Long-term Effects of a Worksite Health Promotion Program for Firefighters

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***Objective*: To describe effects of 2 worksite health promotion programs for firefighters, both immediate outcomes and the long-term consequences for 4 years following the interventions. *Methods*: At baseline, 599 firefighters were assessed, randomized by fire station to control and 2 different intervention conditions, and re-evaluated with 6 annual follow-up measurements. *Results*: Both a team-centered peer-taught curriculum and an individual motivational interviewing intervention demonstrated positive effects on BMI, with team effects on nutrition behavior and physical activity at one year. Most differences between intervention and control groups dissipated at later annual assessments. However, the trajectory of behaviors across time generally was positive for all groups, consistent with lasting effects and diffusion of program benefits across experimental groups within the worksites. *Conclusions*: Although one-year programmatic effects did not remain over time, the long-term pattern of behaviors suggested these worksites as a whole were healthier more than 3 years following the interventions.**

***Key words*: worksite, dietary behaviors, physical activity, BMI**

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Physical inactivity and unhealthy nutrition are prevalent harmful behaviors in the US population, accounting for an estimated 365,000 premature deaths in 2000.[1] As health-enhancing behaviors, regular exercise and healthy eating habits share common features, and available evidence suggests a possible synergistic effect in promoting health.[2] Despite the overwhelming benefits of these behaviors, most Americans neither have a balanced diet nor exercise regularly.[3]

Contrary to public perceptions,

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Table 1
Descriptive Demographic Variables at Baseline (number or mean[sd])

Variable	MI	TEAM	Control
Age (years)[b,c]	41.9 (8.6)	39.3 (8.7)	41.3 (8.8)
Gender			
Male	195	225	159
Female	7	9	4
Ethnicity			
White/Non-Hispanic	176	210	148
Asian/Pacific Islander	7	5	4
Hispanic/Latino	5	4	6
African American	7	5	1
Native American	3	2	1
Other	2	3	1
Marital Status			
Married	159	184	128
Cohabitating	4	11	2
Single	24	20	21
Divorced/Widowed	14	17	12
Time as a firefighter (years)[c]	16.4 (8.5)	14.4 (8.7)	15.7 (8.9)
Time at current station (years)[a,c]	6.0 (7.2)	4.7 (5.8)	3.8 (4.2)

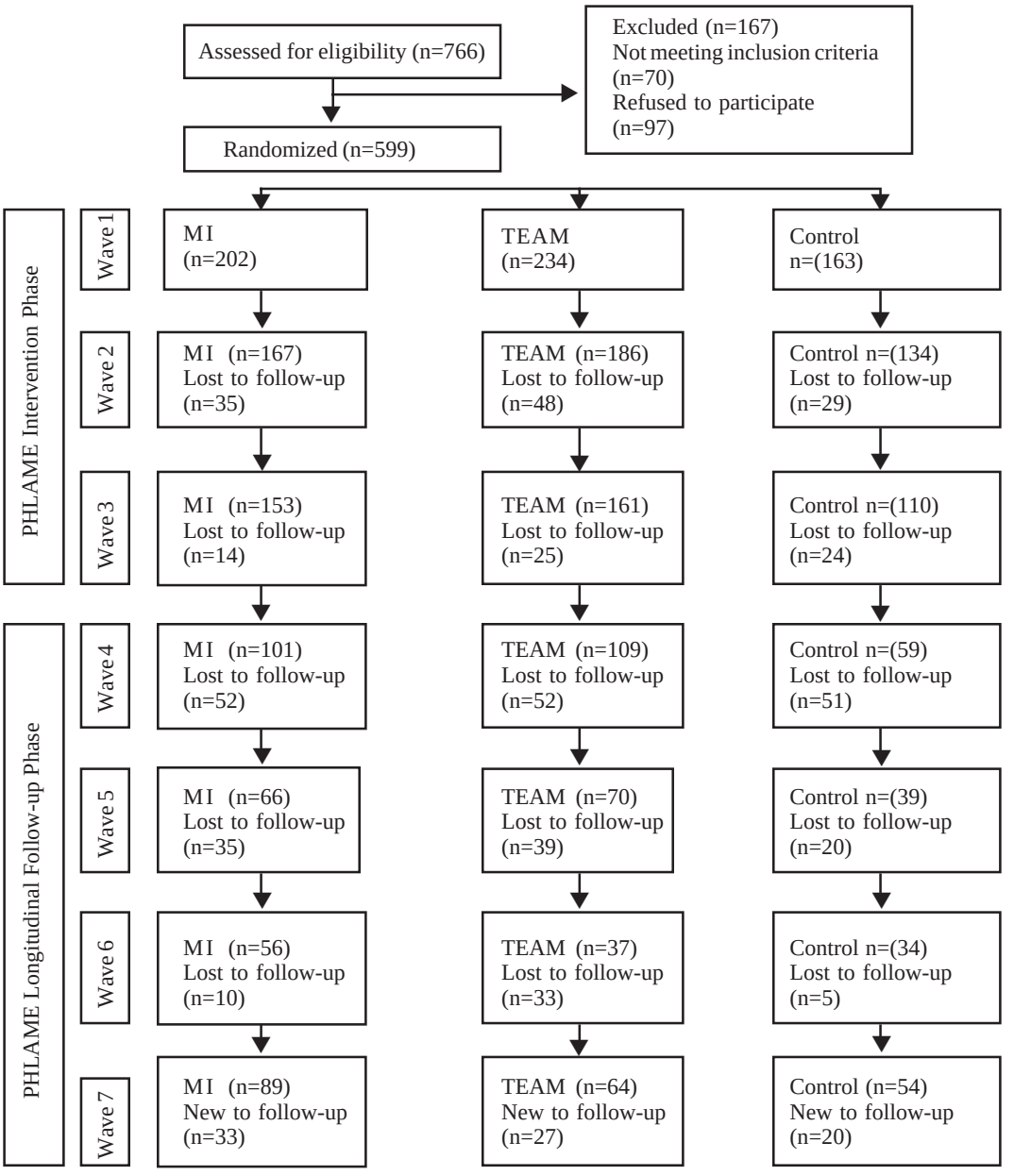
Note.
MI = Motivational interviewing and TEAM = Team-based intervention.
a = MI is significantly different from control
b = TEAM is significantly different from control
c = MI is significantly different from TEAM

firefighters are at higher risk for certain medical problems. Perhaps due to occupational exposures, the incidence of malignancies among firefighters is increased.[4,5] In addition, their cardiovascular risks are comparable to those of other worker groups,[6,7] and that risk profile, combined with episodic extremely physically demanding work, may account for myocardial infarctions being the leading cause of death fighting fires.[8] As a profession, firefighters recognize the disparity between their occupational demands and health habits.[9] However, similar to the general population, attempts to alter their unhealthy behaviors largely have been unsuccessful.[10]

This report presents outcomes of the PHLAME (Promoting Healthy Lifestyles: Alternative Models' Effects) program, a theory-based worksite health promotion intervention for firefighters. The PHLAME trial was originally funded by the National Institutes of Health as a member of the Behavior Change Consortium (BCC). BCC projects were designed to assess new means to promote healthy dietary habits and physical activity.[11] In the original PHLAME intervention trial, there were 3 study conditions: (a) control or usual care, (b) a social-influences-based team-centered curriculum, and (c) a motivational interviewing intervention. The rationale and short-term efficacy of those programs have been reported.[12-15] The team-based intervention takes advantage of the natural team structure of firefighters in order to enhance social norms conducive to proper diet and exercise. The motivational interviewing intervention focuses on improving intrinsic motivation to improve diet and exercise habit.

The PHLAME project was continued with funding from the National Cancer Institute and the Office of Behavioral and Social Sciences Research as a member of the Health Maintenance Consortium[16] to study behavior maintenance. The original PHLAME participants were assessed annually for 4 years

Figure 1
CONSORT Diagram for Participants



to evaluate maintenance of healthier habits. In this report, we present outcomes from all 7 annual data waves (baseline, 2 intervention years, and 4 follow-up years) for targeted endpoints, including self-reported diet and exercise behaviors, measured physical fitness, and body mass index (BMI).

Table 2
Scale Reliability by Measurement Wave
(unstandardized Cronbach's alpha)

	Follow-up						
Baseline	**Wave 1**	**Wave 2**	**Wave 3**	**Wave 4**	**Wave 5**	**Wave 6**	**Wave 7**
Exercise habits	.87	.88	.88	.90	.91	.87	.88
Exercise support	.89	.90	.87	.88	.87	.90	.91
Diet support	.73	.72	.71	.71	.71	.80	.77
Knowledge of fruits & vegetables benefits	.89	.92	.94	.96	.96	.93	.97

METHODS

Participants

Study participants were 599 firefighters (579 males, 20 females) from 5 fire departments in northern Oregon and southern Washington. Involvement was voluntary; all information collected was confidential, and firefighters provided written informed consent at the study enrollment and again when longitudinal follow-up began. The Institutional Review Board of the Oregon Health & Science University approved both study phases. Descriptive statistics by treatment group are listed in Table 1. The original firefighter cohort (fall of 2000) was predominately white (90.5%) and married (79%), with a mean age of 40.7 years. On average, participants had 15.4 years experience as firefighters.

Retention of participants across waves by treatment group is shown in a CONSORT diagram (Figure 1). The first 3 waves were during the intervention phase of the PHLAME study, with the primary intervention between wave 1 (baseline) and wave 2 (one year later) and a scaled-down booster program the following year. During the intervention phase, firefighters who switched stations (the unit of randomization) were excluded from analysis. Initial enrollment was high at 86% of eligible firefighters, of whom 80% were retained at one year. Between the intervention and longitudinal follow-up phase, one of the original 5 departments elected not to participate. Thus, 4 departments are represented in waves 4 through 7.

Beginning with wave 4, all participants received only annual assessments and a written health risk appraisal. As with the control condition in the initial years, firefighters were mailed their results, similar to what might occur following a physician visit. Firefighters also had access to a common Web site that provided additional information about each result, optimum values, and normative findings for firefighters. The last wave of data collection was completed in January 2008.

Measures

Anthropometric and aerobic fitness measures. Anthropometric measures were assessed at baseline and each subsequent measurement wave: height, weight, and calculated body mass index (BMI) (weight in kg/[height in meters]^2).

Aerobic capacity was assessed with measured maximal oxygen uptake during incremental treadmill exercise to maximal exertion using a SensorMedics 2900 or a MedGraphics TEEM 100 metabolic cart during waves 1, 2, 3, and 7. During other waves, maximal oxygen uptake was estimated from submaximal incremental exertion using the individuals' heart rate, workload, and perceived exertion relationships from their prior testing.[17,18]

Questionnaire. At each wave, firefighters completed a survey assessing demographics and self-reported physical activity, self-reported dietary behaviors, and other potentially influential factors. Most questions were answered using an anchored 7-point Likert-type agreement scale (strongly agree to strongly disagree). Individual items were assembled into constructs, based on our prior work and exploratory and confirmatory factor analyses. Construct scores were the items summed and divided by the total number of items. If the response

options differed across items measuring the same construct, as for dietary support, exercise support, and knowledge of fruit and vegetable benefits, each item was standardized prior to adding items for a scale. For these 3 scales, standardization was performed by subtracting the mean at baseline for all scores for all waves and dividing by the standard deviation of the baseline measure. Scales used in this report are based on the same items measured at each of the 7 waves. The reliability of constructs is shown in Table 2. Overall reliability was good across measurement waves, with all alpha values larger than 0.7. All scales were scored so that a higher value was a beneficial outcome. A list of the items making up each scale is available at http://www.public.asu.edu/%7Edavidpm/ripl/PHLAMEScaleAddendum.doc. Dietary habits were indexed using a validated screening instrument for daily servings of fruits and vegetables.[19,20]

Intervention Conditions

The PHLAME intervention rationale and activities have been described[12,14] and are summarized briefly here. Fire department workers are organized by stations; and in general, stations are staffed by 3 stable worker units, with each shift working 24 hours, followed by 48 hours off duty. The 48 stations within the 5 participating PHLAME departments, along with other administrative work groups, were randomized to 3 conditions: (a) a team-based, peer-led scripted health promotion curriculum, (b) one-on-one motivational interviewing health coaching, and (c) a testing-and-results-only comparison condition. Observations and participant responses indicated that the interventions were delivered with fidelity and were acceptable to firefighters. For both intervention groups, the behavioral objectives included eating 5 or more servings of fruits and vegetables each day, being physically active for at least 30 minutes a day, and maintaining a healthy body weight.

Team-centered curriculum (TEAM). For the team program, the intervention was delivered to a shift, with one shift member as the designated team leader. Team leaders used a scripted manual to facilitate a series of eleven 45-minute sessions, with other participants using corresponding workbooks. Each session was composed of 3 to 6 activities. The core content involved nutrition and physical activity, and 25% were scripted electives selected by the team from a menu of additional topics, eg, stress, sleep deprivation, and tobacco use. Activities were designed to be interactive, enjoyable, and consistent with principles of adult education, emphasizing relevance, active learning, and application of new abilities.[21] During the initial session, firefighters reviewed their baseline assessment and discussed goals and ways to collaborate on reaching or maintaining their objectives. During weeks without scheduled sessions, teams utilized bridging activities, such as behavior tracking and healthy games, intended to promote disclosure of outcome behaviors and reinforce PHLAME's objectives. Friendly competition and positive peer pressure were encouraged both among team members and across teams at a station. During the second year, teams received a 6-session booster curriculum, which commenced after receiving their wave 2 test results.

Firefighters' work environment is a natural fit for a team-centered intervention. A team has the potential to add to social cognitive models[22] by heightening interpersonal influences and support. Teams differ from groups in that they have interdependence among members, complementary abilities, a common commitment, mutual accountability, and an identity that results in a team's effects being greater than the sum of its members.[23]

Motivational interviewing (MI). Traditional counseling has limited efficacy when used to promote healthy nutrition and regular physical activity.[24,25] MI is a specific counseling technique designed to resolve ambiguity, establish individuals' intrinsic motivation and allow them to define a personally relevant change process.[26-29] Firefighters from stations randomized to MI met individually while at work with a counselor skilled in MI for a series of approximately 4 one-hour meetings, with the possibility of up to 5 hours of additional in-person or phone contacts. During the second study year, participants met at least twice with their MI counselor, with options for 6 additional meetings.

Comparison condition. Firefighters from control stations received their test results, accompanied by brief explana-

Table 3
Outcome Variables Across All Waves and Groups (mean [sd])

		Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 6	Wave 7
Maximum oxygen uptake (ml/kg/min)[a]	MI	38.91 (6.49)	40.95 (7.68)	43.19 (7.07)	46.13 (8.21)	46.80 (8.96)	46.99 (8.63)	44.42 (7.55)
	TEAM	38.08 (7.48)	41.34 (7.73)	42.88 (8.18)	44.35 (8.36)	45.51 (7.86)	45.52 (6.29)	44.81 (8.10)
	Control	37.40 (6.57)	39.07 (7.67)	42.41 (7.53)	43.34 (6.82)	43.88 (7.59)	42.73 (5.47)	41.21 (8.49)
Exercise habits	MI	2.65 (1.48)	2.87 (1.45)	3.11 (1.41)	2.94 (1.46)	3.39 (1.47)	3.47 (1.43)	3.34 (1.41)
	TEAM	2.87 (1.53)	3.17 (1.48)	3.07 (1.42)	3.17 (1.42)	3.35 (1.42)	3.57 (1.35)	3.44 (1.41)
	Control	2.61 (1.40)	2.86 (1.50)	2.97 (1.45)	3.42 (1.49)	3.38 (1.52)	3.15 (1.46)	2.83 (1.33)
Exercise support [a,b]	MI	0.01 (0.88)	0.05 (0.96)	0.10 (0.85)	0.18 (0.98)	0.70 (0.89)	0.33 (0.90)	0.39 (1.00)
	TEAM	0.05 (0.86)	0.05 (0.84)	0.14 (0.83)	0.11 (0.90)	0.10 (0.82)	0.40 (1.03)	0.52 (0.99)
	Control	-0.23 (0.81)	-0.25 (0.80)	0.09 (0.89)	0.02 (0.96)	0.08 (0.87)	0.22 (1.01)	0.31 (0.82)
Fruits & vegetables intake (servings/day)	MI	5.65 (3.31)	6.20 (3.64)	6.55 (4.41)	6.82 (4.40)	8.21 (4.91)	6.56 (3.32)	6.60 (4.17)
	TEAM	5.75 (3.32)	7.34 (4.54)	6.80 (3.83)	7.37 (4.57)	7.60 (4.19)	8.47 (5.44)	8.30 (4.64)
	Control	5.60 (3.50)	5.84 (3.73)	6.31 (3.68)	7.37 (4.16)	6.49 (3.80)	6.60 (3.33)	6.56 (4.98)
Dietary support	MI	-0.07 (0.75)	0.18 (0.68)	0.39 (0.64)	0.47 (0.67)	0.40 (0.57)	0.35 (0.75)	0.34 (0.75)
	TEAM	0.01 (0.71)	0.35 (0.66)	0.47 (0.66)	0.27 (0.69)	0.37 (0.69)	0.35 (0.75)	0.21 (0.76)
	Control	-0.01 (0.81)	0.17 (0.77)	0.21 (0.74)	0.23 (0.73)	0.22 (0.68)	0.31 (0.72)	0.38 (0.72)
Knowledge of fruits & vegetables benefits	MI	0.06 (0.83)	0.09 (0.92)	0.22 (0.92)	0.22 (1.03)	0.46 (0.86)	0.44 (0.70)	0.14 (1.20)
	TEAM	-0.05 (0.87)	0.34 (0.85)	0.39 (0.94)	0.25 (1.14)	0.26 (0.93)	0.45 (0.85)	0.31 (0.94)
	Control	0.07 (0.77)	0.06 (0.81)	0.27 (0.85)	0.41 (0.86)	0.38 (0.79)	0.58 (0.70)	0.41 (0.75)
BMI [a]	MI	27.24 (3.31)	27.30 (3.35)	27.46 (3.66)	27.33 (3.19)	26.59 (2.33)	27.03 (3.27)	27.41 (3.06)
	TEAM	27.78 (3.97)	27.51 (3.92)	27.69 (3.81)	27.35 (3.86)	27.75 (4.00)	27.26 (3.69)	27.09 (4.15)
	Control	28.34 (3.75)	28.38 (4.00)	28.05 (3.89)	27.88 (2.75)	27.55 (2.57)	27.58 (2.57)	27.86 (2.59)

Note.
a = MI is significantly different from control
b = TEAM is significantly different from control

tions and a listing of normal values. Control participants were informed that they were free to use their test results and take their own initiative to alter their lifestyles.

Statistical Analysis

Baseline differences between groups were assessed with t-tests. The focus of the longitudinal analysis was 2 contrasts: (a) comparison of the TEAM intervention and the control group and (b) comparison of the MI intervention and control group. These 2 contrasts were tested using a multilevel model with adjustment for baseline dependent variable measures and clustering of observations in stations. The analysis of covariance model assumes that any baseline differences were due to random error, and generally it is the correct model because there was random condition assignment. However, if baseline differences are found, it is possible that the randomization was not ideal in balancing observed covariates. If statistically significant baseline differences were observed between groups, a difference score model also was estimated to investigate whether differences over time were attributable to stable baseline differences. Results are presented in Table 4 for the analysis of covariance, and difference score models are described in the text when there were baseline differences between groups.

Age was a predictor of missingness, because firefighters who retired were absent from later waves, and accordingly, age was a covariate in all analyses. The analysis used all available measures, including data from participants who were not measured at all waves.

RESULTS

Baseline Measurements

Firefighters were comparable to US adults in their body weights. The average BMI for the entire sample at baseline was 27.7, slightly higher than the national average of 26.6.[30] At baseline, participants' average consumption of fruits and vegetables was 5.6 servings a day, and

Table 4
Program Effect Estimates (standard error) for Baseline Adjusted Analysis of Covariance Model

	Motivational Interviewing Group Compared to the Control Group at Each Wave					
	Measurement Wave					
	2	3	4	5	6	7
Maximum oxygen uptake	0.70 (0.65)	0.70 (0.71)	**2.39 (0.87)**	**2.29 (1.09)**	**3.36 (1.24)**	**1.98 (0.99)**
Exercise habits	0.13 (0.15)	**0.32 (0.16)**	-0.12 (0.20)	-0.06 (0.22)	0.24 (0.26)	**0.61 (0.20)**
Exercise support	**0.20 (0.12)**	0.00 (0.12)	0.05 (0.15)	**0.40 (0.17)**	-0.03 (0.19)	0.09 (0.17)
Total daily servings f & v	0.62 (0.48)	0.52 (0.51)	0.31 (0.64)	**1.67 (0.74)**	.10 (0.84)	0.39 (0.68)
Diet support	0.04 (0.08)	**0.20 (0.09)**	0.10 (0.11)	-0.07 (0.14)	-0.08 (0.15)	-0.02 (0.13)
Knowledge of f & v benefits	0.08 (0.11)	-0.01 (0.12)	-0.13 (0.15)	0.11 (0.18)	-0.09 (0.20)	-0.14 (0.16)
BMI	**-0.37 (0.18)**	-0.15 (0.19)	-0.06 (0.24)	-0.21 (0.28)	-0.17 (0.30)	**-0.56 (0.26)**

	Team Intervention Group Compared to the Control Group at Each Wave					
	Measurement Wave					
	2	3	4	5	6	7
Maximum oxygen uptake	0.81 (0.64)	-0.03 (0.70)	0.62 (0.85)	0.51 (1.10)	1.15 (1.37)	1.30 (1.04)
Exercise habits	0.19 (0.14)	0.09 (0.15)	-0.16 (0.20)	-0.02 (0.22)	0.14 (0.28)	0.38 (0.22)
Exercise support	0.16 (0.11)	-0.02 (0.12)	0.00 (0.15)	-0.03 (0.17)	0.18 (0.20)	0.26 (0.18)
Total daily servings f & v	**1.45 (0.47)**	0.67 (0.50)	0.67 (0.63)	0.58 (0.73)	0.71 (0.89)	0.58 (0.74)
Diet support	**0.21 (0.08)**	**0.27 (0.08)**	-0.07 (0.11)	0.04 (0.14)	-0.11 (0.16)	-0.20 (0.14)
Knowledge of f & v benefits	**0.31 (0.11)**	0.19 (0.12)	-0.06 (0.15)	-0.04 (0.17)	-0.00 (0.22)	-0.13 (0.18)
BMI	**-0.38 (0.18)**	0.11 (0.19)	-0.07 (0.23)	-0.15 (0.28)	0.02 (0.33)	-0.26 (0.28)

Notes.
Table entries are the difference between treatment group and the control group adjusted for baseline measures and covariates.
Bold indicates coefficients statistically significant at the P<0.05 level.

less than one-third (28%) consumed the recommended 5 servings a day, compared to the national average of 23% for adult males.[31-33] Firefighters also did slightly better than the national average for their exercise habits. More than half (55%) performed at least 30 minutes of moderate exercise 5 times per week or 20 minutes of intense exercise at least 3 times per week.[32]

Baseline demographic variables across experimental groups were comparable. Although statistical differences were observed, those were small in magnitude (Table 1). Table 3 shows the unadjusted group means (no adjustment for missing data, clustering, or other covariates) for the study outcomes by group at baseline and across the 6 following annual measurement waves. Of the 21 potential baseline differences, the MI and control group differed significantly for knowledge of fruit and vegetable benefits and maximum oxygen uptake; TEAM and control group differed significantly only for maximum oxygen uptake. When age was included as a covariate, these baseline differences remained. No other outcome variables differed significantly at baseline.

Program Effects

Table 4 shows program effects for MI compared to control and for TEAM compared to control during each follow-up wave. The estimates accounted for clustering of firefighters in stations, age, and the baseline measure of the variable; those included are firefighters with baseline and at least one additional follow-up measurement.

Wave 2 findings represent the short-term program effects at one year, and both interventions achieved significant benefits on BMI for the analysis of covariance model. For the difference score model, the effect on BMI was marginally significant (P=.06) for the TEAM condition. In contrast, for the difference score

model, the MI effect estimate was close to zero and nonsignificant, suggesting that the baseline difference between the MI and control conditions was maintained at the follow-up. The TEAM participants also reported significantly more daily servings of fruit and vegetables, greater dietary support, and knowledge of benefits of eating fruits and vegetables. Across subsequent annual assessments, although significant differences were seen in some waves, other than a sustained benefit in aerobic endurance (measured maximum oxygen uptake) among the MI participants, few intervention benefits were maintained. When a difference score model was estimated, the effect on aerobic endurance measure for the MI group was no longer statistically significant, consistent with baseline differences between the MI and control group being maintained at later waves. Although not all effects were statistically significant at Wave 2, all effect estimates were in a positive direction.

Several patterns in the program effects were promising. Means in Table 3 demonstrate that firefighters in all groups improved health behaviors over the entire study, including control participants. These patterns are presented in Figure 2 (A – F), which depicts selected outcomes by condition over time.

In general, when differences are not maintained in longitudinal studies, the interpretation is that intervention-group benefits were not sustained. However, the figures indicate a different pattern, and the Y axes also provide an index of the magnitude of change over time. Figure 2 A is the objective measure of aerobic endurance. Both intervention groups, and to a lesser extent the control condition, appeared to increase their fitness following the intervention years, with some decrement in the final assessment.

Without regular training, an aging cohort would be anticipated to experience a decrease in aerobic endurance of approximately 1% per year.[34,35] The observed increase among PHLAME participants might represent changing demographics, with a younger mean age. However, Figure 2 F depicts the average age for the 3 groups across time, and it demonstrates that as expected, the PHLAME population's age increased.

Figure 2 C shows daily servings of fruits and vegetables. Although no statistical difference was observed between the interventions and control condition at latter waves, both interventions reported more servings of fruits and vegetables compared to controls at most time points. In general, TEAM participants appeared on a sustained upward trajectory, and MI and control groups' daily intakes in the final wave were approximately one serving per day greater than baseline levels. Population studies indicate increases of 0.3 servings per day may have significant health benefits.[36]

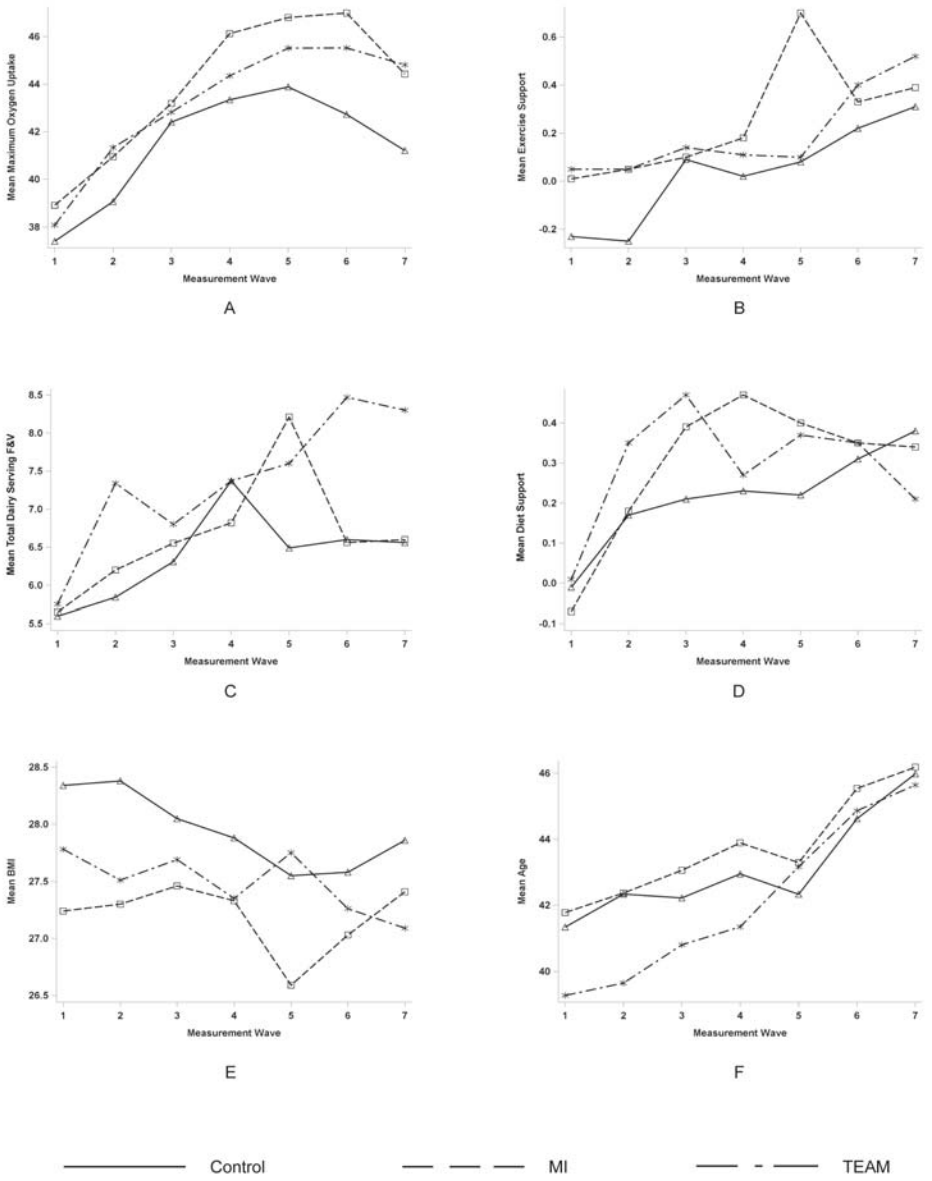
Finally, Figure 2 E presents the BMI for each group across the 7 study measurement waves. Population trends indicate that BMI would be expected to have increased approximately one BMI unit (representing an 8-pound weight gain) over the 7 waves among this aging cohort.[30,37,38] The social support constructs for regular physical activity and healthy eating habits (Figure 2 B and D, respectively) also appeared to show upward trends across the 7 annual assessments.

DISCUSSION

As previously reported, both a worksite team-centered curriculum and one-on-one motivational interviewing achieved positive outcomes in this relatively healthy group of firefighters.[13,14] Few studies have assessed dietary and physical activity behaviors more than one or 2 years following interventions, and in general, effects have not been maintained.[39-42] Annual comparison of PHLAME intervention to control groups following these successful interventions indicated that initial program-specific positive effects were lost by the fourth wave of data collection.

Limitations often inherent in longitudinal studies may have contributed to that finding. No booster interventions were delivered after initial program delivery. Participant loss due to retiring, changing jobs, and tiring of the repeated measurements may limit study power in long-term investigations. Despite a stable occupational cohort and our strong working relationships with participants, one entire department was lost to follow-up. At the fifth, sixth, and seventh wave there were 175, 127, and 207 firefighters measured, which limited power to detect program effects at later years. The use of an analysis that included even partial data improved power, but attrition may have limited identifying significant effects at

Figure 2
Longitudinal Changes in Outcome Variables by Groups across Study Waves



later waves.

However, the pattern of PHLAME outcomes over time suggests that rather than intervention groups returning to baseline levels, control participant improvement also contributed to lack of sustained intervention effects. Contrary to predicted changes in these aging participants, across groups, weights did not vary, eating habits improved, and objectively measured fitness levels increased. Two factors may have contributed to these observed changes. The first relates to study design, high participation rate at enrollment, and potential unique characteristics of fire departments. The randomization unit was fire stations within departments, and although geographically dispersed, over time, station members communicated due to transfers and cross talk at department-wide trainings. Thus, there were opportunities for admixing of study groups. A critique of prior worksite studies is their limited external validity, noting that those participating often are individuals already interested in changing their behaviors.[43-45] Unlike many occupational wellness programs, our study participation was high at the outset, which may have allowed maintaining healthier behavioral norms and sustained positive environmental influences at stations. In addition, as workers, firefighters have traditions of adopting uniform work habits, which, over follow-up years, may have further facilitated treatment diffusion to control groups.

All conditions also received annual testing and their personalized results. In general, worksite health assessments and feedback on dietary habits, fitness levels, and body weight increase awareness but have limited effect on behavior.[46-50] The Centers for Disease Control critically reviewed the evidence that risk assessment with feedback altered behavior and concluded that this type of intervention did not change health habits.[51] Although not sufficient to change behavior, repeated assessment combined with healthier coworkers' behaviors may have been an intervention in its own right. In that context, all conditions may have received a powerful intervention.

Our study has limitations. Firefighters have a unique work structure, and local demographics resulted in narrow distributions by gender, race, and ethnicity. In addition, it is possible that findings represented secular trends in firefighters' behaviors. Local and nationwide data are not available to assess that hypothesis, but available information concerning cardiovascular risks and obesity prevalence among other firefighter cohorts suggests that their risk profiles parallel population trends and have not improved.[52] As in other studies, the self-report measures in this report are subject to social desirability bias, but there was not reason to believe that these biases would differ across groups. A modern approach to incorporate partial and complete data across waves was used in the analysis, but there may still be some unknown influence on attrition that could affect results. There were several tests for significance conducted in this research which increase the risk of a type I error. However, beneficial intervention effects were primarily expected at the first 2 follow-ups when the interventions would have stronger effects, and there was less attrition at these earlier waves.

The PHLAME program was designed to evaluate 2 health interventions for firefighters, each based on different theories of behavior change. There was evidence that both programs led to immediate benefits, with more widespread effects from the team intervention. Long-term results suggest that firefighters from all experimental conditions continued to improve for several years following the programs. A *tipping point* describes a situation in which an incremental change past a threshold produces a nonlinear and much larger effect, for example as occurs with climate change[53] and insect social behavior.[54] The PHLAME longitudinal findings indicate that involving 2 thirds of employees from these unique worksites in effective interventions may have surpassed a tipping point in achieving and maintaining positive health behaviors for all workers.

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