 8.3	6.9	0.23
Baseline leisure-time total physical activity, min/wk			
0–240		Reference	
240–480	5.9	7.8	0.45
>480	9.7	7.5	0.20
Baseline cholesterol, mg/dL			
<200		Reference	
≥200	– 15.0	5.5	0.007
Sex			
Female	16.0	5.8	0.007
Male		Reference	
Nutrition/diet education†			
Yes		Reference	
No	10.0	7.7	0.19
Physical fitness education†			
Yes		Reference	
No	– 3.5	6.6	0.60
Weight management education†			
Yes		Reference	
No	– 7.6	6.8	0.27
Do you think your total cholesterol is			
Good		Reference	
Not good	17.6	7.4	0.02
Unsure	– 2.3	6.3	0.72
Do you know what your current total blood cholesterol is?			
Yes		Reference	
No	– 3.1	10.3	0.76
Do you currently take cholesterol-lowering medication?			
Yes		Reference	
No	29.0	6.8	<0.0001
Fast food consumed/wk‡			
≤1		Reference	
2	7.9	7.6	0.3
≥3	3.8	6.7	0.6
Fruit and vegetables combined (servings/d)			
<5	– 3.9	5.5	0.48
≥5		Reference	
Breakfast consumed (times/wk)			
<6	– 16.9	5.9	0.005
6	– 11.3	11.2	0.31
7		Reference	
Feeling down, blue, or depressed			
Never		Reference	
Sometimes	5.2	5.6	0.35
Often	14.7	11.0	0.18
Always	112.4	42.3	0.009

(*Continues*)

TABLE 4. (*Continued*)

	Change in TC (mg/dL) From Baseline	Standard Error	P
Family problems that irritate or bother you			
Never		Reference	
Sometimes	− 3.4	6.8	0.62
Often	− 36.5	11.6	0.002
Always	− 35.5	35.7	0.32
Cohort			
DUE		Reference	
LBP	4.6	6.3	0.46

*TC changes = study completion TC − baseline TC.
†Throughout the duration of this study, have you received any education (your doctor, the Internet, magazines, etc.)?
‡How many times do you eat restaurant or fast food in a typical week (eg, Chili's™, McDonald's™, Burger King™, or your local diner; take home leftovers count twice)?
BMI, body mass index; DUE, distal upper extremity; LBP, low back pain.

be disposed to improvements in weight, TC, and other weight-related comorbidities.

Strengths of this study include (1) anthropometric measures, (2) ability to collect data from the same population up to 9 years apart, (3) recruitment from a wide array of employment settings to improve generalizability of the results, and (4) computerized data collection methods of questionnaires.

Several factors limit these findings. Measurements were taken at two time points, which were mostly 5 to 9 years apart. We also cannot address temporal relationships for measures taken only at the exit, particularly knowledge of BMI, TC, and dietary recall. Recall error and bias may particularly affect reporting of physical activity levels. Prior evidence suggests that overweight individuals tend to overestimate their activity level.[47,48]

CONCLUSIONS

Results suggest that most of the reported associations with increases in weight and TC levels among production workers are amenable to interventions and may be a target for workplace intervention programs. The need for these programs is also warranted by the high prevalence of obesity among workers. Given that the state of Utah ranks among the lowest obesity prevalence rates in the United States, we were not only able to fill a gap in the literature but also identify a target population that is in need of weight loss interventions.

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