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CHANGE IN INTRA-ABDOMINAL FAT PREDICTS THE RISK OF HYPERTENSION IN JAPANESE AMERICANS

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Abstract

In Japanese Americans, intra-abdominal fat area measured by computed tomography is positively associated with the prevalence and incidence of hypertension. Evidence in other populations suggests that other fat areas may be protective. We sought to determine whether a change in specific fat depots predicts the development of hypertension. We prospectively followed 286 subjects (mean age 49.5 yrs, 50.4% male) from the Japanese American Community Diabetes Study for 10 years. At baseline subjects did not have hypertension (defined as blood pressure 140/90 mmHg) and were not taking blood pressure or glucose-lowering medications. Mid-thigh subcutaneous fat area, abdominal subcutaneous fat area, and intra-abdominal fat area were directly measured by computed tomography at baseline and 5 years. Logistic regression was used to estimate odds of incident hypertension over 10 years in relation to a 5-year change in fat area. The relative odds of developing hypertension for a 5-year increase in intra-abdominal fat was 1.74 (95% CI 1.28–2.37), after adjusting for age, sex, BMI, baseline intra-abdominal fat, alcohol use, smoking status and weekly exercise energy expenditure. This relationship remained significant when adjusted for baseline fasting insulin and 2-hour glucose levels or for diabetes and prediabetes classification. There were no significant associations between baseline and change in thigh or abdominal subcutaneous fat areas and incident hypertension. In conclusion, in this cohort

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of Japanese Americans, the risk of developing hypertension is related to the accumulation of intra-abdominal fat rather than the accrual of subcutaneous fat in either the thigh or abdominal areas.

Keywords

Adiposity; intra-abdominal fat; visceral fat; hypertension; Asian Americans

Introduction

Excess adiposity is known to have harmful effects on health, specifically on cardiovascular wellbeing. Research has shown that not only fat quantity, but the location of specific adipose depots has an important role in the development of cardiometabolic disease.^{1–4} Prior work from the Japanese American Community Diabetes Study (JACDS) has shown that greater intra-abdominal adipose area, or visceral fat, is positively associated with both the prevalence and incidence of hypertension.^{5, 6} Cross-sectional data in Japanese men additionally found that the amount of intra-abdominal fat is related to the prevalence of hypertension, whereas other areas, including abdominal subcutaneous area, are not.⁷ Other studies have proposed that additional adipose depots may play a role in cardiovascular disease. Cross-sectional data in Caucasian subjects from the Framingham Heart Study found that both computed tomography (CT) measured visceral and abdominal subcutaneous adipose volumes are associated with hypertension, with the former depot carrying a greater effect.⁸

Some data has suggested that specific fat depots may actually be protective against cardiovascular disease. In a Japanese cohort, leg fat mass has been negatively associated with cardiovascular risk factors, such as hypertension, hypertriglyceridemia, dyslipidemia and diabetes, after adjusting for trunk fat mass and leg lean tissue mass quantified using DEXA imaging.⁹ In African American females, DEXA measured lower extremity fat depots have also been negatively associated with cardiovascular risk factors such as systolic blood pressure and triglyceride levels when controlled for total body fat.¹⁰ These studies suggest that leg fat accumulation may be protective against the development of cardiovascular disease. The data supporting this association, though, are not consistent. A cross sectional study of older Caucasian and African American subjects reported a positive association between CT-measured thigh subcutaneous fat and hypertension in African American males; however these results were not adjusted for other measured fat areas.¹¹

To our knowledge, to date there are no prospective studies comparing the relationship between the change in specific adipose depots and development of hypertension. Intra-abdominal fat deposition is greater in younger individuals, but continues to accumulate with aging, thereby resulting in the potential for prolonged exposure to its adverse health effects.^{12, 13} We therefore examined the relationship between change in CT-measured abdominal and thigh fat areas over a 5 year period and the incidence of hypertension over 10 years in a Japanese-American cohort of men and women, with the hypothesis that an increase in intra-abdominal fat accumulation will be positively and more strongly associated with development of hypertension than other measured fat depots.

Methods

Subjects

The cohort used in this prospective analysis comes from the JACDS, which enrolled second and third generation Japanese Americans of 100% Japanese ancestry from 1983 through 1988 residing in King County, Washington. Details on study group characteristics and recruitment methods have been previously described.^{14–16} Participants had follow up visits at 5 to 6 years and 10 to 11 years after the baseline study visit. The University of Washington Human Subjects Division approved the study and all subjects provided written informed consent prior to participation.

For our current analysis, subjects were excluded from the original cohort of 658 individuals if they had a diagnosis of hypertension at baseline, defined by systolic blood pressure ≥ 140 mm Hg, diastolic blood pressure ≥ 90 mm Hg or use of antihypertensive medications. Subjects on oral glucose-lowering medications or insulin at baseline were also excluded. As outlined in Figure 1, a total of 286 subjects from 381 were eligible by these criteria and included in the analysis.

History, Anthropometric Measurements and Glucose Tolerance

Body weight was measured in kilograms and used to calculate body mass index (BMI) as weight in kilograms divided by the square of measured height in meters. Abdominal circumference was measured at the level of the umbilicus in centimeters. After a rest period of approximately 30 minutes, blood pressure was measured with a mercury sphygmomanometer in the recumbent position to the nearest 2 mm Hg and reported as an average recording from the second and third of three consecutive measurements. Daily dietary sodium intake in milligrams was assessed from a food frequency questionnaire at baseline as described previously.¹⁷ Alcohol consumption was obtained via questionnaires and measured in grams per week. Smoking status was defined at the baseline visit as current, former or never smoker. Weekly energy expenditure, in kcal per week, was estimated by responses from questionnaires on self-reported activities, including data on sports, strenuous activities, distance walked and stairs climbed.^{15, 18} Self reported physical activity level at baseline was obtained and ranked on a categorical scale from sedentary to heavy.

Following an overnight 10-hour fast, plasma glucose levels from a 75-g oral glucose tolerance test (OGTT) were used to define diabetes and prediabetes using American Diabetes Association criteria.¹⁹ Fasting insulin levels were measured by radioimmunoassay and used as a surrogate marker of insulin sensitivity.^{20, 21}

CT was used to obtain single slice imaging of the abdomen at the level of the umbilicus to measure the cross-sectional abdominal subcutaneous and intra-abdominal fat areas. Thigh subcutaneous fat area was measured midway between the greater trochanter and superior margin of the patella. All areas were calculated in cm^2 , as detailed previously.²² Intra-abdominal fat area was used to estimate visceral adiposity, as this fat depot has been shown to have a high correlation with visceral adipose tissue volume estimates with CT or magnetic resonance imaging.^{23, 24}

Subjects underwent repeat testing of all measurements including laboratory and CT-measurements at 5–6 and 10–11 year follow-up examinations.

Calculations and Statistical Analysis

Change in CT-measured fat area was calculated as the difference between the 5-year and baseline measurements. Subjects were defined as developing hypertension if they met diagnostic criteria (systolic blood pressure ≥ 140 mm Hg, diastolic blood pressure ≥ 90 mm Hg, or use of antihypertensive medications) at either the 5 to 6 year or 10 to 11 year visit.

Multiple logistic regression analysis was used to calculate the adjusted odds ratio (OR) of incident hypertension at 10-year follow up in relation to a 5-year increase in specific CT-measured fat depots. Presence of multicollinearity in multivariable models was evaluated using the variance inflation factor, with a value greater than 4 suggesting its presence.²⁵ Both BMI and baseline fat depot were included in models looking at change in fat depots as evidence for correlation between these variables was low (online supplement (OS) S1). OR and the 95% confidence interval (CI) for continuous variables are listed for a 1-standard deviation (SD) increment. Quartiles of baseline intra-abdominal fat area were used in logistic models as prior analyses in this cohort have demonstrated that this fat depot has a non-linear association with hypertension.^{5, 6} The better fit of the models predicting hypertension that included quartiles of baseline intra-abdominal fat area as compared to the continuous form of this variable was confirmed in our analysis by the Akaike Information Criteria (AIC).²⁶ The continuous measurement of change in intra-abdominal fat area was used for our analysis as this resulted in a better fit in a bivariate model predicting hypertension incidence as judged by AIC. Interaction by sex and age with change in fat areas in relation to incident hypertension was tested by insertion of first order interaction terms between these variables into regression models. P values were two-tailed and determined to be statistically significant if <0.05 . Statistical analysis was performed using STATA, version 12.1 (Stata Corp., College Station, Texas.)

Results

Baseline Characteristics

A total of 286 subjects were followed from baseline to a 10 or 11-year follow up. Baseline characteristics of the cohort were 50.4% male, mean age of 49.5 ± 11.6 years, BMI 23.7 ± 3.1 kg/m², and intra-abdominal fat area of 70.3 ± 43.6 cm² ($\pm$ SD). Even with the exclusion of subjects on glucose-lowering medications, there were 105 subjects with a classification of prediabetes and 21 with diabetes. Eighty-two cases of hypertension developed over the follow up period. Baseline characteristics of the subjects by incident hypertension are shown in Table 1.

Unadjusted Predictors of Development of Hypertension

Table 2 lists the unadjusted OR for incident hypertension at follow up. Baseline and 5-year change in intra-abdominal fat area had a significant association with the odds of incident hypertension. Baseline abdominal subcutaneous fat area was significantly associated with hypertension, however change in this fat depot was not. Neither baseline thigh subcutaneous

fat area nor a change in this region was significantly related with the development of hypertension. Unadjusted age, systolic and diastolic blood pressures, fasting and 2-hour plasma glucose levels, prediabetes status and BMI all were significantly associated with incident hypertension.

Adjusted Predictors of Development of Hypertension

We next examined multivariable models to determine the adjusted OR for incident hypertension by baseline and change in specific adipose depots. All models were adjusted for age, sex, BMI, alcohol intake, weekly energy expenditure and smoking status. The adjusted 3rd and 4th quartiles of baseline intra-abdominal fat area were significantly associated with a 10-year incidence of hypertension (OR 2.85 [95% CI 1.00–8.10] for quartile 3 versus 1 and OR 3.37 [95% CI 1.04–10.86] for quartile 4 versus 1). Baseline thigh and abdominal subcutaneous fat areas were not associated with incident hypertension (data not shown.)

Table 3 lists the adjusted OR for a 5-year change in fat depots. Change in intra-abdominal fat area was significantly associated with incident hypertension. If additionally adjusted for baseline systolic or diastolic blood pressure, change in intra-abdominal fat area remained associated with incident hypertension (OR 1.89 [95% CI 1.36–2.62] and OR 1.73 [95% CI 1.27–2.36] respectively. Change in intra-abdominal fat area remained associated with incident hypertension when further adjusted for either change in thigh or abdominal subcutaneous fat area. Neither change in thigh nor change in abdominal subcutaneous fat area was significantly related to the development of hypertension, even when adjusted for baseline or change in the intra-abdominal fat area. Adjusting these models for self-reported physical activity in place of weekly energy expenditure did not change these associations (data not shown).

These models were further adjusted for baseline fasting insulin and 2-hour plasma glucose and baseline diabetes and prediabetes classification (OS, S2). Change in intra-abdominal fat area remained significantly associated with incident hypertension, while the change in thigh or abdominal subcutaneous fat area was not associated with the outcome. The associations between change in fat areas and incident hypertension did not vary by sex or by age as first-order interaction terms between sex or age and change in the intra-abdominal, abdominal subcutaneous, and thigh fat depots were all nonsignificant when inserted in Table 3 models ($P > 0.05$). Although there was no significant interaction in the association between hypertension and change in fat depot area by sex, we present sex-stratified results in OS, S3–8. The combined analyses in men and women though constitute the main results.

We additionally examined the 5-year change in BMI and abdominal circumference and incident hypertension. A 5-year change in BMI, adjusted for sex, age, baseline BMI, alcohol intake, weekly energy expenditure and smoking status as baseline was significantly associated with incident hypertension. However, when further adjusted for change in intra-abdominal fat area, this relationship was no longer significant. A 5-year change in abdominal circumference was not significantly associated with incident hypertension (results not shown).

A subset analysis was performed by excluding subjects who developed hypertension by the 5 or 6-year follow up to examine subjects who developed hypertension after the measured change in fat depots. Fifty-two subjects were removed from this analysis, resulting in a sub-cohort of 234 subjects with a 12.8% incidence of hypertension. In this model, a 5-year change in intra-abdominal fat (adjusted for age, sex, BMI, baseline intra-abdominal fat, alcohol intake, weekly energy expenditure and smoking status) remained significantly associated with incident hypertension (data not shown.)

Discussion

In this prospective cohort study, we have demonstrated that in Japanese Americans, the risk of developing hypertension is related to the accrual of intra-abdominal adipose tissue. This observation was independent of age, sex, BMI, alcohol intake, weekly energy expenditure, smoking status, diabetes or prediabetes classification, and surrogate markers of insulin sensitivity. Neither change in abdominal subcutaneous fat nor thigh subcutaneous fat was related to incident hypertension.

Prior research has demonstrated that fat depot locations differ in their associations with cardiometabolic disease. Prior work from the JACDS demonstrated that baseline intra-abdominal fat area is associated with the prevalence and incidence of hypertension in participants not on blood pressure or glucose-lowering medications.^{5, 6} The current analysis is unique in that it demonstrates that change in CT-measured intra-abdominal fat is associated with incident hypertension, independent of other adipose depot areas as well as generalized adiposity as measured by BMI. A subset analysis was performed to determine whether change in intra-abdominal fat precedes development of hypertension. After excluding subjects who developed hypertension at the 5-year follow up, change in intra-abdominal fat remained associated with incident hypertension suggesting that change in this depot may precede the development of hypertension and play a role in its pathogenesis. A related longitudinal study in Canada examined change in cardiorespiratory fitness, including blood pressure, by 6-year change in visceral fat among healthy men and women.²⁷ Change in visceral fat was significantly associated with variance explained for both change in systolic and diastolic blood pressure, but it is not clear whether participants developed hypertension. In addition, a cross-sectional study in French Canadian young adults found that MRI-measured visceral adipose tissue had a positive and stronger association with markers of cardiovascular health, including systolic and diastolic blood pressures, than other adipose depots.²⁸

While previous studies have suggested certain adipose depots may be protective against the metabolic syndrome and cardiovascular disease, we did not find a protective effect of greater lower body or abdominal subcutaneous adipose tissue on incident hypertension, even after adjusting for intra-abdominal fat area. This difference may be because most data has been reported from cross-sectional analyses. Additionally, some studies suggesting lower adiposity has favorable effects on cardiovascular disease did not control for the intra-abdominal adipose depot, which may have influenced results.¹⁰ Previous cross sectional data from the AusDiab study that demonstrated greater hip circumference was associated with lower prevalence of hypertension in men cannot be directly compared to our data, as

this circumferential measurement does not distinguish between adipose versus muscle at this location.²⁹ Some data suggesting lower body adiposity is cardio-protective has focused on other components of the metabolic syndrome such as insulin sensitivity, HDL levels or triglycerides or did not examine hypertension independent of the metabolic syndrome, and therefore it may not be possible to infer a similar effect on risk of hypertension.^{30–33}

We additionally examined the relationship between change in BMI, a marker of total body adiposity, and incident hypertension. An unadjusted change in BMI appeared to have a significant association with incident hypertension, however when this measurement was further adjusted for change in intra-abdominal fat area, the association was lost. Change in abdominal circumference additionally did not appear to be associated with development of hypertension. These findings are not surprising, as BMI is not considered to be a useful measure of specific fat depots and abdominal circumference measurements cannot distinguish between visceral and subcutaneous adiposity.⁴ These findings suggest that simple anthropometric measurements have limitations when investigating the relationship between regional fat depots and risk of hypertension and perhaps other cardiovascular risks.

There are potential limitations to this study. First, our results are from a Japanese-American cohort and it is unknown whether the findings can be applied to other ethnic groups. However, recent data from the Dallas Heart Study, comprised of African American, Caucasian and Hispanic individuals, demonstrated greater visceral adipose tissue and, in particular, retroperitoneal fat, was significantly associated with incident hypertension.³⁴ Second, we used a single CT slice to estimate adipose depot size. Previous work with this cohort has demonstrated that intra-abdominal fat measurement from a single slice is highly correlated with visceral fat volume as assessed from a multiple-slice CT scanning protocol ($r = 0.89–0.94$).^{23, 24} For our analysis, intra-abdominal fat was measured at the L4-L5 level, and CT-measurement at this site has been shown to be an accurate estimate of total visceral fat.²³ In using a single slice for adipose measurement, there is also a potential limitation when comparing longitudinal CT fat areas of measurement error due to positioning of subjects and acquisition of images. Third is a potential for confounding bias in our results. We addressed this problem by adjusting our models for age, sex, BMI, 2-hour glucose level, fasting insulin, diabetes and prediabetes classification, alcohol intake, weekly energy expenditure and smoking status at baseline. As is true for any observational study, the presence of potentially unknown or unmeasured confounding variables cannot be excluded. Fourth, there may have been a selection bias from excluding participants who were lost to follow up or had missing data. Seventy-five percent of subjects who qualified for entry into the study completed follow up. The potential exists for bias if this excluded group had a different risk of hypertension in relation to visceral fat deposition than those who were included in the analysis. However, baseline characteristics did not differ between those included in and those excluded from the study, except for mean fasting insulin (data not shown), suggesting this is unlikely, as there was no significant association between fasting insulin concentration and incident hypertension.

Based on the observational study design used for this analysis, one cannot assume a causal mechanism between the higher odds of hypertension development in association with intra-abdominal fat increase. There are multiple theories on how adipose and specific fat depots

contribute to the development of hypertension. One notion is the insulin resistance and hyperinsulinemia seen with abdominal obesity contributes to the pathogenesis of hypertension via endothelial dysfunction, sodium retention, increased sympathetic activity and vascular hypertrophy.¹⁻³ In our study, change in the intra-abdominal adipose depot remained associated with hypertension after adjusting for fasting plasma insulin (a surrogate marker of insulin sensitivity) and 2-hour glucose levels as well as for diabetes and prediabetes classification. These findings suggest that the influence of this adipose depot may be independent of effects of insulin resistance or dysglycemia on hypertension. Other proposed mechanisms include increased angiotensinogen gene expression in this fat depot, an inverse relationship with beneficial fat hormones, such as adiponectin, and increased free fatty acid production.³⁵⁻³⁷ Additionally, it is thought that intra-abdominal adipose tissue compared to subcutaneous adipose tissue is unable to continuously accommodate to increased deposition in this region.^{37, 38} This may be in part due to the loss of the ability of adipocytes to differentiate into effective lipid storage cells and an imbalance between free fatty acid and leptin production; thus, fat accumulation in this depot is expected to have deleterious effects on the cardiovascular system.^{37, 39}

In conclusion, we have demonstrated in Japanese Americans that change in the intra-abdominal adipose tissue depot is the critical region related to the development of hypertension. None of the other fat depots studied were associated with the development of hypertension. Further, it appears that accumulation of intra-abdominal fat precedes the increase in blood pressure, and therefore may play a role in the development of hypertension and cardiovascular disease in Japanese Americans. Future study will be required to determine if causality explains this association, which may provide targets for adipose-directed interventions for the prevention or treatment of hypertension.

Perspectives

In this Japanese-American population, change in the intra-abdominal fat depot is associated with development of hypertension, independent of other measured adipose depots. None of the other fat areas studied or anthropometric measurements of adiposity were associated with incident hypertension. Further, it appears that the accumulation of intra-abdominal fat precedes the increase in blood pressure and therefore may play a role in the development of hypertension. Further work needs to be done to investigate this relationship and potential therapeutic interventions to better prevent or treat hypertension.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Novelty and Significance

What Is New

Change in intra-abdominal fat is related to the development of hypertension among Japanese Americans.

What Is Relevant

Fat deposition and its location have an important role in cardiovascular disease and hypertension and certain fat depots play a more significant role in development of cardiovascular disease than others.

Summary

This study demonstrates that a recent change in the intra-abdominal fat depot is related to the development of hypertension. None of the other fat depots studied were associated with the development of hypertension. These results suggest a potential causal relationship between the accumulation of intra-abdominal fat and hypertension risk.

Figure 1.
Flow diagram of subjects included and excluded in the analysis.

Table 1

Baseline characteristics of subjects by incident hypertension at 10 year follow up *

Characteristic	Hypertension status at follow up			P value
	Total (n=286)	Normotensive (n=204)	Hypertensive (n=82)	
Age, years	49.5±11.6 [†]	47.1±11.1	55.4±10.9	<0.001
% Male	50.4	47.1	58.6	0.079
Systolic blood pressure, mm Hg	120.6±10.1	118.5±9.6	125.9±9.3	<0.001
Diastolic blood pressure, mm Hg	73.4±7.5	72.4±7.5	75.8±7.1	<0.001
Fasting Insulin, pmol/L	76.8±37.3	74.4±34.9	83.4±42.2	0.066
Fasting glucose, mmol/L	5.23±1.11	5.10±1.01	5.57±1.26	0.001
2-hour glucose, mmol/L	7.50±2.92	7.18±2.65	8.29±3.39	0.003
Diabetes, n (%)	21 (7.34 %)	11 (5.39 %)	10 (12.2 %)	0.046
Prediabetes, n (%)	105 (36.71 %)	67 (32.84 %)	38 (46.34 %)	0.032
<i>Body measurements</i>				
Weight, kg	62.24±11.64	61.41±11.54	64.29±11.69	0.058
BMI, kg/m ²	23.7±3.1	23.4±3.1	24.5±3.1	0.006
Abdominal circumference, cm [‡]	84.55±8.29	83.46±8.24	87.23±7.83	<0.001
<i>CT-Measured Adipose Depots</i>				
Intra-abdominal fat area, cm ²	70.3±43.6	62.9±41.8	88.8±42.8	<0.001
Intra-abdominal fat area quartiles, n (%)				
Quartile 1	72 (25.17 %)	65 (31.86 %)	7 (8.54 %)	<0.001
Quartile 2	71 (24.83 %)	54 (26.47 %)	17 (20.73 %)	
Quartile 3	72 (25.17 %)	47 (23.04 %)	25 (30.49 %)	
Quartile 4	71 (24.83 %)	38 (18.63 %)	33 (40.24 %)	
Abdominal subcutaneous fat area, cm ²	151.6±73.0	144.7±70.1	168.9±77.6	0.010
Thigh subcutaneous fat area, cm ²	66.3±32.6	67.5±32.1	63.3±34.0	0.333
<i>Lifestyle Factors</i>				
Sodium intake, mg/d	2634±1174	2604±1045	2706±1450	0.507
Daily alcohol consumption, g/d	5.03±10.9	5.46±11.97	3.97±7.47	0.297
Weekly energy expenditure, kcal/wk	2774±2024	2827±2096	2640±1840	0.479
Smoking history				
Never	141 (49.3 %)	99 (48.53 %)	42 (51.22 %)	0.531
Former	103 (36.01 %)	72 (35.29 %)	31 (37.8 %)	
Current	42 (14.69 %)	33 (16.18 %)	9 (10.98 %)	

* Continuous values listed as means

[†] Results with ± represent mean ± SD for continuous values[‡] Total n= 284; Normotensive n=202; Hypertensive n=82

Table 2

Unadjusted relative odds of incident hypertension

Variable	Odds ratio [*]	95% CI	P value
Age, yrs	2.09	1.59–2.75	<0.001
Male	1.59	0.95–2.67	0.080
Systolic blood pressure, mm Hg	2.34	1.71–3.19	<0.001
Diastolic blood pressure, mm Hg	1.62	1.23–2.15	0.001
Plasma insulin, pmol/L	1.26	0.98–1.61	0.069
Fasting plasma glucose, mmol/L	1.55	1.14–2.10	0.005
2-hr plasma glucose, mmol/L	1.43	1.11–1.84	0.006
Diabetes classification	2.43	0.99–5.98	0.052
Prediabetes classification	1.95	1.16–3.29	0.012
Weight, kg	1.28	0.99–1.65	0.060
BMI, kg/m ²	1.43	1.10–1.85	0.007
Intra-abdominal fat area, cm ²	1.80	1.38–2.35	<0.001
Intra-abdominal fat area quartiles			
Quartile 2 versus quartile 1	2.92	1.13–7.57	0.027
Quartile 3 versus quartile 1	4.94	1.97–12.37	0.001
Quartile 4 versus quartile 1	8.06	3.25–20.00	<0.001
Change in intra-abdominal fat area, cm ²	1.39	1.07–1.80	0.014
Abdominal subcutaneous fat area, cm ²	1.38	1.07–1.78	0.012
Change in abdominal subcutaneous fat area, cm ²	0.91	0.70–1.18	0.470
Thigh subcutaneous fat area, cm ²	0.88	0.67–1.14	0.332
Change in thigh subcutaneous fat area, cm ²	1.13	0.88–1.46	0.328
Sodium intake, g/d	1.09	0.85–1.40	0.506
Daily alcohol consumption, g/d	0.86	0.64–1.15	0.300
Weekly energy expenditure, kcal/wk	0.91	0.69–1.19	0.479
Current smoker [†]	0.64	0.29–1.40	0.264

* Odds ratios calculated for a 1-SD magnitude increase for continuous variables

[†] Current smoker based on status at baseline visit

Table 3

Adjusted relative odds of incident hypertension at 10–11 year follow up by 5-year change in fat depots

Model 1*		
Adipose Depot	Odds Ratio [†]	P value
Change in intra-abdominal fat area	1.74 (1.28–2.37)	<0.001
Change in thigh subcutaneous fat area	1.22 (0.89–1.67)	0.216
Change in abdominal subcutaneous fat area	1.22 (0.89–1.65)	0.221
<i>Below adipose depot adjusted for baseline intra-abdominal fat area</i>		
Change in thigh subcutaneous fat area	1.27 (0.92–1.75)	0.151
Change in abdominal subcutaneous fat area	1.25 (0.92–1.71)	0.167
<i>Below pairs of adipose depots additionally adjusted for each other</i>		
Change in thigh subcutaneous fat area	1.16 (0.83–1.62)	0.383
Change in intra-abdominal fat area	1.70 (1.25–2.33)	0.001
Change in abdominal subcutaneous fat area	1.00 (0.70–1.41)	0.979
Change in intra-abdominal fat area	1.74 (1.24–2.43)	0.001

* Model 1: Adjusted for age, sex, BMI, smoking, alcohol, and weekly energy expenditure at baseline and respective baseline adipose depot

[†] Odds ratios calculated for a 1-SD magnitude increase for continuous variables