Published in final edited form as:
Alzheimer Dis Assoc Disord. 2012 April ; 26(2): 101–105. doi:10.1097/WAD.0b013e318222f0d4.

Central obesity in the elderly is related to late onset Alzheimer's disease

JA Luchsinger, MD, MPH[1,3,4,6], **D Cheng, MPH**[1], **MX Tang, PhD**[3,4,7], **N Schupf, PhD**[1,3,4], and **R Mayeux, MD**[1,2,3,4,5]

[1]Department of Neurology, College of Physicians and Surgeons, Columbia University, New York, NY

[2]Gertrude H. Sergievsky Center, College of Physicians and Surgeons, Columbia University, New York, NY

[3]Taub Institute for Research on Alzheimer's Disease and the Aging Brain, College of Physicians and Surgeons, Columbia University, New York, NY

[4]Department of Psychiatry, College of Physicians and Surgeons, Columbia University, New York, NY

[5]Department of Medicine, College of Physicians and Surgeons, Columbia University, New York, NY

[6]Department of Biostatistics, Joseph P. Mailman School of Public Health, Columbia University, New York, NY

Department of Epidemiology, Joseph P. Mailman School of Public Health, Columbia University, New York, NY

Abstract

The evidence relating obesity measured with body mass index (BMI) in the elderly to late onset Alzheimer' disease (LOAD) is conflicting. Central obesity in middle age is related to a higher risk of LOAD, but data in the elderly are lacking. We explored whether measures of central obesity, waist circumference (WC), and waist to hip ratio (WHR) were better predictors of LOAD compared to BMI in the elderly. Participants were 1459 persons aged 65 years and older without dementia at baseline, with follow-up, and with anthropometric data from a longitudinal study of aging in New York City. Proportional Hazards regression was used for multivariable analyses relating BMI, WC, and WHR to LOAD. There were 145 cases of AD in 5,734 person-years of follow-up. Only WHR was related to higher LOAD risk (HR of the 4th quartile compared to the first =2.5; 95% CI = 1.3, 4.7) after adjustment for age, sex, education, ethnic group, APOE-ε4, type 2 diabetes, hypertension, non-HDL cholesterol, HDL cholesterol and stroke. Measures of central obesity, particularly WHR, are better predictors of cardiovascular outcomes compared to BMI. Our results support the notion that central obesity is related to a higher risk of LOAD.

Correspondence/Requests for reprints: José A. Luchsinger, MD, 630 West 168th St., PH9E-105, New York, NY 10032, Telephone: 212-3054730, Fax: 212-3059349, jal94@columbia.edu.

Disclosure: Nicole Schupf is a consultant for Elan Pharmaceuticals.

Keywords

obesity; body mass index; waist circumference; waist to hip ratio; Alzheimer's disease

Introduction

The most common form of dementia is late onset Alzheimer's disease (LOAD) which likely accounts for 70–90% of all cases [1]. Despite the lack of precise prevalence and incidence data in the United States, there are estimates that the prevalence of LOAD will quadruple by 2047 [2] and the incidence of late-onset LOAD among patients over age 65 with dementia may be as great as 58% [3].

Obesity in middle age is associated with an increased risk of dementia including LOAD[4–7]. However, the data relating obesity in the elderly with LOAD is conflicting-some studies show increased risk[8], some show an inverse risk[6, 9], some show non-linear associations[10], and some show no association[11]. Explanations for the conflicting data include potential survival bias, and decreased validity of body mass index as a measure of obesity in the elderly[12]. Measures of central obesity, particularly waist to hip ratio, seem to be better predictors of cardiovascular outcomes compared to body mass index (BMI)[13], and central obesity in middle age is related to a higher risk of dementia. There is a paucity of data on the association between central obesity in the elderly and LOAD risk. We previously reported that BMI had a non-linear association with LOAD risk, and that high waist circumference (WC) in younger elderly was associated with higher LOAD risk in younger elderly[10] in a cohort recruited in 1992–1994 in Northern Manhattan. In this study we explore the association of a better measure of central obesity, waist-to-hip-ratio (WHR) with LOAD risk in a larger cohort recruited in 1999–2001 in Northern Manhattan, and compare the associations with those of BMI and WC. We hypothesized that measures of central obesity in the elderly would predict LOAD better than BMI in the elderly.

Methods

Participants were recruited by random sampling of healthy Medicare eligible persons aged >65 years in several low-income neighborhoods with a high proportion of Hispanics in northern Manhattan. They were part of the Washington Heights–Inwood Columbia Aging Project (WHICAP)—a longitudinal population-based cohort in which clinical and epidemiologic data are collected at regular intervals and vital status is continually updated. Recruitment occurred in two cohorts; recruitment for the first cohort began in 1992. The geographic study area was the 14 census tracts comprising that area of Manhattan between approximately 155th and 181st streets. Lists of all persons in receipt of Medicare or Medicaid the study area were obtained from the Health Care Financing Administration. Potential study subjects were then drawn by systematic random sampling into one of six strata formed on the basis of ethnicity (Hispanics, non-Hispanic Blacks and non-Hispanic whites) and age (65–74, 75+). A total of 4,865 individuals were sent letters in this first recruitment. Of these, attempts at follow-up by phone or in-person visit indicated that 470 (9.6%) had died, 896 (18.4%) no longer lived in the region, 47 (1%) were ineligible and 1324 (27%) did not wish to participate. The total number recruited was 2,128. The overall recruitment rate for eligible individuals living in the study area was therefore 60%. A "refreshment" cohort of 2,183 additional participants was formed in 1999 using generally similar methods. The main exceptions are as follows: new lists of beneficiaries were obtained but all those drawn into the 1992 cohort were excluded; within the course of contacting and arranging for the initial evaluation, participants who reported that a physician had diagnosed them with dementia were excluded; the study area was extended to the south

and to the north and now encompassed all of Manhattan north of (approximately) 145th Street. For this refreshment cohort, recruitment letters were sent to a total of 7,120 persons living in households with a known phone number. Of these, 265 (3.7%) were found to have died, 1541 (21.6%) no longer lived in the region, 662 (9.3%) were ineligible and 2,810 (39.5%) refused to participate. The total number recruited was therefore 2174 and the overall recruitment rate for eligible individuals living in the study area for the refreshment cohort was 40%. Of the 2174 persons in the 1999 cohort, 222 had dementia at baseline, and 462 had no follow-up. Of the remaining 1488, 31 did not have anthropometric data: 1431 had data on BMI, 1456 had data on WC, and 1406 had data on WHR. Compared to the final sample (Supplemental Table 1), persons excluded due to baseline dementia were older, more likely to be Hispanic, and less likely to be Non-Hispanic White. Persons excluded due to loss to follow-up were older, more likely to be Hispanic, and less likely to be White. Persons with no anthropometric data were younger. APOE-ε4 data was available in 1190 participants and non-HDL cholesterol and HDL cholesterol was available in 1130 participants.

Diagnosis of Dementia

The diagnosis of dementia was established based on all available information gathered from the initial and follow-up assessments. Dementia was determined by consensus at a conference of physicians, neurologists, neuropsychologists and psychiatrists. The diagnosis of dementia was based on standard research criteria [14] and required evidence of cognitive decline, including memory impairment, on the neuropsychological test battery as well as evidence of impairment in social or occupational function (clinical dementia rating > 0.5) [15]. The diagnosis of LOAD was based on the National Institute of Neurological and Cognitive Disorders and Stroke/Alzheimer's Disease and Related Disorders Association Criteria [16]. A diagnosis of *probable* LOAD was made when the dementia could not be explained by any other disorder. A diagnosis of *possible* LOAD was made when the most likely cause of dementia was LOAD, but there were other disorders that could contribute to the dementia such as stroke and Parkinson's disease. A diagnosis of vascular dementia (VD) was made when the dementia started within 3 months of the stroke.

Measures of Obesity and Other Covariates

Body mass index (BMI) was defined as weight (kg) divided by height in meters squared (m^2) [17]. Waist circumference (WC) was measured at the minimum circumference between the iliac crest and the rib cage. Waist to hip ratio (WHR) was calculated WC and hip girth (cm) measured at the maximum width over the greater trochanters [17, 18].

Other covariates

History of type 2 diabetes mellitus was ascertained by self-report or by the use of diabetes medications at baseline and each follow-up visit. Hypertension, heart disease and smoking were defined by self report. Heart disease included a history of atrial fibrillation and other arrhythmias, congestive heart failure, myocardial infarction, and angina pectoris. Smoking was classified into never, current, and past smoking. Fasting plasma total cholesterol and triglyceride levels were determined at the first follow-up using standard enzymatic techniques. High-density lipoprotein (HDL) cholesterol levels were determined after precipitation of apolipoprotein B containing lipoproteins with phosphotungstic acid [19]. Low-density lipoprotein (LDL) cholesterol was recalculated using the formula of Friedewald et al. [20]. APOE genotypes were determined as described by Hixson and Vernier [21] with slight modification [22]. We classified persons as homozygeous or heterozygeous for the APOE ε4 allele or not having any ε4 allele.

Statistical Methods

Clinical and demographic characteristics were first compared with the presence and absence of LOAD to determine crude associations. Continuous variables were compared using T-test, and categorical variables were compared using the chi-square test.

Cox proportional hazards regression models[23] were used to examine the association between obesity measures (BMI, WC, WHR) and LOAD. Time from baseline to dementia onset was the time-to-event variable. A left censoring term for age at baseline was included in all models. The first model adjusted for age and sex, the second model adjusted for age, sex, ethnic group, education, and APOE-ε4 allele, and a third model adjusted additionally for, hypertension, heart disease, non-HDL cholesterol, HDL cholesterol, and history of stroke. The rationale for the first model was adjustment for common demographics. The rationale for the second model was adjustment for LOAD risk factors in our sample. The rationale for the third model was to adjust for theoretical mediations between obesity and LOAD; attenuation of the hazard ratios in this model was interpreted as evidence of mediation, not confounding. SAS for Windows version 9 (SAS Institute, Cary, NC) was used for all analyses.

Results

The general characteristics of the study sample are presented in Table 1. BMI was strongly correlated with WC (Pearson coefficient (pc) =0.8; $p<0.0001$) but weakly correlated with WHR (pc=0.1; $p<0.001$). WHR was moderately correlated with WC (pc=0.6; $p<0.001$).

We conducted bivariate analyses comparing persons with and without LOAD (Table 1). Persons with LOAD were older, more likely to be Hispanic, less likely to be White, more likely to have T2D, stroke, had a lower non-HDL cholesterol, and a higher HDL cholesterol. BMI was lower in persons with LOAD, while WHR was higher.

BMI (HR, 0.9; 95% CI: 0.7, 1.1) and WC (HR, 0.9; 95% CI: 0.8, 1.2) as continuous variables were not significantly associated with LOAD. WHR as a continuous variable was associated with higher LOAD risk (HR, 1.4; 95% CI: 1.1, 1.8) in the fully adjusted model.

In the multivariate analyses by quartiles using the first as the reference (Table 2), BMI quartiles were not related to LOAD. The highest WC quartile was related to LOAD in the model adjusted for age and sex, but this association was markedly attenuated in the model adjusting for ethnic group, education, and APOE-ε4. The main covariate driving this attenuation was education. The highest quartile of WHR was strongly associated with LOAD, and this association was robust in all models.

Discussion

Among obesity measures, only higher WHR was robustly associated with LOAD risk. The association between WC and LOAD was strongly attenuated by adjustment for education. The potential mechanisms linking obesity and LOAD are not clear. Obesity is a risk factor for hyperinsulinemia and T2D[24], and both are risk factors in our cohort[25] and in other studies[12]. Obesity is also related to other vascular risk factors such as hypertension and dyslipidemia, heart disease, and stroke[24], which have also been reported to be associated with LOAD in isolation and in aggregate[26]. Obesity is also related to the production of adipokynes and cytokines[27]. However, they are correlates of hyperinsulinemia and T2D and their independent role in LOAD is less clear.

Elevated BMI in middle age may be associated with higher dementia risk [5, 7]. Central obesity in middle age is related to a higher risk of dementia in older age[4]. Higher BMI at ages 70, 75 and 79 years may also predict higher dementia risk [8]. However, there have been reports of no association at mid-life [11] and of lower BMI related to higher LOAD risk[9, 28] at older ages. There are several explanations for this apparent paradox. First, age of the obesity measure in relationship to clinical dementia onset varies across studies. A previous study from our cohort recruited in 1992–1994 [10] found that in younger elderly (65 to 76 years of age), the association between BMI quartiles and LOAD resembles a U shaped-curve, while in the oldest old (> 76 years) higher BMI is related to a lower LOAD risk. This U-shaped association has been reported for the relation between obesity and cardiovascular mortality[29] and underscores the difficulty in studying the effects of obesity in older age[30]. This study also found that higher WC is related to higher LOAD risk in the younger elderly, but not in the oldest old. WHR was not available as an obesity measure in that cohort. The Cardiovascular Health Study recently reported that elevated self-reported BMI at age 50 years was associated with a higher risk of dementia, while BMI at age 65 or older in the same individuals did not[6]. This study underscores the importance of the period in life at which obesity is ascertained in relation to dementia. Another potential explanation for the paradox linking **low** weight in old age to dementia seems to be weight loss. The mechanisms for this are not entirely clear. They may include loss of olfaction[31, 32], one of the earliest manifestations of LOAD, which may lead to decreased caloric intake, forgetfulness of meals[33], and metabolic changes related to LOAD that are not well understood. In this regard, LOAD is accompanied by abnormalities in brain insulin signaling[34] which could affect appetite and food intake. It is not clear if weight loss is a consequence of LOAD, a parallel process, or if it is related to potential causes of LOAD, such as insulin resistance[35]. Our results are consistent with the concept that BMI loses predictive ability in the elderly, but is also consistent with the idea that measures of central obesity such as WHR are better measures of outcomes including vascular disease [13] across different ethnic group, sex groups, and age groups.ta

The generalizability of our findings to other populations is not clear. It is important to point out that our sample is subject to survival bias, and we may not be capturing the effects of obesity earlier in life. However, it demonstrates that central obesity may be important in the fastest growing age group in our society. To the best of our knowledge, this is the first study demonstrating that WHR in the elderly is a better predictor of LOAD compared to other measures of obesity and helps explain the apparent discrepancies in studies reporting on obesity in the elderly and LOAD. Interventions that target central obesity in middle age and the elderly, such as diet and exercise, could be tested for the prevention of LOAD.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This work was supported by National Institutes of Health grants P01 AG07232, AG029949, and P60 MD000206. Funders had no role in design and conduct of the study; collection, management, analysis, and interpretation of the data; and preparation, review, or approval of the manuscript

References

1. Ritchie K, Lovestone S. The dementias. Lancet. 2002; 360(9347):1759–1766. [PubMed: 12480441]
2. Brookmeyer R, Gray S, Kawas C. Projections of Alzheimer's disease in the United States and the public health impact of delaying disease onset. Am J Public Health. 1998 Sep; 88(9):1337–1342. [PubMed: 9736873]

3. Tomlinson BE, Blessed G, Roth M. Observations on the brains of demented old people. J Neurol Sci. 1970 Sep; 11(3):205–242. [PubMed: 5505685]
4. Whitmer RA, Gustafson DR, Barrett-Connor E, Haan MN, Gunderson EP, Yaffe K. Central obesity and increased risk of dementia more than three decades later. Neurology. 2008; 71:1057–1064. [PubMed: 18367704]
5. Whitmer RA, Gunderson EP, Barrett-Connor E, Quesenberry CP Jr, Yaffe K. Obesity in middle age and future risk of dementia: a 27 year longitudinal population based study. BMJ. 2005 May 16. 2005:bmj.38446.466238.E466230.
6. Fitzpatrick AL, Kuller LH, Lopez OL, et al. Midlife and late-life obesity and the risk of dementia: cardiovascular health study. Arch Neurol. 2009 Mar.66:336–342. [PubMed: 19273752]
7. Kivipelto M, Ngandu T, Fratiglioni L, et al. Obesity and vascular risk factors at midlife and the risk of dementia and Alzheimer disease. Arch Neurol. 2005 Oct.62:1556–1560. [PubMed: 16216938]
8. Gustafson D, Rothenberg E, Blennow K, Steen B, Skoog I. An 18-Year Follow-up of Overweight and Risk of Alzheimer Disease. Arch Intern Med. 2003; 163:1524–1528. [PubMed: 12860573]
9. Nourhashemi F, Deschamps V, Larrieu S, et al. Body mass index and incidence of dementia: the PAQUID study. Neurology. 2003; 60:117–119. [PubMed: 12525731]
10. Luchsinger JA, Patel B, Tang MX, Schupf N, Mayeux R. Measures of adiposity and dementia risk in elderly persons. Arch Neurol. 2007; 64:392–398. [PubMed: 17353383]
11. Stewart R, Masaki K, Xue Q-L, et al. A 32-Year Prospective Study of Change in Body Weight and Incident Dementia: The Honolulu-Asia Aging Study. Arch Neurol. 2005; 62:55–60. [PubMed: 15642850]
12. Luchsinger JA. Adiposity, hyperinsulinemia, diabetes and Alzheimer's disease: an epidemiological perspective. Eur J Pharmacol. 2008; 585:119–129. [PubMed: 18384771]
13. Yusuf S, Hawken S, Ounpuu S, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. Lancet. 2004; 364:937–952. [PubMed: 15364185]
14. Diagnostic and statistical manual of mental disorders, 4th edition. :DSM IV. Washington, D.C.: American Psychiatric Association; 1997.
15. Hughes CP, Berg L, Danziger WL, Coben LA, Martin RL. A new clinical scale for the staging of dementia. Br J Psychiatry. 1982; 140:566–572. [PubMed: 7104545]
16. McKhann G, Drachman D, Folstein M, Katzman R, Price D, Stadlan EM. Clinical diagnosis of Alzheimer's disease: report of the NINCDS-ADRDA Work Group under the auspices of Department of Health and Human Services Task Force on Alzheimer's Disease. Neurology. 1984; 34(7):939–944. [PubMed: 6610841]
17. Mueller WH, Wear ML, Hanis CL, et al. Which measure of body fat distribution is best for epidemiologic research? Am J Epidemiol. 1991; 133:858–869. [PubMed: 2028976]
18. Taylor RW, Keil D, Gold EJ, Williams SM, Goulding A. Body mass index, waist girth, and waist-to-hip ratio as indexes of total and regional adiposity in women: evaluation using receiver operating characteristic curves. Am J Clin Nutr. 1998; 67:44–49. [PubMed: 9440374]
19. Lopes-Virella MF, Stone P, Ellis S, Colwell JA. Cholesterol determination in high-density lipoproteins separated by three different methods. Clin Chem. 1977; 23(5):882–884. [PubMed: 192488]
20. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem. 1972; 18:499–502. [PubMed: 4337382]
21. Hixson JE, Vernier DT. Restriction isotyping of human apolipoprotein E by gene amplification and cleavage with HhaI. J Lipid Res. 1990; 31:545–548. [PubMed: 2341813]
22. Mayeux R, Ottman R, Maestre G, et al. Synergistic effects of traumatic head injury and apolipoprotein-epsilon 4 in patients with Alzheimer's disease. Neurology. 1995; 45:555–557. [PubMed: 7898715]
23. Cox, DR.; Oakes, D. Analysis of survival data. London; New York: Chapman and Hall; 1984.
24. Pi-Sunyer FX. The Obesity Epidemic: Pathophysiology and Consequences of Obesity. Obes Res. 2002; 10(90002):97S–104. [PubMed: 12490658]

25. Luchsinger JA, Tang M-X, Shea S, Mayeux R. Hyperinsulinemia and risk of Alzheimer disease. Neurology. 2004; 63:1187–1192. [PubMed: 15477536]
26. Luchsinger JA, Reitz C, Honig LS, Tang MX, Shea S, Mayeux R. Aggregation of vascular risk factors and risk of incident Alzheimer disease. Neurology. 2005; 65:545–551. [PubMed: 16116114]
27. Yu YH, Ginsberg HN. Adipocyte signaling and lipid homeostasis: sequelae of insulin-resistant adipose tissue. Circ Res. 2005; 96(10):1042–1052. [PubMed: 15920027]
28. Atti AR, Palmer K, Volpato S, Winblad B, De Ronchi D, Fratiglioni L. Late-life body mass index and dementia incidence: nine-year follow-up data from the Kungsholmen Project. J Am Geriatr Soc. 2008; 56:111–116. [PubMed: 18028342]
29. Stevens J, Cai J, Pamuk ER, Williamson DF, Thun MJ, Wood JL. The effect of age on the association between body-mass index and mortality. N Engl J Med. 1998; 338:1–7. [PubMed: 9414324]
30. Stevens J. Impact of age on associations between weight and mortality. Nutr Rev. 2000; 58:129–137. [PubMed: 10860392]
31. Tabert MH, Liu X, Doty RL, et al. A 10-item smell identification scale related to risk for Alzheimer's disease. Ann Neurol. 2005; 58(1):155–160. [PubMed: 15984022]
32. Devanand DP, Michaels-Marston KS, Liu X, et al. Olfactory deficits in patients with mild cognitive impairment predict Alzheimer's disease at follow-up. Am J Psychiatry. 2000; 157(9): 1399–1405. [PubMed: 10964854]
33. Gustafson D. A life course of adiposity and dementia. Eur J Pharmacol. 2008; 585(1):163–175. [PubMed: 18423446]
34. Steen E, Terry BM, Rivera EJ, et al. Impaired insulin and insulin-like growth factor expression and signaling mechanisms in Alzheimer's disease--is this type 3 diabetes? J Alzheimers Dis. 2005; 7:63–80. [PubMed: 15750215]
35. Wedick NM, Mayer-Davis EJ, Wingard DL, Addy CL, Barrett-Connor E. Insulin Resistance Precedes Weight Loss in Adults without Diabetes : The Rancho Bernardo Study. Am. J. Epidemiol. 2001; 153:1199–1205. [PubMed: 11415955]

Table 1

General characteristics of the total study sample and comparison between persons with and without incident late onset Alzheimer's disease (LOAD)

Variable	Total n = 1,459	No LOAD n = 1,314	LOAD n = 145	P value
Age in years, mean (SD)	75.9 (6.5)	75.5 (6.2)	80.8 (7.1)	<0.0001
Female sex, (%)	1,001 (67.3)	887 (67.5)	97 (67.1)	0.88
Black, (%)	477 (32.1)	428 (32.6)	44 (30.3)	0.58
Hispanic, (%)	496 (33.3)	410 (31.2)	74 (51.0)	<0.0001
White, (%)	515 (34.6)	476 (36.2)	27 (18.6)	<0.0001
Education, mean in years, (SD)	10.9 (4.8)	11.3 (4.6)	7.3 (4.9)	<0.0001
APOE ε4 allele %†	310 (26.1)	273 (25.6)	31 (28.4)	0.51
Diabetes history (%)	27.3 (5.5)	213 (16.2)	36 (24.8)	0.01
Stroke history (%)	94.8 (12.6)	103 (7.8)	19 (13.0)	0.03
Hypertension history %	0.88 (0.07)	792 (60.3)	99 (68.3)	0.06
Mean Non-HDL cholesterol (mg/dl) (SD)‡	253 (17.0)	151.9 (36.9)	140.2 (36.7)	0.002
Mean HDL cholesterol level (mg/dl) (SD)‡	124 (8.3)	48.6 (14.6)	45.7 (13.5)	0.05
History of heart disease, (%)	901 (61.0)	348 (26.5)	43 (29.7)	0.41
Current smoking, (%)	150.9 (37.1)	131 (9.9)	13 (8.9)	0.70
Body mass index *	27.3 (5.5)	27.4 (5.5)	26.5 (5.9)	0.06
Waist circumference **	94.8 (12.6)	94.8 (12.4)	95.1 (14.1)	0.77
Waist to hip ratio ***	0.9 (0.07)	0.8 (0.07)	0.9 (0.07)	0.002

*Available in 1431 persons;

**Available in 1437 persons;

***Available in 1406 persons;

†Available in 1177 persons;

‡Available in 1118 persons

HDL = high density lipoprotein

TABLE 2

Hazard ratios (HR) and 95% confidence intervals (CI) relating adiposity and late onset Alzheimer's disease (LOAD). Model 1 is adjusted for gender and age; Model 2 is also adjusted for ethnicity, education, and APOE ε4 allele; Model 3 is additionally adjusted for type 2 diabetes, hypertension, heart disease, non-HDL cholesterol, HDL cholesterol, and stroke.

	At risk	LOAD cases	Model 1	Model 2	Model 3
Body Mass Index Quartiles					
1	359	49	1.0	1.0	1.0
2	358	27	0.7 (0.5, 1.2)	0.4 (0.3, 0.8)	0.4 (0.2, 0.7)
3	357	31	1.0 (0.6, 1.6)	0.6 (0.4, 1.1)	0.7 (0.4, 1.2)
4	357	33	1.3 (0.8, 2.1)	0.7 (0.4, 1.2)	0.6 (0.3, 1.1)
P for trend	NA		0.12	0.40	0.19
Waist Circumference Quartiles					
1	389	44	1.0	1.0	1.0
2	393	34	0.9 (0.6, 1.4)	0.5 (0.3, 0.9)	0.4 (0.2, 0.7)
3	344	32	1.2 (0.8, 2.0)	0.8 (0.5, 1.4)	0.7 (0.4, 1.3)
4	330	35	1.6 (1.0, 2.6)	0.9 (0.5, 1.6)	0.8 (0.4, 1.4)
P for trend	NA		0.01	0.89	0.61
Waist to Hip Ratio Quartiles					
1	342	29	1.0	1.0	1.0
2	360	29	0.8 (0.5, 1.4)	0.6 (0.4, 1.1)	0.8 (0.5, 1.6)
3	354	28	1.0 (0.6, 1.7)	1.0 (0.6, 1.8)	1.0 (0.5, 1.9)
4	350	55	2.6 (1.7, 4.1)	2.2 (1.3, 3.8)	2.5 (1.3, 4.7)
P for trend	NA		<0.0001	0.0011	0.0019