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Abdominal obesity and the risk of young-onset dementia in women: a nationwide cohort study

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Abstract

Background and objectives The association between obesity and young-onset dementia (YOD, defined as dementia diagnosed before age 65) is established, but the specific impact of abdominal obesity in women remains unclear. Abdominal obesity, driven by excess visceral fat, may increase dementia risk through metabolic and vascular pathways. We investigated the association between abdominal obesity and YOD risk in women using a large nationwide cohort.

Methods We analyzed 964,536 Korean women aged 40–60 years who underwent national health checkups in 2009. General obesity was defined by body mass index (BMI), and abdominal obesity was categorized by waist circumference (WC) into < 75 cm, 76–84 cm, 85–94 cm, and ≥ 95 cm. YOD was identified using ICD-10 codes and dementia medication prescriptions. Hazard ratios (HRs) for YOD were estimated using multivariable Cox proportional hazard models adjusted for lifestyle and clinical factors.

Results Over a median follow-up of 8.2 years, YOD incidence increased progressively with higher WC. Women with WC ≥ 95 cm had a 55% increased risk of YOD (HR 1.55; 95% CI 1.34–1.79) compared to those with WC < 75 cm. The association was particularly strong for vascular dementia (VD), with HR 1.83 (95% CI 1.30–2.57). By contrast, BMI showed a U-shaped relationship, with the lowest YOD risk observed in women with normal BMI (18.5–22.9 kg/m^2), and significantly elevated risks in both underweight (BMI < 18.5 kg/m^2; HR 1.39, 95% CI 1.13–1.71) and morbidly obese women (BMI ≥ 30 kg/m^2; HR 1.26, 95% CI 1.10–1.45).

Discussion Abdominal obesity is a significant, independent risk factor for YOD in women, particularly for VD. These findings underscore the importance of addressing abdominal obesity in middle-aged women to reduce dementia risk.

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Introduction

Obesity is a critical global health issue, with its prevalence more than doubling since 1990, according to the World Health Organization (WHO) [1]. In South Korea, the prevalence of obesity (body mass index ≥ 25 kg/m² based on Asia-Pacific WHO criteria) and abdominal obesity has risen steadily over the past decade, reaching 49.2% and 27.8% in 2021, respectively [2, 3]. Notably, among Korean women aged 40 to 59 years—the target demographic of our study—the prevalence of abdominal obesity rose from 19.9% in 2009 to 27.2% in 2019, emphasizing a significant upward trend in this high-risk group [4]. These trends are particularly concerning because abdominal obesity, characterized by visceral fat accumulation, is strongly associated with metabolic dysfunction and neurodegenerative risks, which are central to this study's focus on dementia. Beyond its well-known metabolic consequences, obesity contributes significantly to the global burden of disease and healthcare costs. In 2019, high body mass index (BMI) ranked among the leading risk factors globally, with an increasing burden over the past decade. Specifically, high BMI was associated with approximately 2.54 million deaths (9.8% of all female deaths) worldwide, making it one of the top five contributors to female mortality [5]. In a large-scale Korean cohort study involving over 400,000 adults, individuals with severe obesity (BMI ≥ 30 kg/m²) had a 27% higher risk of death compared to those with overweight, with the risk rising to 58% among participants younger than 60 years [6]. Additionally, high BMI was a major contributor to disability-adjusted life years (DALYs), underscoring its profound impact on both mortality and long-term health [5].

While obesity is traditionally associated with metabolic conditions such as type 2 diabetes and cardiovascular disease, it is increasingly recognized as a risk factor for non-metabolic diseases, including neurodegenerative disorders, respiratory diseases, and cancer [7–9]. Chronic inflammation, oxidative stress, and insulin resistance—key pathophysiological mechanisms associated with obesity—are believed to accelerate pathological processes in various organs, including the brain [10–12]. Emerging evidence suggests a strong association between obesity and cognitive decline, with higher BMI in midlife correlating with an increased risk of dementia in later life [13, 14]. This connection is particularly significant for young-onset dementia (YOD, typically defined as dementia diagnosed before age 65), as midlife obesity may accelerate neurodegenerative processes that manifest earlier in life. Interestingly, this relationship often follows a U-shaped pattern, where both low and high BMI are associated with elevated dementia risk, indicating a complex interplay between weight, metabolic health, and brain function [15]. Moreover, abdominal obesity has shown a stronger and more linear correlation with cognitive impairment than general obesity, emphasizing the critical role of fat distribution in neurodegenerative diseases [16].

YOD presents unique challenges due to its early impact on patients' working lives, families, and broader socioeconomic systems [17–19]. For example, individuals diagnosed with YOD often face premature job loss, with studies indicating that up to 60% of patients are forced to leave employment within two years of diagnosis, leading to significant financial strain on households. Unlike late-onset dementia, which is primarily age-related, YOD is thought to be influenced by a range of risk factors, including genetic predisposition, head trauma, and modifiable factors such as obesity [20]. Identifying modifiable risk factors for YOD is crucial to mitigating its profound socioeconomic impact on individuals in the prime of their careers and family lives [17].

On the other hand, gender differences play a significant role in the prevalence and impact of both obesity and dementia. Women generally have higher body fat percentages than men, with fat distribution patterns changing notably during menopause [21]. Additionally, women are at a higher risk for certain types of dementia, such as Alzheimer's disease (AD), compared to men [22]. These gender-specific factors underscore the importance of investigating the relationship between obesity and YOD specifically in women. By focusing on this demographic, we aim to better understand the unique risk factors and develop targeted preventive strategies, including lifestyle modifications, tailored weight management programs, and early screening initiatives, to mitigate the burden of YOD among women.

This study investigated the relationship between obesity and YOD in women, emphasizing the differential impacts of general and abdominal obesity on dementia risk. By elucidating these associations, we aim to provide actionable insights that can inform public health interventions, ultimately reducing the burden of dementia and improving quality of life for middle-aged women.

Methods

Data resource and study participants

The Korean National Health Insurance Service (K-NHIS) is a government-operated, mandatory social health insurance program that provides coverage for nearly the entire Korean population (approximately 97%). In South Korea, the NHIS offers standardized biennial health check-ups to all insured adults aged ≥ 40 years. Participation is voluntary but strongly encouraged, and the participation rate for the 2009 screening program among individuals aged 40–60 years was approximately 74%. The K-NHIS database, which includes comprehensive claims and mortality data, is accessible to researchers following approval

by both the K-NHIS Review Committee and an Institutional Review Board (IRB). This study received ethical approval from the IRB of Hallym University Sacred Heart Hospital (IRB: 2024-03-009). All participants in the national health check-ups provided written informed consent for their data to be used in this study.

From the K-NHIS database, 4,234,415 adults who participated in health checkups in 2009 were identified. Of these, 2,100,861 individuals aged 40–60 years were selected as the initial cohort. We selected the 2009 baseline because this was the first year in which national health screening data were fully standardized and made available for research use in the NHIS database. This allowed for comprehensive linkage with long-term follow-up outcomes, including dementia diagnoses and prescription records. A longer follow-up period was particularly important given the low incidence and latency of young-onset dementia. Exclusion criteria included prior diagnoses of dementia ($n = 847$) and missing data ($n = 117,176$). To mitigate reverse causation, a 1-year lag period was applied, excluding participants diagnosed with dementia within the first year of follow-up ($n = 3,329$). After these exclusions, a total of 1,979,509 participants remained for analysis (Supplemental Fig. 1). Among this final cohort, 1,014,973 were men and 964,536 were women. For the current study, only female participants were included in the final analysis.

Definitions of obesity and abdominal obesity

Participant body weight (kg), height (cm), and waist circumference (WC; cm) were measured by trained examiners during health check-ups. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). Obesity was classified according to the Asia-Pacific criteria of the World Health Organization guidelines, with BMI ≥ 25 kg/m^2 defining obesity. For further analysis, BMI was categorized as follows [23]: underweight (BMI < 18.5 kg/m^2), normal weight (BMI 18.5–22.9 kg/m^2), overweight (BMI 23.0–24.9 kg/m^2), obese (BMI 25.0–29.9 kg/m^2), and morbidly obese (BMI ≥ 30.0 kg/m^2). Abdominal obesity in women was defined as WC ≥ 85 cm according to the Korean Society for the Study of Obesity [23]. For stratified analysis, WC was categorized into four groups: WC < 75 cm, WC 76–84 cm, WC 85–94 cm, and WC ≥ 95 cm.

Study outcome and follow-up

The primary endpoint of this study was newly diagnosed all-cause YOD, defined as dementia diagnosed before the age of 65 years. YOD was identified only when both relevant ICD-10 codes for dementia and at least two prescriptions for anti-dementia medications (rivastigmine, galantamine, memantine, or donepezil) were present. The following ICD-10 codes were used to define dementia subtypes: F00, F01, F02, F03, G30, and G31 for all-cause dementia; F00 and/or G30 for Alzheimer's disease (AD); and F01 for vascular dementia (VD). In cases where both AD and VD codes were assigned to an individual, the primary diagnosis code was used to determine the final classification. Study participants were followed until December 31 of the year they turned 64 or until December 31, 2018, for those who had not yet reached 64 years of age, to assess YOD incidence. The median follow-up duration was 8.2 years (interquartile range: 8.0–8.5 years).

Definitions of anthropometric, laboratory measurements, and covariates

Anthropometric and laboratory assessments were conducted after overnight fasting, and health-related behaviors were collected through self-reported questionnaires. Smoking status was categorized as current smokers, ex-smokers, or never-smokers. Alcohol consumption was classified into three groups: heavy drinkers (≥ 20 g/day for women), mild drinkers (less than these thresholds), and nondrinkers (0 g/day). Regular exercisers were defined as those engaging in more than 30 min of moderate physical activity at least five times per week or more than 20 min of strenuous physical activity at least three times per week. The household income level was categorized as being within the lowest 20% or higher.

Diabetes mellitus was defined as a fasting plasma glucose level of ≥ 126 mg/dL or having at least one prescription claim per year for antidiabetic medications under ICD-10 codes E11–E14. Hypertension was identified by either systolic blood pressure ≥ 140 mmHg, diastolic blood pressure ≥ 90 mmHg, or the prescription of antihypertensive medications under ICD-10 codes I10–I13 or I15. Dyslipidemia was defined by total cholesterol levels ≥ 240 mg/dL or using lipid-lowering agents under ICD-10 code E78. Chronic kidney disease (CKD) was determined based on an estimated glomerular filtration rate (eGFR) of < 60 mL/min/1.73 m^2 or evidence of dialysis prior to the health check-up, recorded under special exemption codes (V001 for hemodialysis, V003 for peritoneal dialysis, and V005 for kidney transplant). Depression was defined as having at least one claim featuring ICD-10 codes F22–F33. Stroke was identified using ICD-10 codes I63 and I64, supported by claims for brain imaging (magnetic resonance imaging or computed tomography) during hospitalization. Atrial fibrillation was diagnosed using ICD-10 code I48 and its subcodes.

Statistical analysis

Baseline characteristics were summarized as means ± standard deviations (SD) for continuous variables and as numbers (percentages) for categorical variables. Group comparisons were conducted using analysis

of variance (ANOVA) for continuous variables and the chi-square test for categorical variables.

A multivariable Cox proportional hazard regression analysis was used to assess the association between obesity, defined by BMI and abdominal obesity, and the risk of YOD (all-cause dementia, AD, and VD). Hazard ratios (HRs) and 95% confidence intervals (CIs) were calculated for these outcomes. Three models were constructed: Model 1 was adjusted for age; Model 2 was adjusted for age, smoking status, alcohol consumption, physical activity, and low-income status; and Model 3 included additional adjustments for diabetes, hypertension, dyslipidemia, depression, atrial fibrillation, and stroke, in addition to the confounders in Model 2. HRs (95% CIs) for incident YOD were analyzed according to BMI categories, with BMI < 23 as the reference, and abdominal obesity categories, with WC < 75 cm as the reference. To evaluate the presence of linear trends, p-for-trend analyses were conducted across WC categories. We also performed an additional analysis using WC as a continuous variable to estimate the hazard ratio per 1 cm increase. Subgroup analyses were conducted to explore the associations within strata defined by age (< 50 and 50–60 years), household income, smoking status, alcohol consumption, regular exercise status, and the presence of diabetes, hypertension, dyslipidemia, depression, atrial fibrillation, or stroke. Statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC, USA). Two-sided *P*-values < 0.05 were considered statistically significant.

Results

In a cohort of 964,536 women, baseline characteristics were analyzed according to four categories of WC: <75 cm, < 85 cm, < 95 cm, and ≥ 95 cm (Table 1). The results demonstrated clear trends across several metabolic and lifestyle factors as WC increased. Women with larger WC were generally older, with higher BMI, blood pressure, and fasting glucose levels. For instance, the mean BMI increased from 21.4 kg/m² in the < 75 cm group to 31.1 kg/m² in the ≥ 95 cm group, while mean fasting glucose rose from 92.1 mg/dL to 107.8 mg/dL. The prevalence of comorbid conditions, such as diabetes, hypertension, and dyslipidemia, also escalated with greater WC. Specifically, the prevalence of diabetes was significantly higher among those with a WC ≥ 95 cm (20.5%) compared to those in the < 75 cm category (2.6%). Additionally, lifestyle factors were influenced by abdominal obesity; the proportion of current smokers and heavy drinkers increased with higher WC, while the proportion engaging in regular exercise decreased.

The incidence of YOD was assessed across the WC categories over the study period, revealing a clear dose-response relationship (Table 2; Fig. 1). The incidence rates of all-cause dementia per 1,000 person-years were found to increase with higher WC: 0.40 for women with a WC < 75 cm, 0.67 for < 85 cm, 0.95 for < 95 cm, and 1.31 for ≥ 95 cm. In fully adjusted models, the adjusted hazard ratios (HRs) for all-cause dementia were 1.13 (95% CI 1.05–1.21) for < 85 cm, 1.24 (95% CI 1.14–1.36) for < 95 cm, and 1.55 (95% CI 1.34–1.79) for ≥ 95 cm, using the < 75 cm group as the reference. These results indicate a clear linear increase in the risk of dementia with greater abdominal obesity, independent of age, smoking status, alcohol consumption, physical activity, and other comorbidities. Secondary outcome analyses regarding dementia types showed that for AD, the HR in the ≥ 95 cm group was 1.49 (95% CI 1.25–1.78) compared to the < 75 cm group. For VD, the HR in the ≥ 95 cm group was 1.83 (95% CI 1.30–2.57) compared to the < 75 cm group.

Figure 1. Cumulative incidence of young-onset dementia by waist circumference categories. (A) All-cause dementia, (B) Alzheimer's disease, and (C) Vascular dementia.

Subgroup analyses demonstrated that the association between abdominal obesity and YOD risk was consistent across most subgroups, with no significant interactions observed for age strata, socioeconomic status, or comorbidities (Table 3, Supplemental Tables 1–2). However, the presence of depression revealed a more pronounced risk of YOD in the WC 85–95 cm group compared to those without depression, with a significant interaction (p for interaction < 0.005) (Table 3). No other significant interactions were identified (Supplemental Tables 1 and 2).

When analyzed by BMI categories, baseline characteristics in Supplemental Table 3 reveal significant metabolic differences, with higher rates of diabetes, hypertension, and dyslipidemia observed as BMI increases, particularly among participants categorized as morbidly obese (BMI ≥ 30.0 kg/m²). A U-shaped association between BMI and YOD risk was observed (Table 4 and Supplemental Fig. 2), with both underweight and morbidly obese participants demonstrating elevated risks. Using a BMI of 18.5–23 kg/m² as the reference group, the fully adjusted HRs for all-cause dementia were 1.39 (95% CI 1.13–1.71) for underweight (BMI < 18.5 kg/m²) and 1.26 (95% CI 1.10–1.45) for morbid obesity (BMI ≥ 30.0 kg/m²). For VD, the risk consistently increased with higher BMI, with a pronounced association observed in morbid obesity (HR 1.65, 95% CI 1.23–2.22), while the relationship with AD was comparatively weaker. Subgroup analyses, as presented in Supplemental Tables 4–6, indicate that the association between BMI and YOD risk persisted across most subgroups, with no significant interactions detected.

Table 1 Baseline characteristics stratified by abdominal obesity categories defined by waist circumference

	Total	Waist circumference			
		< 75	< 85	< 95	≥ 95
N	964,536	413,249	398,540	129,472	23,275
Age, years	49.3 ± 6.0	47.7 ± 5.6	50.1 ± 5.9	51.4 ± 6.0	51.5 ± 6.1
Height, cm	156.5 ± 5.3	156.5 ± 5.2	156.5 ± 5.3	156.6 ± 5.4	157.0 ± 5.5
Weight, kg	57.8 ± 8.1	52.5 ± 5.2	59.3 ± 5.7	66.5 ± 6.7	76.7 ± 9.0
BMI, kg/m^2	23.6 ± 3.1	21.4 ± 1.9	24.2 ± 2.1	27.1 ± 2.5	31.1 ± 3.4
Waist circumference, cm	76.6 ± 8.0	69.5 ± 3.6	79.0 ± 2.8	88.2 ± 2.7	99.1 ± 4.6
Smoking					
Never	921,469 (95.5)	394,270 (95.4)	382,016 (95.9)	123,353 (95.3)	21,830 (93.8)
Ex	13,528 (1.4)	6,040 (1.5)	5,251 (1.3)	1,811 (1.4)	426 (1.8)
Current	29,539 (3.1)	12,939 (3.1)	11,273 (2.8)	4,308 (3.3)	1,019 (4.4)
Alcohol consumption					
Non	740,543 (76.8)	312,607 (75.7)	308,092 (77.3)	101,492 (78.4)	18,352 (78.9)
Mild	204,217 (21.2)	93,303 (22.6)	82,109 (20.6)	24,634 (19.0)	4,171 (17.9)
Heavy	19,776 (2.1)	7,339 (1.8)	8,339 (2.1)	3,346 (2.6)	752 (3.2)
Regular exercise	174,826 (18.1)	74,801 (18.1)	74,258 (18.6)	22,203 (17.2)	3,564 (15.3)
Household income, low	253,082 (26.2)	108,999 (26.4)	104,664 (26.3)	33,374 (25.8)	6,045 (26.0)
Systolic BP, mmHg	119.7 ± 15.0	116.0 ± 13.9	121.0 ± 14.8	125.5 ± 15.3	130.0 ± 15.9
Diastolic BP, mmHg	74.6 ± 10.1	72.5 ± 9.6	75.4 ± 10.0	78.1 ± 10.2	80.9 ± 10.5
Fasting glucose, mg/dL	95.4 ± 20.4	92.1 ± 15.9	96.2 ± 20.6	101.4 ± 26.4	107.8 ± 32.8
Total cholesterol, mg/dL	199.8 ± 36.9	194.0 ± 34.9	202.6 ± 37.2	207.8 ± 38.7	209.9 ± 39.7
Triglyceride, mg/dL*	97.7 (97.6–97.8)	83.5 (83.4–83.7)	104.6 (104.4–104.7)	123.0 (122.7–123.4)	135.7 (134.8–136.5)
HDL-C, mg/dL	59.4 ± 30.4	61.9 ± 30.1	58.2 ± 30.6	56.1 ± 29.6	55.1 ± 30.6
LDL-C, mg/dL	119.3 ± 37.9	114.6 ± 36.7	121.9 ± 37.9	125.0 ± 39.7	125.3 ± 39.0
Estimated GFR, mL/min/1.73m^2	86.6 ± 28.6	87.1 ± 29.2	86.3 ± 27.8	86.0 ± 28.7	86.3 ± 31.0
Comorbidity					
Diabetes mellitus	56,947 (5.9)	10,924 (2.6)	25,356 (6.4)	15,897 (12.3)	4,770 (20.5)
Hypertension	203,346 (21.1)	49,505 (12.0)	93,554 (23.5)	48,087 (37.1)	12,200 (52.4)
Dyslipidemia	185,691 (19.3)	52,403 (12.7)	86,550 (21.7)	38,396 (29.7)	8,342 (35.8)
CKD	48,610 (5.0)	19,828 (4.8)	20,284 (5.1)	7,082 (5.5)	1,416 (6.1)
Depression	39,600 (4.1)	14,907 (3.6)	16,993 (4.3)	6,441 (5.0)	1,259 (5.4)
AF	2,657 (0.3)	912 (0.2)	1,177 (0.3)	453 (0.4)	115 (0.5)
Stroke	8,067 (0.8)	2,006 (0.5)	3,715 (0.9)	1,898 (1.5)	448 (1.9)

*Geometric Mean (95% CI)

#All *p*-values for the variables were < 0.0001

Abbreviation: BMI, body mass index; BP, blood pressure; HDL-C, high density lipoprotein-cholesterol; LDL-C, low density lipoprotein-cholesterol; GFR, glomerular filtration rate; CKD, chronic kidney disease; AF, atrial fibrillation

Discussion

This study highlights the significant association between abdominal obesity and the risk of YOD in women, particularly its stronger impact on VD. Among women with abdominal obesity, the risk of all-cause dementia and VD increased linearly with WC, independent of confounding factors such as age, socioeconomic status, and comorbidities. Women with a WC ≥ 95 cm exhibited a 55% higher risk of all-cause dementia compared to those with a WC < 75 cm, with the strongest association observed for VD (HR 1.83). These findings emphasize the critical role of abdominal obesity, likely mediated through distinct metabolic and vascular mechanisms, in driving YOD risk.

Unlike BMI, which showed a U-shaped association with dementia risk, WC exhibited a more linear and positive association. This distinction highlights the importance of fat distribution over general adiposity in predicting dementia risk. The pronounced association between WC and VD compared to AD aligns with the hypothesis that abdominal obesity disproportionately impacts vascular pathways, leading to cerebrovascular damage and subsequent dementia. Visceral fat is strongly linked to systemic inflammation, endothelial dysfunction, and insulin resistance, which collectively contribute to vascular injury and neurodegenerative processes. Emerging research also suggests that alterations in the gut-brain axis, driven by visceral fat, may further exacerbate cerebrovascular and cognitive decline [12, 24]. Further, subgroup analyses revealed that the relationship between abdominal obesity and dementia risk was more pronounced in women

Table 2 Hazard ratios (HRs) and 95% confidence intervals (CIs) for incident young-onset dementia across abdominal obesity categories defined by waist circumference

	Total (*n*)	Events (*n*)	Person-years	IR[a]	HR (95% CI)		
					Model 1[b]	Model 2[c]	Model 3[d]
All-cause dementia							
< 75	413,249	1,320	3,306,210	0.40	1 (Ref.)	1 (Ref.)	1 (Ref.)
< 85	398,540	2,048	3,053,504	0.67	1.19 (1.11–1.27)	1.19 (1.11–1.28)	1.13 (1.05–1.21)
< 95	129,472	905	955,556	0.95	1.41 (1.30–1.54)	1.41 (1.29–1.53)	1.24 (1.14–1.36)
≥ 95	23,275	222	169,816	1.31	1.92 (1.67–2.22)	1.90 (1.65–2.19)	1.55 (1.34–1.79)
					P for trend < 0.0001	P for trend < 0.0001	P for trend < 0.0001
Per 1 cm increase in waist circumference					1.043 (1.040–1.046)	1.019 (1.015–1.022)	1.012 (1.008–1.016)
Alzheimer's disease							
< 75	413,249	922	3,306,210	0.28	1 (Ref.)	1 (Ref.)	1 (Ref.)
< 85	398,540	1,353	3,053,504	0.44	1.10 (1.01–1.20)	1.11 (1.02–1.20)	1.06 (0.98–1.16)
< 95	129,472	616	955,556	0.64	1.34 (1.21–1.49)	1.34 (1.21–1.48)	1.21 (1.09–1.35)
≥ 95	23,275	147	169,816	0.87	1.78 (1.49–2.12)	1.76 (1.47–2.09)	1.49 (1.25–1.78)
					P for trend < 0.0001	P for trend < 0.0001	P for trend < 0.0001
Per 1 cm increase in waist circumference					1.042 (1.037–1.046)	1.016 (1.011–1.020)	1.010 (1.006–1.015)
Vascular dementia							
< 75	413,249	202	3,306,210	0.06	1 (Ref.)	1 (Ref.)	1 (Ref.)
< 85	398,540	405	3,053,504	0.13	1.66 (1.40–1.97)	1.66 (1.40–1.97)	1.50 (1.26–1.78)
< 95	129,472	174	955,556	0.18	1.99 (1.62–2.44)	1.99 (1.62–2.45)	1.58 (1.28–1.95)
≥ 95	23,275	42	169,816	0.25	2.68 (1.92–3.75)	2.66 (1.90–3.72)	1.83 (1.30–2.57)
					P for trend < 0.0001	P for trend < 0.0001	P for trend < 0.0001
Per 1 cm increase in waist circumference					1.054 (1.046–1.061)	1.036 (1.028–1.044)	1.024 (1.015–1.032)

HRs (95% CIs) were calculated using multivariable Cox proportional hazard regression analysis. CI, confidence interval; HR, hazard ratio; IR, incidence rate

[a]Incidence per 1000 person-years

[b]Model 1 was adjusted for age; [c]Model 2 was adjusted for age, smoking status, alcohol consumption, regular exercise, low household income; [d]Model 3 was adjusted for age, smoking status, alcohol consumption, regular exercise, low household income, diabetes mellitus, hypertension, dyslipidemia, depression, atrial fibrillation, stroke

without pre-existing metabolic or vascular conditions such as diabetes or stroke. While these findings were not statistically significant, they suggest that abdominal obesity may exert direct neurodegenerative effects, particularly in the absence of competing risk factors. This hypothesis warrants further investigation in studies with larger sample sizes and comprehensive stratified analyses.

Our findings align with previous research demonstrating the impact of obesity on dementia risk, particularly through mechanisms involving chronic inflammation, oxidative stress, and insulin resistance [7, 10, 12, 13, 16]. However, this study advances the field by emphasizing the stronger association between abdominal obesity and VD. The U-shaped association with BMI further corroborates prior evidence, suggesting that extremes of weight, both underweight and morbid obesity, may impair cognitive health through nutritional deficiencies and metabolic dysregulation [15]. Although both BMI and WC were analyzed in the same population, we did not perform a direct comparative analysis to determine which better predicts YOD risk, due to potential multicollinearity between the two. Nonetheless, the more linear and consistent association observed with WC may indicate that abdominal obesity is a more informative marker in this context. Future studies using predictive modeling approaches may help clarify the comparative utility of these anthropometric measures.

Gender-specific factors may further explain these findings. Women generally have higher fat percentages than men, with visceral fat accumulation accelerating during menopause due to hormonal shifts [25]. These changes, coupled with the increased prevalence of dementia in women, may amplify the impact of abdominal obesity on cognitive health. Notably, while AD is more prevalent in women [26], our results suggest that obesity-related risks are more pronounced for VD. This emphasizes the need for gender-specific and subtype-specific prevention strategies targeting abdominal obesity. Our decision to focus solely on women was based on these biological and epidemiological rationale. Hormonal shifts during menopause promote the redistribution of fat from subcutaneous to visceral depots [25], potentially increasing cognitive vulnerability in midlife and thereby contributing to the association observed in this study. This targeted approach allowed us to investigate these mechanisms within a more homogeneous population.

From a public health perspective, the association between abdominal obesity and YOD highlights the

Table 3 Hazard ratios (HRs) and 95% confidence intervals (CIs) for incident young-onset all-cause dementia across subgroups by waist circumference categories

Subgroup		All-cause dementia				
		< 75	< 85	< 95	≥ 95	p for interaction
Age	40–49	1 (Ref.)	1.21 (1.04–1.42)	1.56 (1.26–1.94)	1.77 (1.17–2.68)	0.142
	50–60	1 (Ref.)	1.10 (1.02–1.19)	1.19 (1.08–1.31)	1.50 (1.28–1.75)	
Household income, low	No	1 (Ref.)	1.13 (1.04–1.22)	1.24 (1.13–1.37)	1.53 (1.30–1.81)	0.995
	Yes	1 (Ref.)	1.14 (0.98–1.32)	1.24 (1.03–1.50)	1.60 (1.18–2.18)	
Smoking	No	1 (Ref.)	1.14 (1.06–1.23)	1.24 (1.14–1.36)	1.57 (1.35–1.83)	0.454
	Yes	1 (Ref.)	0.91 (0.65–1.27)	1.23 (0.84–1.81)	1.15 (0.61–2.18)	
Alcohol consumption	No	1 (Ref.)	1.12 (1.04–1.22)	1.24 (1.13–1.37)	1.57 (1.34–1.84)	0.935
	Yes	1 (Ref.)	1.15 (0.97–1.35)	1.24 (1.01–1.52)	1.41 (0.98–2.04)	
Regular exercise	No	1 (Ref.)	1.14 (1.05–1.23)	1.26 (1.15–1.39)	1.54 (1.31–1.80)	0.805
	Yes	1 (Ref.)	1.08 (0.92–1.28)	1.15 (0.93–1.42)	1.63 (1.14–2.34)	
Diabetes mellitus	No	1 (Ref.)	1.14 (1.05–1.22)	1.27 (1.15–1.39)	1.63 (1.37–1.92)	0.462
	Yes	1 (Ref.)	1.02 (0.80–1.30)	1.06 (0.82–1.37)	1.25 (0.90–1.73)	
Hypertension	No	1 (Ref.)	1.15 (1.06–1.25)	1.30 (1.17–1.46)	1.47 (1.16–1.87)	0.424
	Yes	1 (Ref.)	1.06 (0.92–1.21)	1.14 (0.98–1.32)	1.51 (1.24–1.85)	
Dyslipidemia	No	1 (Ref.)	1.14 (1.05–1.23)	1.27 (1.14–1.41)	1.54 (1.26–1.87)	0.922
	Yes	1 (Ref.)	1.11 (0.96–1.27)	1.19 (1.02–1.39)	1.54 (1.23–1.93)	
Depression	No	1 (Ref.)	1.12 (1.04–1.21)	1.17 (1.07–1.29)	1.55 (1.33–1.82)	0.005
	Yes	1 (Ref.)	1.20 (0.97–1.48)	1.75 (1.39–2.20)	1.56 (1.05–2.32)	
Atrial fibrillation	No	1 (Ref.)	1.13 (1.06–1.22)	1.25 (1.14–1.36)	1.55 (1.34–1.79)	0.616
	Yes	1 (Ref.)	0.66 (0.30–1.48)	1.03 (0.42–2.48)	1.31 (0.37–4.70)	
Stroke	No	1 (Ref.)	1.14 (1.06–1.22)	1.25 (1.15–1.37)	1.61 (1.38–1.87)	0.225
	Yes	1 (Ref.)	0.94 (0.66–1.36)	1.01 (0.68–1.51)	0.77 (0.39–1.53)	

[a]HRs (95% CIs) were calculated using a multivariable Cox proportional hazard regression analysis after adjusting for age, smoking status, alcohol consumption, regular exercise, low household income, diabetes mellitus, hypertension, dyslipidemia, depression, atrial fibrillation, stroke. HRs should be interpreted with caution due to potential instability of estimates

urgency of addressing modifiable risk factors during midlife. Given that YOD disproportionately affects individuals during their working years, the social and economic burden of this condition is substantial. Abdominal obesity, being reversible, offers a critical intervention point. Prior studies indicate that weight reduction, dietary improvements, and physical activity can reduce visceral fat and improve metabolic profiles, potentially mitigating dementia risk [27]. Public health initiatives focusing on lifestyle interventions tailored to midlife women could thus have potential benefits.

Despite its strengths, including a large, nationally representative cohort and robust follow-up, this study has several limitations. First, the observational design precludes establishing causality. Second, WC was measured only at baseline, and changes in abdominal obesity over time were not accounted for, which could affect the accuracy of the associations. Third, residual confounding from genetic predispositions or unmeasured factors may influence the results. Future longitudinal studies with repeated measurements and comprehensive adjustments for potential confounders are needed to confirm and extend these findings. Fourth, although the participation rate was relatively high, some degree of selection bias remains possible, as individuals who undergo regular health check-ups are typically ambulatory and may differ from non-participants in terms of health consciousness or socioeconomic status. Fifth, we were unable to directly assess menopausal status due to the lack of relevant clinical data such as menstrual history or age at menopause. Although we used age stratification (40–49 vs. 50–60 years) as a proxy, and most Korean women enter menopause around age 50, this indirect method cannot fully capture individual menopausal transitions. Future studies with detailed reproductive and hormonal profiles are warranted to better delineate the role of menopause in the association between abdominal obesity and dementia.

In conclusion, this study provides robust evidence that abdominal obesity is a significant and independent risk factor for YOD in women, with a particularly strong association observed for VD. These findings emphasize the importance of early interventions targeting abdominal obesity to mitigate the growing burden of YOD. Given the increasing prevalence of obesity worldwide, implementing public health initiatives to promote healthy body composition in midlife women could have far-reaching benefits for reducing dementia risk.

Table 4 Hazard ratios (HRs) and 95% confidence intervals (CIs) for incident young-onset dementia across obesity categories defined by body mass index

	Total (*n*)	Events (*n*)	Person-years	IR[a]	HR (95% CI)		
					Model 1[b]	Model 2[c]	Model 3[d]
All-cause dementia							
< 18.5	22,568	96	179,912	0.53	1.40 (1.14–1.73)	1.37 (1.12–1.69)	1.39 (1.13–1.71)
< 23	422,942	1,541	3,349,847	0.46	1 (Ref.)	1 (Ref.)	1 (Ref.)
< 25	240,476	1,196	1,851,544	0.65	1.11 (1.03–1.20)	1.12 (1.04–1.21)	1.08 (1.00–1.17)
< 30	244,865	1,418	1,849,266	0.77	1.19 (1.11–1.28)	1.20 (1.11–1.28)	1.09 (1.01–1.17)
≥ 30	33,685	244	254,514	0.96	1.54 (1.35–1.77)	1.53 (1.34–1.76)	1.26 (1.10–1.45)
Alzheimer's dementia							
< 18.5	22,568	63	179,912	0.35	1.35 (1.05–1.74)	1.31 (1.02–1.69)	1.32 (1.02–1.71)
< 23	422,942	1,063	3,349,847	0.32	1 (Ref.)	1 (Ref.)	1 (Ref.)
< 25	240,476	804	1,851,544	0.43	1.07 (0.98–1.18)	1.08 (0.98–1.18)	1.05 (0.96–1.15)
< 30	244,865	954	1,849,266	0.52	1.15 (1.05–1.25)	1.15 (1.05–1.25)	1.07 (0.98–1.17)
≥ 30	33,685	154	254,514	0.61	1.39 (1.18–1.65)	1.38 (1.17–1.64)	1.19 (1.00–1.41)
Vascular dementia							
< 18.5	22,568	12	179,912	0.07	1.05 (0.59–1.88)	1.03 (0.58–1.84)	1.07 (0.60–1.92)
< 23	422,942	249	3,349,847	0.07	1 (Ref.)	1 (Ref.)	1 (Ref.)
< 25	240,476	232	1,851,544	0.13	1.40 (1.17–1.67)	1.41 (1.17–1.68)	1.30 (1.09–1.56)
< 30	244,865	273	1,849,266	0.15	1.52 (1.28–1.81)	1.52 (1.28–1.81)	1.27 (1.06–1.52)
≥ 30	33,685	57	254,514	0.22	2.38 (1.78–3.17)	2.37 (1.77–3.16)	1.65 (1.23–2.22)

HRs (95% CIs) were calculated using multivariable Cox proportional hazard regression analysis. CI, confidence interval; HR, hazard ratio; IR, incidence rate

[a]Incidence per 1000 person-years

[b]Model 1 was adjusted for age; [c]Model 2 was adjusted for age, smoking status, alcohol consumption, regular exercise, low household income; [d]Model 3 was adjusted for age, smoking status, alcohol consumption, regular exercise, low household income, diabetes mellitus, hypertension, dyslipidemia, depression, atrial fibrillation, stroke

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Author contributions

YSY wrote the main manuscript, KDH planned and perfromed statistical analysis. CDY reviwed and revised the manuscript. ML planned the entire study and wrote and revised the main manuscript.

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Data availability

The authors are unable to share the data analysed in this study because the Korean National Health Insurance Service (NHIS) owns the data. Researchers can request access on the NHIS website (https://nhiss.nhis.or.kr). Details of this process and a provision guide are now available at http://nhiss.nhis.or.kr/bd/ab/bdaba000eng.do.

Declarations

Ethics approval and consent to participate

This study received ethical approval from the IRB of Hallym University Sacred Heart Hospital (IRB: 2024-03-009). All participants in the national health check-ups provided written informed consent for their data to be used in this study.

Competing interests

The authors declare no competing interests.

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