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The association of hip circumference with incident hip fracture in a cohort of postmenopausal women: The Iowa Women's Health Study

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Abstract

PURPOSE—As the mean age of the US population increases, the public health burden of osteoporotic fractures is expected to increase. This study prospectively examined the independent association of hip circumference with hip fracture.

METHODS—The prospective association of hip circumference and hip fracture was examined in a cohort of 30,652 postmenopausal women.

RESULTS—Compared to the lowest quintile, successive quintiles of hip circumference were associated with a reduced hazard of hip fracture over 18 years of follow-up (HRs = 1.00, 0.78, 0.74, 0.76, 0.69, *p* for trend = 0.0015) after adjusting for age. Controlling for waist, this association persisted (HRs = 1.00, 0.78, 0.73, 0.72, 0.54, *p* for trend = 0.0006). Additionally controlling for BMI, the association of hip fracture with hip circumference was attenuated to the null while the association with successive quintiles of BMI remained significant and inverse (HRs = 1.00, 0.55, 0.45, 0.40, 0.35, *p* for trend <0.0001).

CONCLUSIONS—Although hip circumference has a strong inverse association with risk of hip fracture, this association was not independent of BMI. These results suggest that in the prediction of hip fracture risk, overall body size may be more important than body composition of the femoral-gluteal region.

Keywords

anthropometry; hip fractures; cohort studies

PURPOSE

Aging of the US population will be an important occurrence in the coming decades. As the mean population age increases, the public health burden of osteoporotic fractures is expected to rise, which will have a profound impact on subsequent functional limitations^{1,2}, disability, morbidity² and mortality^{2,3} in older populations. Furthermore, given population increases in overweight and obesity, it is important to further our understanding of adiposity and body shape and hip fracture.

Larger hip circumference may represent a body habitus associated with reduced risk of hip fracture. Larger hip circumference likely indicates greater subcutaneous fat accumulation^{4,5}. Smaller hips relative to waist, on the other hand, may indicate a greater relative abdominal fat accumulation^{2,4}. Smaller hips may also represent gluteo-femoral muscle loss, particularly in older adults⁵. Hip circumference may represent differences in body shape associated with hip fracture risk.

This study examined the association of hip circumference, independent of waist circumference and body mass index (BMI), with risk of fractures in postmenopausal women in the Iowa Women's Health Study (IWHs). We hypothesized that women with larger hip circumferences will have a reduced risk of hip fracture over follow-up compared to women with smaller hip circumferences, after controlling for waist circumference, BMI and other risk factors.

METHODS

The IWHs is a prospective cohort study of lifestyle risk factors and chronic diseases in postmenopausal women. Women aged 55–69 years were randomly selected from the 1985 Iowa Department of Transportation driver's license list. Of the 99,826 potentially eligible women sent a questionnaire, 41,836 responded. Based on driver's license information, nonrespondents were, on average, 3 months younger than respondents, had slightly higher BMI (0.4 kg/m^2), and were more likely to live in a rural area⁶. There have been five follow-up mailed questionnaires in 1987 (91% response rate), 1989 (89%), 1992 (83%), 1997 (79%), and 2004 (69%).

Data collection

The baseline questionnaire included standard questions on demographic information, behavioral and lifestyle factors, and personal medical history. Women were asked to report education level, age, and marital status. The questionnaire included three questions about participation in leisure time physical activity and the frequency of moderate- and heavy-intensity activities. These latter two questions were combined to create a 3-level activity score (low, moderate, and high). A food frequency questionnaire was included to ascertain usual diet and alcohol consumption over the past year⁷. Women were asked about smoking status and pack years of cigarettes, hormone therapy, and number of live births and age of first live birth. Disease at baseline was ascertained by asking the women if they had ever been told by a doctor if they had any form of cancer other than skin cancer, angina or other heart disease, myocardial infarction, hypertension or diabetes.

Exposure measures

Enclosed with the baseline questionnaire was a paper tape measure and written instructions to have a friend measure circumferences of the waist (2.5 cm above the umbilicus) and hips (maximal protrusion). From these measures, the waist-hip ratio (WHR) was computed. Participants reported current height and weight, from which BMI was derived. The reliability of the self-measured or self-reported anthropometric variables obtained by this protocol were tested by Kushi et al⁸. Initial and repeated measurements were not statistically different from initial measurement based on paired t-test comparisons. Intra-class correlations of these girth measurements were high (0.96 for waist, 0.97 for hip), thus suggesting that little error is associated with their measurement.

Endpoint measures

Women were followed for self-reported hip fracture by mailed surveys in 1987, 1989, 1992, 1997, and 2004. Munger et al⁹ assessed validity in a small sample of subjects who reported a hip fracture in 1987 or 1989. Participants were asked to provide more information on their

fracture and consent for the release of medical records⁹. Self-reporting of hip fracture incidence was reported to have high validity; of 58 cases of hip fracture, 44 of women's physicians (75.9%) responded to a request for validation and in each of the 44 cases the hip fracture was confirmed by the physician⁹. Deaths were identified via the mailed survey and by linkage to the Iowa death certificate files and the National Death Index.

Exclusions

Women were excluded from the study sample if they reported having any cancer other than skin at baseline (n=3,830), or if they reported being premenopausal at baseline (n=547). If women were missing data for anthropometric variables (n=166) they were excluded from the study sample. Women who had reported a baseline history of fractures after the age of 35 years (n=5,163) were also excluded. After excluding women with missing data for other covariates of interest, the final study sample was 30,652.

Analysis

SAS 9.1¹¹ (SAS Institute Inc, Cary, NC) software was used for all descriptive and prospective analyses. Pearson correlations of anthropometrics at baseline were generated. Descriptive characteristics for baseline characteristics were generated as means and standard deviations for continuous variables and percents for binary variables.

The association of hip circumference with incident fractures was modeled using Cox proportional hazards regression¹⁰. Person-years of follow-up were calculated from the completion of the baseline questionnaire until the last completed follow-up questionnaire or death. If a hip fracture was reported on a follow-up questionnaire, the date of the hip fracture was estimated as the midpoint between the date of the questionnaire in which the first hip fracture was reported and the participant's most recent previous questionnaire. Hip fractures and fractures other than hip (wrist, forearm, upper arm, vertebra/spine, rib) were modeled separately in a series of models to assess confounding and possible mediating variables based on variables found to be important risk factors in previous IWH analyses^{9,11-14}. In order to assess the independent association of hip circumference with incident fracture prospectively, hip circumference and other measures of body size were included in the same model. Tolerance did not exceed the criterion value of ≤ 0.10 as an unacceptable level of multicollinearity. Hazard ratios and 95% confidence intervals were computed in relation to quintiles of hip circumference. Model 1 included anthropometric variables in quintiles and was adjusted for age only. Model 2 included Model 1 variables plus potential confounding variables: education (high school graduate yes/no), physical activity (low/moderate/high), baseline smoking status (current yes/no) and pack years of cigarettes (0, 1–19, 20–39, and ≥ 40 years), alcohol use (none/any), baseline history of estrogen use (current/former/never), and parity (any live births yes/no), and diabetes at baseline in 1987 (yes/no). Trends in hazard ratios across quintiles of anthropometric variables, designated by their median values, were tested by a χ^2 statistic.

RESULTS

Hip circumference at baseline was highly correlated with waist circumference ($r=0.80$), BMI ($r=0.86$), body weight ($r=0.89$), and calf circumference ($r=0.69$) as shown in Table 1. Characteristics at baseline stratified by quintile of hip circumference are shown in Table 2. Compared to women in the lowest quintile of hip circumference, alcohol consumption and smoking were less prevalent in the higher quintiles of hip circumference. Women in the higher quintiles of hip circumference were less likely to report vigorous physical activity and having graduated from high school. Diabetes at baseline was more prevalent among the highest quintile of hip circumference. Parity and current hormone replacement therapy use were similar across categories of hip circumference.

Hazard ratios and 95% confidence intervals for the association of hip circumference with incident hip fracture are shown in Table 3. Compared to women in the lowest quintile of hip circumference, those in the highest quintile had a 31% reduced hazard of incident hip fracture after adjustment for age (HR for successive quintiles of hip circumference = 1.00, 0.78, 0.74, 0.76, 0.69, p for trend = 0.0030, Model 1). The association was unchanged after adjusting for other confounding variables at baseline – education, physical activity, smoking status and pack years of cigarettes, alcohol use, hormone therapy, parity, and diabetes status (Model 2). There was a significant, inverse age-adjusted association of BMI with hip fractures (HR for successive quintiles of BMI = 1.00, 0.63, 0.59, 0.61, 0.60, p for trend <0.0001). The association of BMI with hip fracture was slightly attenuated after adjusting for confounders (HR for successive quintiles of BMI = 1.00, 0.65, 0.61, 0.61, 0.57, p for trend <0.0001). There was no association of waist circumference with hip fractures.

To assess the association of hip circumference independent of waist circumference and BMI, these variables were modeled simultaneously with hip circumference (Table 4). After controlling for waist circumference and confounding variables, successive quintiles of hip circumference were associated with a significantly reduced hazard of incident hip fracture, (HRs = 1.00, 0.78, 0.73, 0.72, 0.54, p for trend = 0.0006). When hip circumference and BMI were modeled simultaneously, the association of hip circumference with incident hip fracture was null, while the association with successive quintiles of BMI was strong and confidence intervals excluded the null (HRs = 1.00, 0.62, 0.54, 0.52, 0.49, p for trend = 0.0007). In the model including BMI, hip and waist circumferences together, the association of hip circumference with incident hip fracture was attenuated to the null (HR = 0.90, 95% confidence interval 0.60–1.33 for the highest compared to the lowest quintile, Table 4). Compared to the lowest quintile, successive quintiles of waist circumference were associated with an increased hazard of incident hip fracture (HRs = 1.26, 1.61, 1.46, 2.18, p for trend 0.0002). Compared to the lowest quintile of BMI, successive quintiles of BMI were associated with a reduced hazard of incident hip fracture (HRs = 0.55, 0.45, 0.40, 0.35, p for trend <0.0001).

In addition to hip fractures, women reported the occurrence during follow-up of fractures of the upper arm, forearm, wrist, spine or ribs. In these supplemental analyses, we observed no associations of hip circumference with incident fractures other than hip fracture (data not shown).

CONCLUSIONS

This prospective study of a cohort of postmenopausal women found a statistically significant, inverse association of hip circumference with incident hip fractures. This association persisted after controlling for waist circumference. However, after controlling for BMI, the association of hip circumference with hip fracture was attenuated to the null while a robust and inverse association of BMI with incident hip fractures was observed. Our findings suggest that BMI is a stronger predictor than hip circumference of hip fracture risk. It is possible that in the association with incident hip fracture, larger hips represent greater overall body size rather than any particular properties that may offer protection from hip fracture.

To our knowledge, there has been only one other study to report the association of hip circumference with incident hip fracture¹⁵. Ensrud et al¹⁵ observed a two-fold increased risk of fracture among women in the lowest compared to the highest quartile of hip circumference. These results are concordant with our findings presented, however Ensrud et al did not assess the association of hip circumference and hip fracture independent of abdominal fat and/or body size. By ignoring the potential effect of BMI, important attributes of adiposity that may be related to bone remodeling may not have been accounted for in Ensrud et al's multivariate

models. Our findings suggest that hip circumference is not associated with a significant reduced hazard of hip fracture after adjusting for BMI.

On one hand hip circumference may represent adiposity of the hip region and on the other hand relative lean mass in the gluteo-femoral region. Lower body mass, specifically around the hip region, may offer cushioning and consequent protection from fractures upon falling¹⁶⁻¹⁸. Compared to larger hips, small hips may not offer this protection from fractures. Our findings that larger hip circumference unadjusted for BMI is associated with reduced risk of hip fracture support this hypothesis. Furthermore, our findings for the association of BMI and hip fracture suggest that it is larger body size, regardless of body fat distribution, that may offer protection from hip fractures. However, we have no measurement of risk of falls and therefore are unable to determine whether larger hip circumference or larger body size offers protection through cushioning or some other mechanism.

Studies in the epidemiologic literature have consistently shown that larger body size, as indicated by higher BMI and body weight, is inversely associated with hip fracture^{15,19-21}. Body mass index is typically a proxy for body fat, but has many limitations as a measure of body composition. Because the BMI neither distinguishes between lean or fat mass, nor does it distinguish between subcutaneous and visceral fat depots, it is unclear which body compartments contributing to an increased BMI are associated with the reduced risk of hip fracture. It may be simply that the excess mechanical force on lower limbs by excess weight stimulates stronger bone^{22,23}. Interestingly, we found that in the model with BMI, hip and waist circumferences, there was an increased risk associated with greater waist circumference. This finding may indicate that carrying excess weight on the torso rather than hips increases the risk of hip fracture, perhaps due to a higher center of gravity. A previous report from the IWHs observed an increased risk of hip fracture associated with higher WHR¹⁴. It is possible that the observed increased risk associated with larger WHR is driven by relatively small hips.

Strengths and limitations

The strengths of IWHs were its large cohort size, long follow-up time, and relatively high retention of participants over follow-up. An important strength was the ability to investigate associations with incident hip fractures in a population of Caucasian older women, a population that tends to have high rates of fractures. However, this study was not without limitations. Hip fracture was ascertained by self-report and therefore subject to misclassification. This limitation was not thought to be a threat to validity as Munger et al found a high correlation between self-reported fractures and medical record review in this cohort⁹. Another important limitation is that we were unable to distinguish between traumatic and osteoporotic hip fractures.

The results of this study may be limited in terms of generalizability. The study population was exclusively white women, which limits generalizing the finding to other populations. During administration of the five follow-up questionnaires, additional women were lost to follow-up and censored when lost. Mortality within one-year of a hip fracture is relatively high³. Because hip fractures were assessed at intervals greater than one year, many of those who died within a year of suffering a hip fracture would be censored. Selection bias in this manner may distort the true association of hip circumference and hip fracture.

Conclusions

In this large, prospective study of postmenopausal women, we observed an inverse association of hip circumference with report of hip fractures over of follow-up, but this association was nonsignificant after adjusting for BMI. Thus, BMI appears to be a more important predictor than hip circumference of hip fracture risk in this cohort of postmenopausal women. Consistent

with other findings in the literature^{15,19-21}, we conclude that older Iowan women with greater BMI are at decreased risk of hip fracture.

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List of abbreviations and acronyms

BMI, Body Mass Index; CI, Confidence Interval; g, gram; HR, Hazard Ratio; IWHHS, Iowa Women's Health Study; kg, kilogram; SD, Standard Deviation; WHR, waist-hip ratio.

REFERENCES

1. Ensrud KE, Nevitt MC, Yunis C, Cauley JA, Seeley DG, Fox KM, Cummings SR. Correlates of impaired function in older women. *J Am Geriatr Soc* 1994;42(5):481–9. [PubMed: 8176141]
2. Keen RW. Burden of osteoporosis and fractures. *Curr Osteoporos Rep* 2003;1(2):66–70. [PubMed: 16036067]
3. Browner WS, Pressman AR, Nevitt MC, Cummings SR. Mortality following fractures in older women. The study of osteoporotic fractures. *Arch Intern Med* 1996;156(14):1521–5. [PubMed: 8687260]
4. Seidell JC, Oosterlee A, Thijssen MA, Burema J, Deurenberg P, Hautvast JG, Ruijs JH. Assessment of intra-abdominal and subcutaneous abdominal fat: relation between anthropometry and computed tomography. *Am J Clin Nutr* 1987;45(1):7–13. [PubMed: 3799506]
5. Hughes VA, Roubenoff R, Wood M, Frontera WR, Evans WJ, Fiatarone Singh MA. Anthropometric assessment of 10-y changes in body composition in the elderly. *Am J Clin Nutr* 2004;80(2):475–82. [PubMed: 15277173]
6. Folsom AR, Kaye SA, Prineas RJ, Potter JD, Gapstur SM, Wallace RB. Increased incidence of carcinoma of the breast associated with abdominal adiposity in postmenopausal women. *Am J Epidemiol* 1990;131(5):794–803. [PubMed: 2138863]
7. Rimm EB, Giovannucci EL, Stampfer MJ, Colditz GA, Litin LB, Willett WC. Reproducibility and validity of an expanded self-administered semiquantitative food frequency questionnaire among male health professionals. *Am J Epidemiol* 1992;135(10):1114–26. [PubMed: 1632423]discussion 1127-36
8. Kushi LH, Kaye SA, Folsom AR, Soler JT, Prineas RJ. Accuracy and reliability of self-measurement of body girths. *Am J Epidemiol* 1988;128(4):740–8. [PubMed: 3421240]
9. Munger RG, Cerhan JR, Chiu BC. Prospective study of dietary protein intake and risk of hip fracture in postmenopausal women. *Am J Clin Nutr* 1999;69(1):147–52. [PubMed: 9925137]
10. Cox DR. Regression models and life tables (with discussion). *J R Stat Soc (B)* 1972;34:187–220.
11. Nicodemus KK, Folsom AR. Type 1 and type 2 diabetes and incident hip fractures in postmenopausal women. *Diabetes Care* 2001;24(7):1192–7. [PubMed: 11423501]
12. Nicodemus KK, Folsom AR, Anderson KE. Menstrual history and risk of hip fractures in postmenopausal women. The Iowa Women's Health Study. *Am J Epidemiol* 2001;153(3):251–5. [PubMed: 11157412]
13. French SA, Folsom AR, Jeffery RW, Zheng W, Mink PJ, Baxter JE. Weight variability and incident disease in older women: the Iowa Women's Health Study. *Int J Obes Relat Metab Disord* 1997;21(3):217–23. [PubMed: 9080261]
14. Folsom AR, Kushi LH, Anderson KE, Mink PJ, Olson JE, Hong CP, Sellers TA, Lazovich D, Prineas RJ. Associations of general and abdominal obesity with multiple health outcomes in older women: the Iowa Women's Health Study. *Arch Intern Med* 2000;160(14):2117–28. [PubMed: 10904454]
15. Ensrud KE, Lipschutz RC, Cauley JA, Seeley D, Nevitt MC, Scott J, Orwoll ES, Genant HK, Cummings SR. Body size and hip fracture risk in older women: a prospective study. Study of Osteoporotic Fractures Research Group. *Am J Med* 1997;103(4):274–80. [PubMed: 9382119]

16. Parkkari J, Kannus P, Poutala J, Vuori I. Force attenuation properties of various trochanteric padding materials under typical falling conditions of the elderly. *J Bone Miner Res* 1994;9(9):1391–6. [PubMed: 7817822]
17. Robinovitch SN, McMahon TA, Hayes WC. Force attenuation in trochanteric soft tissues during impact from a fall. *J Orthop Res* 1995;13(6):956–62. [PubMed: 8544034]
18. Slemenda C. Prevention of hip fractures: risk factor modification. *Am J Med* 1997;103(2A):65S–71S. [PubMed: 9302898]discussion 71S–73S
19. Cummings SR, Nevitt MC, Browner WS, Stone K, Fox KM, Ensrud KE, Cauley J, Black D, Vogt TM. Risk factors for hip fracture in white women. Study of Osteoporotic Fractures Research Group. *N Engl J Med* 1995;332(12):767–73. [PubMed: 7862179]
20. Margolis KL, Ensrud KE, Schreiner PJ, Tabor HK. Body size and risk for clinical fractures in older women. Study of Osteoporotic Fractures Research Group. *Ann Intern Med* 2000;133(2):123–7. [PubMed: 10896638]
21. Pruzansky ME, Turano M, Luckey M, Senie R. Low body weight as a risk factor for hip fracture in both black and white women. *J Orthop Res* 1989;7(2):192–7. [PubMed: 2918419]
22. Edelstein SL, Barrett-Connor E. Relation between body size and bone mineral density in elderly men and women. *Am J Epidemiol* 1993;138(3):160–9. [PubMed: 8356959]
23. Ravn P, Cizza G, Bjarnason NH, Thompson D, Daley M, Wasnich RD, McClung M, Hosking D, Yates AJ, Christiansen C. Low body mass index is an important risk factor for low bone mass and increased bone loss in early postmenopausal women. Early Postmenopausal Intervention Cohort (EPIC) study group. *J Bone Miner Res* 1999;14(9):1622–7. [PubMed: 10469292]

Pearson correlation coefficients for baseline anthropometric variables in a cohort of 30,652 postmenopausal women, IWHHS, 1986.

Table 1

	Hip	Waist	BMI	WHR	Weight	Height
Hip						
Waist						
BMI						
WHR						
Weight						
Height						

* p < 0.0001

Table 2
Descriptive characteristics of a cohort of postmenopausal women at baseline, IWHS, 1986.

Means $\pm$ SD or %	1	2	Quantile of hip circumference 3	4	5
Age, yrs	61.6 $\pm$ 4.2	61.4 $\pm$ 4.2	61.6 $\pm$ 4.2	61.4 $\pm$ 4.2	61.4 $\pm$ 4.2
Weight, lb	121 $\pm$ 12	137 $\pm$ 11	149 $\pm$ 12	163 $\pm$ 14	194 $\pm$ 27
Height, inches	63 $\pm$ 2	64 $\pm$ 2	64 $\pm$ 2	65 $\pm$ 3	65 $\pm$ 3
BMI, kg/m ²	22.0 $\pm$ 2.3	24.4 $\pm$ 2.2	26.3 $\pm$ 2.4	28.6 $\pm$ 2.7	33.9 $\pm$ 4.9
Hip, inches	36.1 $\pm$ 1.8	38.8 $\pm$ 0.6	40.6 $\pm$ 0.5	42.8 $\pm$ 0.7	47.7 $\pm$ 3.4
Waist, inches	29.3 $\pm$ 2.9	31.8 $\pm$ 3.0	33.8 $\pm$ 3.2	36.3 $\pm$ 3.5	41.6 $\pm$ 4.9
Waist-hip ratio	0.82 $\pm$ 0.10	0.82 $\pm$ 0.08	0.83 $\pm$ 2.4	0.85 $\pm$ -0.08	0.87 $\pm$ 0.08
>High school graduate, %	84	85	82	80	77
Physical activity category, %					
low	43	42	44	48	60
moderate	27	29	30	28	23
vigorous	30	29	26	24	16
Alcohol, g/week	5.3 $\pm$ 10.9	4.4 $\pm$ 9.5	3.6 $\pm$ 8.4	2.8 $\pm$ 7.2	2.1 $\pm$ 6.7
Never drinker, %	49	50	55	59	67
Smoking status at baseline, %					
Never	58	65	68	70	71
Current	25	16	12	11	9
Former	17	19	20	19	20
Pack years of cigarettes, %					
0	58	65	68	70	71
1-19	15	15	14	12	12
20-39	15	12	10	10	9
40+	12	9	8	7	8
HRT at baseline, %					
Never	59	60	61	62	67
Current	13	13	12	11	8
Former	28	27	27	27	26
HRT duration at baseline ^a , %					
<1 year	29	28	32	32	36
1-2 years	15	13	13	15	15
3 years	56	59	54	53	49
Parity, % any live births	90	90	91	91	89
Prevalent diabetes, %	4	4	5	6	12

^a Among current and former users.

Table 3
Hazard ratios and 95% confidence intervals for the association of anthropometric variables with incident hip fractures in a cohort of postmenopausal women, 1986–2004: The Iowa Women's Health Study.

	1 <i>Ref.</i>	2 <i>HR (95% CI)</i>	3 <i>HR (95% CI)</i>	4 <i>HR (95% CI)</i>	5 <i>HR (95% CI)</i>	<i>p trend</i>
<i>Total *</i>	5,974	6,376	6,082	6,068	6,152	
<i>Cases</i>	186	160	149	149	124	
<i>Person Years</i>						
<i>Observation *</i>	78,011	87,946	82,843	82,000	78,801	
<i>Average follow-up</i>						
<i>Time, years *</i>	13.1	13.7	13.6	13.5	12.8	
<i>Model 1</i>						
Hip	1.00	0.78 (0.63–0.96)	0.74 (0.60–0.92)	0.76 (0.62–0.95)	0.69 (0.55–0.86)	0.0030
Waist	1.00	0.93 (0.75–1.16)	0.97 (0.78–1.21)	0.78 (0.62–0.98)	1.00 (0.80–1.26)	0.65
BMI	1.00	0.63 (0.51–0.78)	0.59 (0.48–0.73)	0.61 (0.50–0.76)	0.60 (0.48–0.75)	<0.0001
<i>Model 2</i>						
Hip	1.00	0.80 (0.65–0.99)	0.77 (0.62–0.95)	0.78 (0.63–0.98)	0.67 (0.53–0.84)	0.0015
Waist	1.00	0.94 (0.71–1.17)	0.98 (0.78–1.21)	0.76 (0.60–0.96)	0.93 (0.74–1.17)	0.25
BMI	1.00	0.65 (0.53–0.81)	0.61 (0.49–0.75)	0.61 (0.49–0.76)	0.57 (0.45–0.72)	<0.0001

Model 1 adjusted for age.

Model 2 adjusted for Model 1 variables plus education ($\leq/\geq$ high school graduate), physical activity (low/moderate/high), baseline smoking status (current yes/no), pack years of cigarettes (0, 1–19, 20–39 and $\geq$ 40 years), alcohol consumption (none/any), baseline history of hormone therapy use (current/former/never), parity (any live births yes/no), and diabetes prevalence at baseline (yes/ no).

* per quintile of hip circumference.

Table 4

Hazard ratios and 95% confidence intervals for the association of hip circumference, independent of waist circumference and BMI, with incident hip fractures in a cohort of postmenopausal women, 1986–2004: The Iowa Women's Health Study.

	1 <i>Ref.</i>	2 <i>HR (95% CI)</i>	3 <i>HR (95% CI)</i>	4 <i>HR (95% CI)</i>	5 <i>HR (95% CI)</i>	<i>p trend</i>
Model 2						
Hip	1.00	0.78 (0.62–0.97)	0.73 (0.57–0.93)	0.72 (0.55–0.94)	0.54 (0.39–0.75)	0.0006
Waist	1.00	1.04 (0.83–1.32)	1.17 (0.91–1.50)	0.99 (0.74–1.31)	1.41 (1.01–1.96)	0.08
Model 2						
Hip	1.00	1.02 (0.81–1.28)	1.15 (0.88–1.51)	1.29 (0.94–1.75)	1.15 (0.79–1.68)	0.42
BMI	1.00	0.62 (0.49–0.78)	0.54 (0.42–0.71)	0.52 (0.38–0.70)	0.49 (0.34–0.72)	0.0007
Model 2						
Hip	1.00	0.95 (0.75–1.20)	1.03 (0.78–1.36)	1.11 (0.81–1.52)	0.90 (0.60–1.33)	0.74
Waist	1.00	1.26 (0.99–1.60)	1.61 (1.23–2.11)	1.46 (1.07–2.01)	2.18 (1.51–3.15)	0.0002
BMI	1.00	0.55 (0.43–0.71)	0.45 (0.34–0.60)	0.40 (0.29–0.57)	0.35 (0.23–0.53)	<0.0001

Model 2 adjusted for age, education (<≥ high school graduate), physical activity (low/moderate/high), baseline smoking status (current yes/no), pack years of cigarettes (0, 1–19, 20–39 and ≥40 years), alcohol consumption (none/any), baseline history of hormone therapy use (current/former/never), parity (any live births yes/no), and diabetes prevalence at baseline (yes/ no).