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Walking attenuates the relationships of high-meat, low-fruit dietary intake to total and regional adiposity in men and women

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Abstract

Vigorous physical activity (running) has been shown to attenuate the association between diet and body weight. Walking is the most popular physical activity, but is a moderate-intensity physical activity because it requires less than six-fold the energy expenditure of sitting at rest. We therefore examined whether reported distance walked per week affected the relationship of diet to BMI and circumferences of the waist, hip, and chest in 30,014 female and 7,133 male participants of the National Walkers' Health Study. Reported meat and fruit intakes served as indicators of high-risk diets for weight gain. The analyses showed that higher meat and lower fruit intake were significantly and consistently associated with greater BMI and waist circumference at all activity levels. Longer usual walking distance significantly attenuated the concordant relationships of diet with women's BMIs ($P < 10^{-8}$), men's BMIs ($P = 0.04$), and women's waist ($P < 10^{-6}$), hip ($P = 0.0001$) and chest circumferences ($P < 10^{-5}$). Compared to walkers who averaged < 1.5 km/d, the association of diet with adiposity in subjects who walked > 1.5 km/d was reduced 21% in women and 31% in men for BMI; 20% in women and 27% in men for waist circumference; 19% for woman's hip circumference; and 26% for women's chest circumference. Thus we conclude that diets characterized by high-meat/low-fruit intake were significantly associated with greater BMI, and this association was attenuated by moderate physical activity. The weaker results in men than women probably related to the smaller sample size, and reduced statistical power of the men.

Keywords

diet; physical activity; prevention; obesity

Introduction

The primary dietary determinant of body fat has been ascribed to energy density [1], although others suggest the evidence for this is inconclusive [2]. Prospectively, weight gain has also been associated with higher meat and lower fruit, vegetable and starchy food intake [2–7]. The epidemiological evidence relating adiposity to dietary intake is weaker for fruit than for meat [2,4,5,8]. These foods may be directly causative, or they may be indicative of high and low energy-density diets.

We have previously reported that BMI increased in association with greater meat and lesser fruit consumption, and that these relationships were attenuated by running [9,10]. Running is defined as vigorous exercise because its energy expenditure exceeds 6 METs, where 1 MET

Conflict of Interest

No industrial relationship to report. PT Williams was responsible for all aspects of the study.

is the energy expenditure of sitting at rest ($1 \text{ MET} = 3.5 \text{ ml O}_2 \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ consumption) [11–13]. Moderate-intensity physical activity requires between 3 to 6 METs [13]. Whereas energy for more-vigorously intense exercise ($\sim 70\% \text{ VO}_{2\text{max}}$) is supplied primarily by glucose, glycogen, and some fat, energy for more-moderately intense exercise ($40\% < \text{VO}_{2\text{max}} < 60\%$) is supplied by fats from adipose tissue and intramuscular stores [14]. This and other differences between moderate-intensity and vigorous-intensity physical activity could affect their relationships to body weight.

The attenuating effect of moderate-intensity exercise in preventing weight gain due to high-risk diets is not currently recognized, and may provide an important intervention tool for combating obesity in the obeseogenic environment. Walking is a moderate intensity physical activity, and it is the most common physical activity performed by Americans [15]. In addition, walking is predictive of lower risk of incident total mortality and cardiovascular disease [16]. Brisk walking is specifically recommended by the Institute of Medicine guidelines for weight maintenance [17] the American Heart Association and the American College of Sports Medicine guidelines for improved health [12], and the 2008 physical activity guidelines for Americans [18]. Walking may be more attractive and readily adopted by overweight and obese individuals who find the prospect of vigorous physical activity daunting [19]. We therefore examined the interactions between diet, walking and total and regional adiposity to assess whether the attenuating effects observed for running are applicable to walking as well.

Subjects and Materials

A two-page mailed questionnaire, sent to subscribers of a walking magazine and to participants of walking events, solicited information on demographics (age, race, education), walking history (age when began walking at least 12 miles per week, current average weekly mileage), weight history (greatest and current weight; weight when started walking; least weight as a walker; body circumferences of the chest, waist, and hips; bra cup size), diet (vegetarianism and the current weekly intakes of alcohol, red meat, fish, fruit, vitamin C, vitamin E, and aspirin), current and past cigarette use, history of heart attacks and cancer, and medications for blood pressure, thyroid, cholesterol, or diabetes [20–22]. Walking distances were reported in miles per week, body circumferences in inches, and body weights in pounds. These values were converted to kilometers per day, centimeters, and kilograms, respectively. The analyses were restricted to nonsmoking, non-diabetic subjects who provided completed data on height, weight, education, and intakes of meat, fruit and alcohol.

Intakes of meat and fruit were based on the questions “During an average week, how many servings of beef, lamb, or pork do you eat”, and “...pieces of fruit do you eat”. Alcohol intake was estimated from the corresponding questions for 4-oz. (112 ml) glasses of wine, 12-oz. (336 ml) bottles of beer, and mixed drinks and liqueurs. Alcohol was computed as 10.8 g per 4-oz glass of wine, 13.2 g per 12 oz. bottle of beer and 15.1 g per mixed drink. Correlations between these responses and values obtained from 4-day diet records in 110 men were $r=0.46$ and $r=0.38$ for consumptions of meat and fruit, respectively. These values agree favorably with published correlations between food records and more extensive food frequency questionnaires for red meat ($r=0.50$), and somewhat less favorably for fruit intake ($r=0.50$) [23].

The walkers’ BMIs were calculated as the weight in kilograms divided by height in meters squared. Self-reported body circumferences of the waist, hip, and chest were in response to the question “Please provide, to the best of your ability, your body circumferences in inches” without further instruction. Self-reported height and weight from the questionnaire have been found previously to correlate strongly with their clinic measurements ($r=0.96$ for

both) [24]. Self-reported waist and hip circumferences are somewhat less precise as indicated by their correlations with self-reported circumferences on a second questionnaire ($r=0.84$ and $r=0.79$, respectively) and with their clinic measurements ($r=0.68$ and $r=0.63$, respectively) [24]. Self-reported chest circumferences also demonstrate strong test-retest correlations across repeated questionnaires ($r=0.93$) and somewhat weaker correlation relative to their clinic measurement ($r=0.77$) [24]. The study protocol was reviewed by the University of California Berkeley committee for the protection of human subjects, and all subjects provided a signed a statement of informed consent.

Statistical analyses

Results are presented as mean $\pm$ SE or slopes $\pm$ SE except where noted. With the exception of the sample description of Table 1, all analyses are adjusted for age (age and age²), education, and alcohol intake, and all analyses are sex-specific. Multiple linear regression analyses were used to estimate the relationship between the walkers' BMI and body circumferences (dependent variables) and their reported meat or fruit intake (independent variables) when adjusted for age, education, and alcohol consumption (covariates). The sample was divided into walking increments of < 1.5 km/d, 1.5–3, 3–4.5, and >4.5 km/day and regression coefficients for meat or fruit were calculated separately within each stratum. To test whether the regression slope differed significantly by distance walked, we combined the data over all distance categories tested whether the coefficient for the interaction between exercise and diet (i.e., “fruit x distance walked” or “meat x distance walked”) differed significantly from zero in a model that also included the separate main effects of exercise (distance walked) and diet (fruit or meat). Thus the formal test for a significant exercise by diet interaction treated walking distance as a continuous variable, whereas the stratified analyses for illustrating the differences in slope treated walking distance as a categorical variable. We also created a composite variable that combined meat and fruit intake into a single dietary index. Specifically, multiple linear regression analyses was used to estimate the best linear combination of meat and fruit intake for predicting BMI or body circumferences within the least-active distance category (<1.5 km/day), i.e., where the walkers' BMI or body circumferences were the dependent variables and their reported meat and fruit intake were the independent variables when adjusted for age, education, and alcohol consumption. Separate dietary indices were computed for males and females and for BMI and each circumference variable. The same dietary index was applied to all walkers (i.e., irrespective of their reported distance walked) and used to estimate the regression slope for BMI vs. the dietary index within each distance category, and to test for an exercise by diet interaction as described above for meat and fruit. Virtually identical significance levels were obtained for distance by dietary index interactions when the coefficients for the index were calculated on all the data rather than just the least active walkers. All analyses were performed separately for males and females.

Results

There were 30,014 female and 7,133 male nonsmoking, nondiabetic participants of the National Walkers' Health Study who provided completed data on height, weight, education, and intakes of meat, fruit and alcohol. Approximately 3.2% of the sample was excluded for missing data for one or more of these variables. Table 1 displays their sample characteristics by reported walking distance. The least active walkers tended to drink less, consume more meat and less fruit, be more overweight, and if female be slightly older and very slightly less educated. Seventeen and nine-tenths percent (17.9%) of the women reported consuming 0 servings of meat per day, 56.9% reported 0.01 to 0.5 serving/day, 22.1% reported 0.51 to 1.0 servings/day, and 3.1% reported >1 servings/day. The corresponding percentages for men were 13.4%, 53.2%, 27.4%, and 6.1%, respectively. Average daily fruit consumption for

women and men respectively, were reported as follows: 2.9% and 4.2% reported zero intake, 38.0% and 41.0% reported 0.1 to 1 pieces, 33.7% and 30.7% reported 1.1 to 2 pieces, 18.4% and 16.3% reported 2.1 to 3 pieces, and 7.0% and 7.9% reported >3 pieces/day.

Associations with reported intakes of meat and fruit in the least active walkers

Table 2 presents regression slopes of BMI and body circumferences vs. daily servings of meat and fruit by walking distance category. The least active category walked < 1.5 km/d. Within this group, the women's and men's BMI and body circumference increased significantly in association with both higher meat intake and lower fruit intake. The one exception was men's fruit intake with chest circumference. The regression analyses of Table 3 included both foods simultaneously in the analyses, and show that meat and fruit contributed independently to BMI and body circumferences in these low-mileage walkers. In fact, their coefficients differed little from their separate regression analyses of Table 2.

Attenuation of diet-weight relationships at higher activity levels

Table 2 also displays the regression slopes relating diet to BMI and body circumferences at different activity levels, and the significance of the interaction between distance walked and diet on body size. In women, the analyses suggest that walking greater distances significantly reduced the association of meat and fruit with BMI and all body circumference measurements. The reduced dietary effect with walking was also observed in men, the interaction usually failed to achieve statistical significance. Most of the interaction appeared to be due to reduced impact of diet from walking 1.5 km/day vis-à-vis shorter distances.

The analyses of Table 2 do not show whether higher BMI and larger body circumferences were directly related to high meat and low fruit intake, or whether meat and fruit content are simply indicators of diets that increase the risk for weight gain. Assuming the latter, the linear combinations of Table 3 provide the best predictors of BMI and body circumferences, and serve as indicators of high-risk diets. For example, the Table shows that the best predictor of BMI was “2.30*meat-0.35* fruit” in women and “1.75* meat-0.34* fruit” in men. These linear combinations were used to define the dietary indices for the analyses that follow. Separate indices were calculated for male and female walkers, and for BMI and each body circumference.

The indices were used to produce the bar graphs of Figures 1 and 2, which shows the attenuating effects of walking on the diet-weight relationships. The analyses are the same as those presented in Table 2, except that the high-risk diet index replace meat and fruit. The coefficient (slope) for the <1.5 km/d walking category is always equal to one because it represents the subset of walkers used to create the index. Coefficients (slopes) less than one measure the percent attenuation associated with walking, i.e., the degree to which exercise reduces the apparent effect of the high-risk diet on BMI and body circumferences. For example, the relationship between the women's dietary index and BMI was given by the slope $1.0 \cdot (2.30 \cdot \text{meat} - 0.34 \cdot \text{fruit})$ for <1.5 km/d, $0.73 \cdot (2.30 \cdot \text{meat} - 0.34 \cdot \text{fruit})$ for 1.5–3 km/d, $0.72 \cdot (2.30 \cdot \text{meat} - 0.34 \cdot \text{fruit})$ for 3–4.5 km/d, and $0.76 \cdot (2.30 \cdot \text{meat} - 0.34 \cdot \text{fruit})$ for 4.5 km/d. Thus relative to the women who walked <1.5 km/d, the relationship of the high-risk diet to BMI was reduced by 27% in those who walked 1.5–3 km/d, 28% for those who walked 3–4.5 km/d, and 24% for those who exceeded 4.5 km/d. This represented a highly significant decline in the relationship of diet to BMI with increasing exercise ($P < 10^{-8}$). Comparable reductions were obtained in men, albeit with much weaker statistical significance. The graph shows that most of the attenuating effect was achieved by walking 1.5 km/d vis-à-vis <1.5 km/d. Specifically, exceeding 1.5 km/d reduced the effect of diet on BMI by 21% in women ($P = 0.0002$), and a 31% in men ($P = 0.04$). The much more significant diet by exercise interaction for women's BMI in Figure 1 comes from analyzing the effect of

distance walked as a continuous rather than a dichotomous variable. Walking also appeared to attenuate the association of diet with circumferences of the waist (Figure 1, $P < 10^{-6}$), hip (Figure 2, $P = 0.0001$) and chest (Figure 2, $P < 10^{-15}$), with the majority of the attenuation due to walking 1.5 km/d.

Self-selection

Because these analyses are cross-sectional, it is possible that self-selection led to the observed associations of Figures 1 and 2. These analyses were therefore repeated when adjusted for the walkers' pre-exercise BMI (i.e., BMI when they first started walking 12 or more miles per week). These analyses suggested that self-selection did not account for the observed association. Specifically, the attenuating effect of exercise on the diet-BMI relationships remained significant when adjusted for their pre-exercise BMI (females: $P < 10^{-4}$; males: $P = 0.0003$). Corresponding analyses that adjusted for the women's pre-exercise body circumferences also suggest that self-selection did not account for the attenuating effect of walking on the relationship of diet to women's waist ($P = 0.006$) and chest circumferences ($P = 0.0001$), but did marginalize the significance of the women's diet-exercise interaction for hip circumference ($P = 0.06$).

Discussion

Consistent with prospective epidemiological data [2–7], the associations of Table 2 show that BMI was concordantly related to average meat intake and inversely related to average fruit intake. The significant associations were, in fact, replicated in eight separate subsets (e.g., females < 1.5 km/d, females 1.5–3 km/d, ..., males > 4.5 km/d). Meat intake was also associated with circumferences of the waist, hip, and chest in all but one of the subsets of Table 2. The associations of body circumferences with fruit intake were more variable, consistent with other reports [2,4,5,8]. The limited dietary assessment used in the survey does not allow us to identify whether meat or fruit intake were specifically responsible, and therefore we also considered their combined effects in a dietary index. The dietary index may reflect high vs. low energy-dense food, or greater fast-food or restaurant-prepared than home-prepared food consumption. More generally, the cross-sectional design precludes us from proving a causal relationship between diet and BMI or body circumferences from our data.

These analyses showed that moderate-intensity physical activity significantly attenuated the association of BMI with higher meat and lower fruit consumption, thereby extending our initial observation based vigorous-intensity physical activity (running) to moderate-intensity physical activity (walking) [9,10]. They also extend our findings by showing moderate exercise attenuated the relationship between women's waist, hip and chest circumferences with diet (the original finding in runners was limited to men) [9]. Although the body circumference results for men were generally consistent with those for women, in the current study they often failed to achieve statistical significance, which is not necessarily unexpected since the sample size for men represented less than one-fourth of that of the women.

We have previously reported that distance walked was inversely related to BMI and body circumferences of both the women and men of this sample [20,21]. Among women, the estimated percent reductions from walking were greatest for BMI, intermediate for waist circumference and least for hip and chest circumferences, and all of the relationships were nonlinear (convex) [20]. Others have also shown walking distance to be inversely related to adiposity in men and women [25,26]. In part, this may be due to the attenuated effects of obesity risk factors, e.g., we have shown that walking attenuates the risk for a parental history of obesity in this cohort [27]. The current results suggest an additional positive effect

of walking to prevent adiposity. The diminished effect of dietary composition on the BMI of higher mileage walkers could be due to improved fat oxidation with exercise [28,29], improved coupling between energy intake and expenditure, such that episodic intakes of energy-dense foods are balanced by reduced energy intake at other times [30–32], or simply greater energy expenditure.

Caveats

The cross-sectional nature of the current analyses prevents our drawing causal inference between walking distance, diet, and adiposity. It is possible that lean individuals may self-select to walk longer distances, prior analyses of these walkers suggest that self-selection accounts for 40% of the association between walking distance and BMI in women, and 17% in men [33]. However, our inability to attribute the observed associations to the walkers' pre-exercise BMI and body circumferences argues against self-selection. We also caution that other dietary components shown by others to be associated prospectively with weight gain were not recorded and therefore were not included in the analyses, including higher potato chips, potatoes, sugar-sweetened beverages and lower vegetable, whole grain, fruit, nut, and yogurt consumption [7].

In conclusion, these observations suggest an important health benefit of regular walking: the apparent greater resistance to diet-induced obesity. This benefit has not been heretofore recognized among the multiple health benefits currently ascribed to physical activity. Walking 1.5 km/day (430 MET minutes) is slightly less than the 450 MET minutes of physical activity currently recommended by the American Heart Association and the American College of Sports Medicine for health benefits [12]. Our previous analyses of runners suggest that higher doses of more vigorous exercise produces even greater attenuation of the dietary influences on obesity [9,10]. Nevertheless, the current results show that for the greater number of Americans who walk than run for exercise, their activity may diminish the effects of poor dietary choices on their risks for unhealthy weight gain and obesity. This benefit may be especially important given the plethora of unhealthy food choices and fast food options that dominate the Western Societies. Patients should be encouraged to perform at a minimum 450 to 750 MET minutes per week of physical activity as currently recommended [12].

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Figure 1.

Bar chart of the regression slopes for BMI and waist circumference vs. the high-risk diet index for different walking distances. Significance levels above the bars represent the significance of the slope within the distance interval. The significance of the diet x exercise interaction tests whether the BMI or waist circumference increase per unit increase in diet differs by walking distance.

Figure 2.

Bar chart of the regression slope for women's hip and chest circumference vs. the high-risk diet index for different walking distances. Significance levels above the bars represent the significance of the slope within the distance interval. The significance of the exercise x diet interaction tests whether the circumference increase per unit increase in diet differs by walking distance.

Table 1

Characteristics (mean±SD) of subjects by average distance walked per day.

	Distance walked (km/day)				Significance (P)
	<1.5	1.5-3	3-4.5	>4.5	
Females					
Sample	8711	9121	5602	6580	
Age (years)	50.96±14.13	50.50±12.82	50.50±12.46	49.64±11.91	<10 ⁻⁵
Education (years)	15.02±2.53	15.25±2.49	15.11±2.50	14.91±2.49	0.005
Alcohol (g/day)	4.40±9.26	5.60±9.95	5.80±10.08	6.07±11.46	<10 ⁻¹⁵
Meat (servings/day)	0.41±0.39	0.38±0.37	0.34±0.33	0.31±0.33	<10 ⁻¹⁵
Fruit (pieces/day)	1.39±1.05	1.61±1.10	1.66±1.07	1.77±1.20	<10 ⁻¹⁵
BMI (kg/m ²)	27.51±6.42	25.52±4.94	24.74±4.43	24.23±4.43	<10 ⁻¹⁵
Waist circumference (cm)	82.80±13.72	78.47±11.49	76.80±10.56	75.12±10.33	<10 ⁻¹⁵
Hip circumference (cm)	103.77±13.34	100.22±10.63	98.90±9.58	97.35±9.36	<10 ⁻¹⁵
Chest circumference (cm)	96.55±10.16	93.98±8.43	92.93±7.88	92.15±7.39	<10 ⁻¹⁵
Males					
Sample	2085	2049	1318	1681	
Age (years)	61.38±14.45	61.48±12.83	61.71±11.87	60.30±12.26	0.49
Education (years)	16.05±2.81	16.12±2.71	16.09±2.68	15.76±2.74	0.38
Alcohol (g/day)	9.66±15.87	10.47±15.79	10.89±16.54	11.19±17.47	0.008
Meat (servings/day)	0.49±0.43	0.46±0.44	0.44±0.41	0.42±0.43	<10 ⁻⁵
Fruit (pieces/day)	1.33±1.12	1.55±1.13	1.62±1.18	1.71±1.34	<10 ⁻¹⁵
BMI (kg/m ²)	27.80±5.01	26.85±4.25	26.76±4.08	26.36±4.06	<10 ⁻¹⁵
Waist circumference (cm)	95.79±11.68	94.28±9.85	93.07±9.34	92.03±9.49	<10 ⁻¹⁵
Chest circumference (cm)	108.26±11.15	107.47±9.97	106.88±9.49	106.72±10.16	0.0002

82.0% of men and 80.2% of women provided waist circumference, 71.6% of men and 78.7% of women provided chest circumference, and 78.5% of women provided hip circumference data.

Table 2

Regression slopes ($\pm$ SE) for body mass index and circumferences (dependent variables) vs. reported intakes of meat (kg/m² or cm per servings/d) or fruit (kg/m² or cm per pieces/d, independent variables) adjusted for age, education, and alcohol intake, stratified by walking distance.

	Dependent variable			
Usual walking distance	BMI (kg/m ²)	Waist circumference (cm)	Chest circumference (cm)	Hip circumference (cm)
Independent variable: meat (servings/day)				
Females				
<1.5 km/d [¶]	2.37 $\pm$ 0.17 [§]	5.83 $\pm$ 0.42 [§]	3.82 $\pm$ 0.31 [§]	5.55 $\pm$ 0.41 [§]
1.5–3 km/d	1.95 $\pm$ 0.14 [§]	5.12 $\pm$ 0.36 [§]	2.96 $\pm$ 0.26 [§]	4.40 $\pm$ 0.33 [§]
3–4.5 km/d	1.98 $\pm$ 0.18 [§]	4.73 $\pm$ 0.46 [§]	2.89 $\pm$ 0.35 [§]	4.55 $\pm$ 0.42 [§]
>4.5 km/d	1.97 $\pm$ 0.16 [§]	4.69 $\pm$ 0.44 [§]	2.92 $\pm$ 0.32 [§]	4.44 $\pm$ 0.40 [§]
Interaction (P) [#]	P<10 ⁻⁵	P=0.0002	P=0.0002	P=0.0005
Males				
<1.5 km/d	1.80 $\pm$ 0.25 [§]	3.98 $\pm$ 0.65 [§]	1.48 $\pm$ 0.67 [*]	
1.5–3 km/d	1.26 $\pm$ 0.21 [§]	2.71 $\pm$ 0.53 [§]	2.18 $\pm$ 0.57 [§]	
3–4.5 km/d	1.24 $\pm$ 0.26 [§]	3.55 $\pm$ 0.65 [*]	2.77 $\pm$ 0.68 [§]	
>4.5 km/d	1.35 $\pm$ 0.23 [§]	3.37 $\pm$ 0.59	3.02 $\pm$ 0.67 [§]	
Interaction (P)	P=0.14	P=0.50	P=0.18	
Independent variable: fruit (pieces/day)				
Females				
<1.5 km/d	-0.42 $\pm$ 0.07 [§]	-1.03 $\pm$ 0.16 [§]	-0.51 $\pm$ 0.12 [§]	-0.66 $\pm$ 0.16 [§]
1.5–3 km/d	-0.18 $\pm$ 0.05 [‡]	-0.38 $\pm$ 0.12 [‡]	-0.02 $\pm$ 0.09	-0.20 $\pm$ 0.12
3–4.5 km/d	-0.15 $\pm$ 0.06 [‡]	-0.14 $\pm$ 0.15	-0.07 $\pm$ 0.11	-0.05 $\pm$ 0.14
>4.5 km/d	-0.30 $\pm$ 0.05 [§]	-0.70 $\pm$ 0.12 [§]	-0.24 $\pm$ 0.09 [‡]	-0.52 $\pm$ 0.11 [§]
Interaction (P)	P=0.0001	P=0.0006	P=0.01	P=0.05
Males				
<1.5 km/d	-0.38 $\pm$ 0.10 [§]	-1.06 $\pm$ 0.25 [§]	-0.49 $\pm$ 0.26	
1.5–3 km/d	-0.24 $\pm$ 0.08 [‡]	-0.81 $\pm$ 0.21 [‡]	-0.58 $\pm$ 0.23 [‡]	
3–4.5 km/d	-0.18 $\pm$ 0.09 [*]	-0.47 $\pm$ 0.24 [*]	-0.29 $\pm$ 0.26	
>4.5 km/d	-0.27 $\pm$ 0.07 [‡]	-0.44 $\pm$ 0.19 [*]	-0.53 $\pm$ 0.21 [‡]	
Interaction (P)	P=0.18	P=0.04	P=0.69	

Adjusted for age, education, and alcohol intake. Significance levels coded:

* P<0.05,

‡ P<0.01,

‡ P<0.001,

[§]P<0.0001.

[¶]The values presented in the table are the effect of meat on BMI within a particular mileage group as obtained from the coefficient “ β ” in the model: BMI= intercept+ β meat+covariates.

[#]The test for whether distance walked affected the relationship of BMI to meat intake refers to the significance of the test of $\gamma=0$ in the model BMI= intercept+ β meat+ δ distance+ γ meat*distance+covariates.

Table 3

Multiple regression to determine the linear combinations of reported intakes of meat and fruit (independent variables) that best predicts body mass index and circumferences (dependent variables) in walkers who averaged <1.5 km/d.

	Slopes $\pm$ SE	
	Meat (servings/day)	Fruit (pieces/day)
Females		
BMI (kg/m ²) [¶]	2.30 $\pm$ 0.17 [§]	-0.35 $\pm$ 0.07 [§]
Waist circumference (cm)	5.63 $\pm$ 0.42 [§]	-0.84 $\pm$ 0.16 [§]
Chest circumference (cm)	3.73 $\pm$ 0.31 [§]	-0.38 $\pm$ 0.12 [‡]
Hip circumference (cm)	5.44 $\pm$ 0.41 [§]	-0.47 $\pm$ 0.16 [‡]
Males		
BMI (kg/m ²)	1.75 $\pm$ 0.25 [§]	-0.34 $\pm$ 0.09 [‡]
Waist circumference (cm)	3.77 $\pm$ 0.65 [§]	-0.94 $\pm$ 0.25 [‡]
Chest circumference (cm)	1.39 $\pm$ 0.67 [‡]	-0.45 $\pm$ 0.26

Adjusted for age, education, and alcohol intake. Significance levels coded:

* P<0.05,

[‡] P<0.01,

^{‡‡} P<0.001,

[§] P<0.0001

[¶]The values presented in the table are the effect of meat and fruit on BMI as obtained from the coefficients “ β ” and “ δ ” in the model: BMI= intercept+ β meat+ δ fruit+covariates.