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Body mass index gain between ages 20-40 years and lifestyle characteristics of men at ages 40-60 years: The Adventist Health Study-2

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Abstract

Background—Obesity increases risk of premature disease, and may be associated with unfavorable lifestyle changes that add to risk. This study analyzed the association of midlife BMI change with current lifestyle patterns among multiethnic men.

Methods—Men aged 40-60 years (n=9864) retrospectively reported body weight between ages 20-40 years and current dietary, TV, physical activity and sleep practices in the Adventist Health Study II, a study of church-goers in the US and Canada. In multivariate logistic regression analysis, odds ratios for BMI gain were calculated for each lifestyle practice controlling for sociodemographic and other lifestyle factors and current BMI.

Results—Men with median or higher BMI gain (2.79 kg/m^2) between ages 20-40 years were more likely to consume a non-vegetarian diet, and engage in excessive TV watching and little physical activity and had a shorter sleep duration compared to men with BMI gain below the median (all $p<0.001$). In multivariate logistic analysis current BMI was significantly associated with all lifestyle factors in multivariate analyses (all $p\leq0.005$). BMI gain was associated with lower odds of vegetarian diet (odds ratio [OR] 0.939; 95% confidence interval [CI] 0.921-0.957) and of physical activity ≥150 minutes/week (OR 0.979, 95% CI 0.960-0.999).

Conclusions—These findings imply that diet and less physical activity are associated with both gained and attained BMI, while inactivity (TV watching) and short sleep duration correlated only with attained BMI. Unhealthy lifestyle may add risk to that associated with BMI. Longitudinal and intervention studies are needed to infer causal relationships.

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Keywords

obesity; diet; physical activity; sedentariness; sleep; men

Background

Weight gain tends to be experienced in early to middle adulthood and is associated with several lifestyle practices including diet and lack of adequate physical activity. On the other hand smoking and high alcohol consumption may limit weight gain. Lifestyle habits may not only lead to weight gain, but may also be a consequence of weight gain. Sugary and fatty foods are highly palatable and provide little satiety [1]. A mirror image of this association is that the liking of sweets and fat increases with increasing BMI [2]. Conversely, vegetarian diets rich in legumes, vegetables and fruits may be protective against weight gain [3, 4]. In one study, participants consuming a vegan diet had a mean BMI that was ~5 units lower than observed in non-vegetarians [5]. Whether people who gain weight favor non-vegetarian diets has not been studied, to our knowledge.

While lack of physical activity is an established determinant of obesity [6], the converse is also true, that obesity hinders physical activity. Furthermore, underlying genetic dispositions may lead to both obesity and inactivity [7].

Sedentary behavior is defined as an immobile state resulting in energy expenditure close to the resting metabolic rate [8], and is associated with obesity, independent of physical activity [9, 10]. TV watching is a major component of sedentariness associated with obesity. A doubling in risk of obesity was seen among those who watch more than 8 hours/day [11]. Again, the converse may be true, with obesity leading to more TV time, because of barriers to physical or social activities among the obese.

Sleep duration may play a role in the pathophysiology of obesity. Short sleep duration may lead to obesity, and obesity impair sleep time [12]. This loss of sleep duration may be attributed to subjective sleep disturbances, emotional stress, and sleep apnea [13, 14].

Among men, being overweight or obese solicits special attention since many men do not see an urgent concern with being overweight or obese. Men tend to consider ‘bigness’ with being healthy or physically attractive [15]. However, risks of obesity in men are considerable. Men tend to accumulate abdominal fat, the origin of metabolic syndrome, diabetes type 2, and cardiovascular disease [15]. Testosterone levels decrease from as early as 30 years of age and are correlated with fat-free mass loss and increases in fat mass [16].

The aim of the current study was to estimate associations of weight gain in men with major lifestyle habits including diet, sedentary behavior, physical activity and sleep. While a number of studies have looked at the individual or combined impact of lifestyle factors on body weight change [17, 18; reviewed in 19], few have considered the association of previous weight gain with current lifestyle including not only nutrition and activity, but also sedentary habits and sleep and compared to the effect of lifestyle on current BMI. Thus, we analyzed the association of retrospectively reported weight change between the ages of 20

and 40 years with reported lifestyle characteristics, among men between the ages of 40 and 60 years in the Adventist Health Study-2 (AHS-2). Seventh-day Adventist church members are encouraged to consume vegetarian diets and most members avoid tobacco and alcohol. This provided a unique "healthy" population in which to study the above associations.

Methods

This investigation was based on data collected from the Adventist Health Study-2 (AHS-2). AHS-2 was an epidemiological research study of Adventists from Canada and the US, designed to identify lifestyle factors, foods, and metabolic risk indicators associated with cancer [20] as well as identify determinants of health and diseases between different ethnic and socioeconomic groups [21]. Each volunteer completed a 48-page questionnaire that included a wide array of questions regarding medical history, demographics, and lifestyle including diet. Participants ranged from 30-112 years old, and were composed of 26.9% blacks and 63.5% non-Hispanic whites with the remaining consisting of other ethnicities [21]. This study obtained committee review and approval by the Institutional Review Board of Loma Linda University.

Recruitment and subject selection

Subjects were recruited among church members living in the US and Canada who were 30 years or older, and sufficiently fluent in English to complete the questionnaire. Churches were divided into two groups, black (n=1 000) and non-black (n=3 500) congregations and recruited church-by-church [21]. In the pursuit to include more black participants, the recruitment process was intensified for black churches [21]. Between February 2002 to May 2007, a total of about 96000 individuals turned in the questionnaire. There were 15506 men between the ages of 40-60 years. Exclusions included 135 who did not indicate race/ethnicity, 273 who were current smokers, 1504 for outlying weight or BMI values (weight <50 kg, BMI <16 or >60 kg/m^2), 152 for missing sleep duration, 289 for missing physical activity, and 1931 for missing TV watching. Those with missing compared to nonmissing variables were more likely to be Black (37.5% vs 20.9%), less likely to be married (79.8% vs 87.2%), and less likely to be college graduates (38.5% vs 55.1%). We also excluded 1358 participants who reported conditions associated with weight change (type 2 diabetes mellitus and/or non-skin cancer). Thus our final analytic population consisted of 9864 males aged 40-60 years.

Questionnaire

Subjects were queried about their weight change as follows: "What was your weight at each of the following ages (answer for each age before your present age)?" These ages included 20, 30, and 40 years of age. Height was self-reported at the time of questionnaire completion and the assumption made that height did not change during the previous decades. Validation of self-reported anthropometrics in this population was published previously [22]. BMI was calculated for the present age and when participants were ages of 20, 30, and 40 years.

Yearly household income was grouped from the listed options in the questionnaire to < $31000, $31000-$50000, $51000-$75000, and ≥$76000). Marital status was grouped into

married, which included “first marriage,” “remarried,” and “common law marriage”, never married, and a third category including “separated,” “divorced,” and “widowed.” Educational level was grouped as high school or less, some college, and college graduate or higher.

Dietary data was obtained from the food frequency questionnaire for foods consumed in the past year. The section listed 130 hard-coded food or food groups of which participants selected or wrote-in those items not listed. Vegetarian status was categorized by defining vegans as those who reported consuming no animal products (red meat, poultry, fish, eggs, milk, and dairy products <1/month), lacto-ovo vegetarians as consuming dairy products and/or eggs equal to or greater than one time per month, but not fish or meat (red meat, poultry <1 time/month), semi-vegetarians as consuming dairy products and/or eggs and meat (red meat and poultry >1 time/month and <1 time/week), and non-vegetarians as consuming animal products (red meat, poultry, fish, eggs, milk, and dairy products >1 time/week) [5]. Validation of the questionnaire was shown previously [23]. Vegans and lacto-ovo vegetarians were grouped together in the current study as the proportion of vegans was small.

The questionnaire queried typical physical activity during the previous year, by asking “how many times per week do you usually engage in regular vigorous activities, such as brisk walking, jogging, bicycling, etc., long enough or with enough intensity to work up a sweat, get your heart thumping or get out of breath?” Duration was based on the question stating “on average, how many minutes do you exercise each session?” A cutoff of ≥150 minutes/ week was chosen for this activity based on the recommendation of 30 minutes daily. The questions were validated previously in this population [24].

Sleep duration was based on a question of “How many hours do you usually sleep each night?” Six hours or more was chosen as a cut-off. Sedentariness was queried according to how many hours a day were spent on watching TV listed as; none, <1 hour, 1 hour, 2 hours, 3-4 hours, and >5 hours with <2 hours/day chosen as a cut-off.

Data Analysis

Descriptive and univariate analyses (Chi-square and student t-tests) were applied to compare the socio-demographic characteristics and current lifestyle practices between men whose BMI changed equal to or above the median (2.79 kg/m^2) versus below the median between ages 20 and 40 years.

Univariate and multivariate logistic regressions estimated the association of BMI change with each of the lifestyle variables (diet, TV watching, physical activity and sleep). In the multivariate analysis we controlled for socio-demographic characteristics (age, marital status, educational level, ethnicity and income), current BMI and other lifestyle practices. Alpha was set at a p=0.05 significance level. Statistical analyses were performed using SAS (Version 9.3: SAS Institute Inc.).

Results

BMI change ranged from -14.09 kg/m^2 to 31.53 kg/m^2. Descriptive characteristics according to change ≥ the median (2.79 kg/m^2) or < the median are shown in Table 1. Men with a BMI change ≥ the median were less likely to have completed some or more college, and more likely to be Black, non-vegetarian, watch ≥2 hours of TV daily, engage in <150 minutes/ week of physical activity, and to sleep six hours or less/night than their counterparts. Marital status and income were not associated with BMI change. A small minority reported any alcohol consumption (7.7%). This proportion did not differ according to BMI change (data not shown). Less than 2% of participants currently smoked cigarettes.

In univariate logistic regression analyses, median or higher change in BMI was associated with lower odds of a vegetarian diet (OR=0.861, 95% CI=0.848-0.874, *P*-value <0.0001), as well as TV watching <2 hours/day (OR=0.912, 95% CI=0.900-0.924, *P*-value <0.0001), physical activity of 150 minutes or more per week (OR=0.967, 95% CI=0.953-0.983, *P*-value <0.0001) and sleep time of more than six hours (OR=0.942, 95% CI=0.930-0.954, *P*-value <0.0001).

Results of the multivariate logistic regression analyses are shown in tables 2-5. Current BMI was associated with less healthy lifestyle factors including nonvegetarian diet (table 2), more TV watching (table 3), less physical activity (table 4) and shorter sleep duration (table 5). Median or higher change in BMI was associated with lower odds of consuming a vegetarian diet (Table 2). Odds of vegetarian diet consumption increased with age, education, less TV watching and more sleep, but decreased with Black ethnicity, being separated/divorced/ widowed, higher income and current BMI.

Median or higher change in BMI was not associated with TV watching (Table 3). Odds of watching <2 hours/day of TV increased with consumption of vegetarian diet and higher education and income, but decreased with age, never having been married, Black ethnicity and current BMI (Table 3).

Median or higher change in BMI was associated with lower odds of engaging in <150 minutes of physical activity weekly, as were being married and current BMI (Table 4). Odds of engaging in ≥150 minutes of physical activity weekly were greater with Black ethnicity, higher education and income of ε$76 000 yearly.

Finally, median or higher change in BMI was not associated with amount of sleep (Table 5). Odds of sleeping 6 hours or more/night increased with consumption of a vegetarian diet, but decreased with increased education, Black ethnicity and current BMI.

Discussion

The main findings of this study were that retrospectively reported gain in BMI among men ages 20-40 years was associated with greater likelihood of consuming a non-vegetarian diet and physical activity of <150 minutes weekly. This suggests that men who gain more weight are likely to be engaged in lifestyle behaviors that are likely to promote further increase in BMI. These findings are concerning in light of evidence indicating that obesity leads to

increased vulnerability to risk factors that cause obesity [25]. Diet and activity were also associated with attained BMI. On the other hand, TV watching and sleep duration were only associated with attained BMI and not BMI gain in multivariate analyses controlling for all other factors.

This study addressed weight gain between ages 20 to 40, a time of life that is susceptible to changes in lifestyle leading to weight gain. Some authors have suggested that gaining weight during adult years is inevitable, even in individuals who actively engage in physical activity [26]. Men gain an average of 2.4% of body weight every 4-year period [27], which adds 7-8 kg over 20 years, a substantial gain when considering risks of disease related to obesity. Men in the current study gained nearly 5 kg over 20 years. Contributors to weight gain with aging include reduction in resting metabolic rate [28], sarcopenia [29], and reductions in total energy expenditure and physical activity levels [30]. While weight gain with aging may be not entirely avoidable, men who gained lesser weight were more likely to report that they ate a plant based diet and engaged in physical activity. These associations were small, but adjusted for current BMI and sociodemographic and lifestyle characteristics, adjustments that weakened associations compared to the univariate analyses.

Participants in the current study were about evenly divided between vegan/lacto-ovo vegetarians and non-vegetarians. Plant based diets are recommended by the Adventist church. Other church tenets include avoiding trivial entertainment and adequate rest. In line with this, consumption of vegetarian diets was associated with less TV watching and more sleep, though not with physical activity. A number of studies have found that weight gain is attenuated in people following vegetarian diets, mostly due to lower energy intakes, higher fiber content, and lower intake of animal fats [4, 31]. This study found that both BMI gain and current BMI were less likely to be associated with a vegetarian diet and suggested that increases in BMI are associated with diets that may further increase BMI.

Obesity may restrict activities of daily living and produces cardiovascular and respiratory stress responses that may further promote sedentary behavior [32, 33]. In this study current BMI was independently associated with more TV watching while BMI gain was not associated with TV watching in the multivariate analysis – only in the univariate analysis. Adjustment for other lifestyle factors including diet, sleep time and physical activity may overcontrol for the association between BMI gain and other factors, however, our purpose was to identify lifestyle factors independently associated with BMI gain. Lifestyle factors tend to be interrelated as they were in this study (data not shown). For example, the association between TV watching and obesity is partially explained by food and beverages consumed during TV watching [34].

Both change in BMI and current BMI were associated with less physical activity though the association with change in BMI was small. Maintaining high amounts of physical activity is a predictor of smaller increases in BMI with age [26]. Our study results are in line with longitudinal studies showing that obesity predicts lower amounts of activity independently of other lifestyle factors [10, 35]. The lower activity level associated with increased BMI may stem from mechanical, psychosocial and other barriers to activity. We measured only

vigorous activity in the current study. More moderate amounts of activity may be maintained or increased in obesity [36].

In this study BMI gain was not related to sleep duration, though current BMI was associated with fewer hours of sleep. Obesity increases risk of sleep apnea and other sleep disorders. Conversely, a number of studies have shown inadequate sleep to be a risk factor for obesity [12, 37, 38], however, causation has not been determined. We chose a cut-off of <6 hours/night, shown earlier to be associated with obesity [39].

We found BMI gain to be associated with Black ethnicity, in line with previous studies [40, 41]. Black ethnicity was associated with other obesogenic factors including non-vegetarian diet, TV watching and less sleep, though notably, higher levels of physical activity were reported by Black church members. BMI gain was not associated with marital status in the current study, though married men watched more TV and were less physically active than their single counterparts. In previous studies [42, 43], it was found that married men experienced a greater increase in BMI than single or divorced men. Putative explanations included more regular meals and larger, less time for leisure activities, and less interest in maintaining a figure that would attract a mate. We have no ready explanation for the divergent finding in the current study.

Education and income are primary determinants of lifestyle and weight gain – and this was confirmed in the present study. A highly cited study [44] showed that higher education may lead to better health decision-making, a higher sense of personal control over health, and less socioeconomic stresses permitting better lifestyles. Most of our findings indicated healthier lifestyles among those with higher education and income, with a notable exception. While education increased the odds of a vegetarian diet, higher income decreased those odds.

Limitations

The data was cross sectional and causality cannot be inferred. We did not assess lifestyle habits at age 20, at the onset of the study's timeline, thus we cannot address changes in lifestyle, or whether the lifestyle habits were present at baseline. Blood tests were not available to examine metabolic variables or chronic viral infection that could affect body weight nor was use of laxatives or diuretics recorded.

Recall bias may distort the results. It remains possible that men with greater weight gain reported healthier lifestyles than the actual ones, however, this seems unlikely given our results. Anthropometrics and lifestyle variables were self-reported. We did not study nonlinear associations. While most studies show that less than six hours of sleep is not the ideal for optimal health, some studies have found that a U-shaped correlation between sleep and BMI indicated risks associated with too many hours of sleep [12].

The study was conducted among church adherents, and the church promotes a vegetarian diet, rest and avoidance of entertainment. Respondents may have reported healthier lifestyles than the actual ones. Respondents with missing data tended to have lower education and were more likely to be Black, thus, the sample was not representative of the entire

population. An advantage of this population is the absence of smoking and heavy alcohol drinking, both factors that may confound the associations observed. We chose as the comparator group to those with high BMI gain, those who had a BMI gain below the median. This group could be heterogenous including men with stable weight, lesser BMI gain and BMI loss; cut-offs for these groups are not readily apparent nor were causes of changes in BMI (intentional versus nonintentional) delineated in the questionnaire. The sample was relatively young, and chronic disease that affects body weight including cancer and diabetes was excluded, though not thyroid disease, as weight loss is limited following thyroid treatment for hypothyroidism [44].

Conclusion

In conclusion, BMI gain between the ages of 20-40 years in men was associated with less healthful current lifestyle practices including diet and physical activity. These practices are likely to result in further BMI increases.

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Table 1

Descriptive characteristics according to BMI change median or above (≥2.79 kg/m^2) vs below the median between ages 20 and 40 years in men aged 40 to 60 years (N=9 864).

Variable	Median or above N=4 925	Below the median N=4 939	*P*-value
Age, years (SD)	49.45 (5.80)	50.66 (5.83)	<0.001
Marital status (%)			0.642
Never married	221 (4.5)	210 (4.3)	
Married	4248 (86.9)	4280 (87.5)	
Separated/divorced/widowed	421 (8.6)	401 (8.2)	
Education (%)			<0.001
High school or less	710 (14.5)	557 (11.4)	
Some college	1621 (33.1)	1517 (30.9)	
College graduate or more	2572 (52.4)	2828 (57.7)	
Ethnicity (%)			<0.001
Other	3687 (74.7)	4115 (83.6)	
Black	1252 (25.3)	810 (16.4)	
Personal income (%)			0.301
< $31000	1418 (28.7)	1372 (27.9)	
$31000 to $50000	1462 (29.6)	1486 (30.2)	
$51000 to $75000	1011 (20.5)	962 (19.5)	
> $76000	1048 (21.2)	1105 (22.4)	
Diet (%)			<0.001
Vegan/lacto-ovo vegetarian	1431 (32.6)	2204 (50.8)	
Non-vegetarian	2954 (67.4)	2133 (49.2)	
TV watching (%)			<0.001
< 2 hours/day	2763 (55.9)	3387 (68.8)	
> 2 hours/day	2176 (44.1)	1538 (31.2)	
Physical activity (%)			<0.001
< 150 min/wk	3861 (78.2)	3701 (75.1)	
> 150 min/wk	1078 (21.8)	1224 (24.9)	
Sleep per night (%)			<0.001
6 hours or less	1894 (38.3)	1493 (30.3)	
More than 6 hrs	3045 (61.7)	3432 (69.7)	

Age was compared using an independent t-test, while the other variables were compared using chi square analyses.

Table 2

Multivariate logistic regression analysis showing odds ratios of following a vegetarian diet versus non-vegetarian diet in 9 864 men. All variables are controlled for the other variables in the table.

Variable	Odds ratio	Confidence limits (95%)		*P*-value
BMI change ages 20 to 40	0.939	0.921	0.957	< 0.0001
Control variables				
Age	1.009	1.000	1.017	0.038
Marital status (Reference: married)				
Never married	0.945	0.749	1.193	0.633
Separated/divorced/widowed				
	0.549	0.458	0.659	< 0.0001
Education (Reference: college graduate or more education)				
Some college	0.597	0.536	0.665	< 0.0001
High school or less	0.557	0.476	0.651	< 0.0001
Ethnicity - Black vs other	0.548	0.481	0.625	< 0.0001
Personal income (Reference: <$31,000/year)				
$31,000 - $50,000	1.187	1.047	1.346	0.007
$51,000 - $75,000	0.837	0.726	0.965	0.014
> $76,000	0.651	0.564	0.750	< 0.0001
TV watching				
< 2 hours/day vs more	1.796	1.626	1.984	< 0.0001
Sleeping				
> 6 hours/night vs less	1.254	1.132	1.390	< 0.0001
Physical activity				
> 150 minutes/wk vs less	0.936	0.839	1.044	0.235
Current BMI	0.924	0.911	0.937	< 0.0001

Table 3

Multivariate logistic regression analysis showing odds ratios of TV watching <2 hours/day versus ≥2 hours/day in 9 864 men. All variables are controlled for the other variables in the table.

Variable	Odds Ratio	Confidence limits (95%)		*P*-value
BMI change ages 20 to 40	0.989	0.971	1.007	0.225
Control variables				
Age	0.978	0.970	0.986	< 0.0001
Marital status (Reference: married)				
Never married	0.691	0.551	0.866	0.001
Separated/divorced/widowed				
	1.012	0.858	1.195	0.885
Education (Reference: college graduate or more education)				
Some college	0.730	0.657	0.812	< 0.0001
High school or less	0.668	0.575	0.775	< 0.0001
Ethnicity - Black vs other	0.568	0.505	0.640	< 0.0001
Diet				
Vegan/lacto-ovo vegetarian vs other				
	1.830	1.657	2.020	< 0.0001
Personal income (Reference: <$31,000/year)				
$31,000 - $50,000	1.128	0.997	1.275	0.055
$51,000 - $75,000	1.228	1.069	1.411	0.004
> $76,000	1.527	1.323	1.762	< 0.0001
Sleeping				
> 6 hours/night vs less	1.048	0.948	1.160	0.358
Physical activity				
> 150 minutes/wk vs less	1.048	0.938	1.170	0.407
Current BMI	0.929	0.917	0.941	< 0.0001

Table 4

Multivariate logistic regression analysis showing odds ratios of physical activity ≥150 minutes/week versus <150 minutes/week in 9 864 men. All variables are controlled for the other variables in the table.

Variable	Odds ratio	Confidence limits (95%)		*P*-value
BMI change ages 20 to 40	0.979	0.960	0.999	0.035
Control variables				
Age	1.006	0.997	1.015	0.210
Marital status (Reference: married)				
Never married	1.682	1.331	2.126	< 0.0001
Separated/divorced/widowed				
	1.570	1.318	1.869	< 0.0001
Education (Reference: college graduate or more education)				
Some college	0.778	0.689	0.878	< 0.0001
High school or less	0.771	0.647	0.918	0.004
Ethnicity - Black vs other	1.169	1.021	1.338	0.024
Personal income (Reference: <$31,000/year)				
$31,000 - $50,000	0.937	0.813	1.079	0.366
$51,000 - $75,000	1.062	0.909	1.242	0.448
> $76,000	1.318	1.130	1.537	0.000
TV watching				
< 2 hours/day vs more	1.061	0.950	1.185	0.295
Diet - Vegan/lacto-ovo vegetarian vs other				
	0.946	0.847	1.055	0.317
Sleeping				
> 6 hours/night vs less	1.051	0.938	1.176	0.392
Current BMI	0.775	0.648	0.926	0.005

Table 5

Multivariate logistic regression analysis showing odds ratios of sleeping ≥6 hours/night versus <6 hours/night in 9 864 men. All variables are controlled for the other variables in the table.

Variable	Odds ratio	Confidence limits (95%)		*P*-value
BMI change ages 20 to 40	1.001	0.983	1.019	0.909
Control variables				
Age	1.005	0.997	1.014	0.211
Marital status (Reference: married)				
Never married	1.116	0.881	1.414	0.363
Separated/divorced/widowed				
	0.849	0.718	1.005	0.057
Education (Reference: college graduate or more education)				
Some college	0.816	0.731	0.911	< 0.0001
High school or less	0.780	0.669	0.909	0.002
Ethnicity - Black vs other	0.254	0.227	0.285	< 0.0001
Personal income (Reference: <$31,000/year)				
$31,000 - $50,000	1.010	0.889	1.147	0.883
$51,000 - $75,000	0.927	0.804	1.070	0.300
> $76,000	0.958	0.828	1.109	0.567
TV watching				
< 2 hours/day vs more	1.052	0.951	1.163	0.324
Diet - Vegan/lacto-ovo vegetarian vs other				
	1.265	1.142	1.401	< 0.0001
Physical activity				
>150 minutes/wk vs less	1.049	0.937	1.175	0.406
Current BMI	0.964	0.952	0.977	< 0.0001