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Body mass index, waist circumference, and urinary incontinence in midlife: A follow-up of mothers in the Danish National Birth Cohort

Sarah Hjorth[1] | Susanne M. Axelsen[2] | Ditte Gommesen[1] | Anne C. M. Kjeldsen[1] | Katja A. Taastrøm[1] | Ellen A. Nohr[1]

[1]Department of Clinical Research, Research unit for Gynecology and Obstetrics, University of Southern Denmark, Odense, Denmark

[2]Department of Obstetrics and Gynecology, Aarhus University Hospital, Aarhus, Denmark

Correspondence
Sarah Hjorth, Department of Clinical Research, University of Southern Denmark, Sdr. Blvd 29, 5000 Odense C, Odense, Denmark.
Email: shjorthandersen@health.sdu.dk

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Abstract

Background: Obesity is a modifiable risk factor for urinary incontinence, yet few studies have investigated how waist circumference as compared to body mass index (BMI) influences the risk of urinary incontinence.

Objective: To estimate how BMI and waist circumference associates with risk of urinary incontinence in midlife and determine which of the two is the strongest predictor of urinary incontinence.

Methods: Cohort study among mothers in the Danish National Birth Cohort. Weight and waist circumference were self-reported 7 years after cohort entry. Symptoms of urinary incontinence in midlife were self-reported using the International Consultation on Incontinence Questionnaire Female Lower Urinary Tract Symptoms (ICIQ-FLUTS) and analyzed continuously and as presence or absence of any, stress (SUI), urgency (UUI), and mixed (MUI) urinary incontinence. Linear and log binomial regressions were used to calculate mean differences and risk ratios (RR) with 95% confidence intervals (CI). Restricted cubic splines were generated to explore nonlinear relationships.

Results: Among 27 254 women at a mean age of 44.2 years, any urinary incontinence was reported by 32.1%, SUI by 20.9%, UUI by 2.4%, and MUI by 8.6%. For all outcomes, increases in risk were similar with higher BMI and waist circumference. The estimates of association were strongest for MUI (RR 1.10, 95% CI 1.08;1.12 and RR 1.12, 95% CI 1.10;1.14 for half a standard deviation increase in BMI and waist circumference, respectively). While increases in risk of the other outcomes were seen across the entire range of

Abbreviations: BMI, body mass index; CI, confidence interval; DNBC, Danish National Birth Cohort; ICIQ-FLUTS, International Consultation on Incontinence Questionnaire Female Lower Urinary Tract Symptoms; IPCW, inverse probability of censoring weights; MUI, mixed urinary incontinence; RR, relative risk; SD, standard deviation; SUI, stress urinary incontinence; UUI, urgency urinary incontinence.

BMI and waist circumference, the risk of SUI rose until BMI 28 kg/m^2 (waist circumference 95 cm), and then fell slightly.

Conclusions: Symptoms of urinary incontinence and prevalence of any urinary incontinence, SUI, UUI, and MUI increased with higher BMI and waist circumference. Self-reported BMI and waist circumference were equally predictive of urinary incontinence.

KEYWORDS

body mass index, Danish National Birth Cohort, obesity, urinary incontinence, waist circumference, women

1 | INTRODUCTION

Urinary incontinence affects 30% of adult women[1] and can be divided into subtypes based on the situations in which the symptoms occur.[2] Stress urinary incontinence (SUI) occurs in situations where an increased pressure on the bladder cannot be resisted by the pelvic floor, for example, during physical exercise.[2] Urgency urinary incontinence (UUI) occurs in connection with a sudden need to void. In mixed urinary incontinence (MUI), the woman has symptoms of both SUI and UUI.[2] Of all three subtypes, MUI is associated with the highest severity and bother for the affected women.[3] A modifiable risk factor for urinary incontinence, especially MUI, is obesity.[4] Indeed, one study found MUI to be the most common subtype of urinary incontinence among women with body mass index (BMI) above 35 kg/m^2.[3] Both high BMI and waist circumference are associated with an increased prevalence of any urinary incontinence with a relative risk at 1.2 per 5 unit increase in BMI, and per 10 cm increase in waist circumference.[4] Most studies have used BMI as a measure of obesity,[4] yet waist circumference could be a better proxy for increased intra-abdominal pressure, and therefore a more important predictor of urinary incontinence.[5] In a study that estimated several parameters for obesity to determine the strongest predictor of any urinary incontinence, waist circumference as a continuous measure performed the best, followed by waist circumference with a cut-off at 88 cm, and BMI with a cut-off at 30 kg/m^2.[6] However, almost 46% of the female participants in the study were obese (BMI ≥ 30 kg/m^2).[6] It is not known whether the same cut-offs apply in a population where obesity is less prevalent. Furthermore, few studies on subtypes of urinary incontinence have used waist circumference as the measure of obesity,[4] and, to our knowledge, no studies have investigated the associations between waist circumference and MUI.

Therefore, the objective of this study was to estimate how general and abdominal obesity, measured as BMI and waist circumference, were associated with urinary incontinence and its subtypes in midlife. Obesity was assessed using different measures and cut-offs to determine the strongest predictors of urinary incontinence.

2 | METHODS

2.1 | Design and population

The study was a prospective cohort study within the Danish National Birth Cohort (DNBC). DNBC is a nationwide ongoing data collection that, between 1996 and 2002, recruited 100 413 pregnancies of 91 381 women, equivalent to approximately 30% of all births during that period.[7] Detailed information about the cohort can be found elsewhere.[8] Women were invited to participate by their general practitioner at the first antenatal visit and completed a telephone interview around week 16 of pregnancy. Approximately 7 years after the index birth (the woman's first birth in the cohort, which may or may not be the birth of her first child), the women were asked to complete a questionnaire either online or by mail, including questions on BMI and waist circumference. Of 94 745 eligible mother-child pairs, 58% (54 906 mother-child pairs, corresponding to 51 849 unique women) participated. Between December 2013 and December 2014, mothers were furthermore invited to respond to an online questionnaire on physical and mental health (the maternal follow-up). Altogether, 53% (43 639 women) of eligible mothers participated. Eligible for the present study were 29 200 women who participated in both the 7-year—and the maternal follow-up and had complete information on the exposure and outcome (Figure 1). Women who were pregnant or had given birth less than 1 year before the 7-year follow-up were excluded (6.7%), as their BMI, and waist circumference could be affected by the pregnancy. Data was linked to Danish population-based health

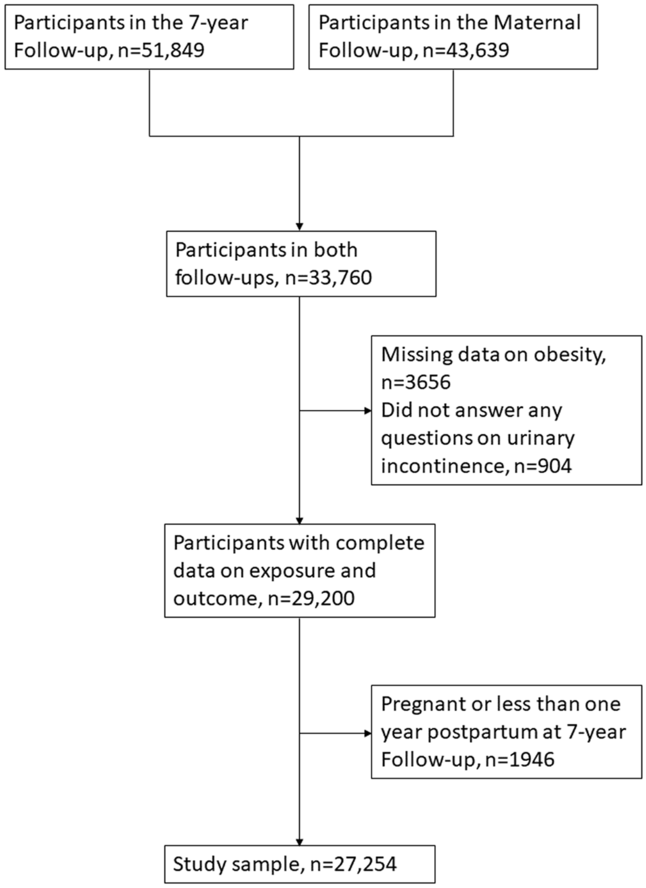

FIGURE 1 Flowchart of study sample.

registries using unique personal identification numbers given to all residents in Denmark.

2.2 | Exposures

Exposures were BMI and waist circumference at the 7-year follow-up. BMI was calculated based on self-reported height and weight and used as both a continuous variable and a categorical variable according to the categories recommended by the World Health Organization: underweight (BMI < 18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25–29.9 kg/m^2), and obese (≥30 kg/m^2).[9] The categories "underweight" and "normal weight" were combined as the focus of the study was on obesity and urinary incontinence, and as few participants in the DNBC were underweight (2% at 7-year follow-up).[10,11] Waist circumference was also self-reported. As part of the 7-year follow-up, women received a posted invitation letter including a tape measure and were instructed to measure the circumference at the narrowest point of the waist. Waist circumference was used as both a continuous variable and a categorical variable. Different recommendations exist regarding the cut-off for waist circumference in women, including 80 cm as recommended by the International Diabetes Federation,[12] and 88 cm as recommended by the Adult Treatment Panel III guidelines.[13] Therefore, we used categories <80, 80–87, and ≥88 cm.

2.3 | Outcome

Information about urinary incontinence was self-reported at the maternal follow-up and covered the past 4 weeks. The main outcome was urinary incontinence score using the incontinence subscale from the International Consultation on Incontinence Questionnaire Female Lower Urinary Tract Symptoms (ICIQ-FLUTS).[14] The subscale consists of five urinary incontinence items (urgency, stress, nocturnal, unpredictable, and frequency of incontinence) with a maximum score of 20, where higher scores represent more frequent symptoms.[14] No cut-off exists for the ICIQ-FLUTS, nor its subscales. The ICIQ-FLUTS has a high internal consistency (Cronbach α 0.75 for the incontinence scale) and ability to detect change after an intervention, with the subscales more sensitive than the combined score.[14]

Secondary outcomes were presence of any urinary incontinence and its subtypes based on the two questions on SUI (Does urine leak when you are physically active, exert yourself, cough, or sneeze?) and UUI (Does urine leak before you can get to the toilet?).[14] We chose a cut-off where women experiencing SUI or UUI "sometimes," "often," or "every time," were considered as having SUI and UUI, respectively, whereas women who experienced symptoms "rarely" or "never" were considered not to have the subtype. This cut-off has not been validated but has been used in previous research.[15] Women who had experienced both SUI and UUI were considered as having MUI, making the outcomes of SUI, UUI, and MUI mutually exclusive. We also included the outcome "any urinary incontinence" defined as presence of SUI, UUI, or MUI, or answers of "sometimes," "often," or "every time" to questions on nocturnal incontinence or unpredictable incontinence (34 women reported nocturnal or unpredictable incontinence as their only incontinence type).

2.4 | Covariates

Covariates were chosen a priori and evaluated via directed acyclic graphs (Supporting Information: Figure S1).[16] Age at 7-year follow-up, number of vaginal births, and number of cesarean sections until the 7-year follow-up were generated using data from the Medical Birth Registry. Socioeconomic position, leisure time physical activity, and chronic illnesses associated with urinary incontinence (chronic obstructive pulmonary disorder, diabetes, and cardiovascular disease[5]) were self-reported at the first pregnancy interview in the DNBC. Data on chronic illnesses were supplemented with self-report at the 7-year follow-up. Smoking and alcohol use were obtained from the 7-year follow-up. Menopausal status was self-reported at the maternal follow-up. Women were asked if they believed they had entered menopause and could reply either yes or no.

2.5 | Statistical analysis

Participant characteristics were displayed as counts and percentages by categorical BMI, and waist circumference. To estimate mean differences with 95% confidence intervals (CI) in ICIQ-FLUTS score, we used linear regression, because parametric methods have shown robustness even in the presence of skewed distributions.[17]

To estimate risk ratios (RR) with 95% CI for urinary incontinence and its subtypes, we used log binomial regression.

The sizes of the estimates of association for each exposure were compared to assess which exposures had the strongest association with each specific outcome. To be able to compare continuous measures of BMI and waist circumference, we a priori chose to display estimates for an increase by half a standard deviation (SD), respectively. For the categorical exposures, it was not possible to compare the predictive properties of for example BMI ≥ 30 to waist circumference ≥88. We therefore also estimated risk estimates for urinary incontinence by comparing women at or below −1SD (reference) with women at or above +1SD.

To account for potential confounding, we adjusted for age, number of cesarean sections, and number of vaginal births as continuous variables, plus socioeconomic position, physical activity, chronic illness, smoking, and alcohol use as categorical variables (categorized as shown in Table 1).

To explore potential nonlinearity in the relationship between obesity and urinary incontinence, we additionally generated restricted cubic splines with six knots for the association between continuous BMI and waist circumference and different measures for urinary incontinence.

2.5.1 | Missing data

Missing data on covariates were imputed using multivariate imputation by chained equations[18] with 50 data sets created. As recommended, both exposure, outcome, and all covariates included in the analytic models were added to the imputation model.[19]

2.5.2 | Sensitivity analysis

We conducted a planned sensitivity analysis adjusting for menopausal status at maternal follow-up, which was considered a predictor of the outcome. We did not have information about prevalent urinary incontinence at 7-year follow-up and therefore could not estimate incident urinary incontinence, but in a sensitivity analysis, women who reported a history of urinary incontinence before childbirth were excluded. A complete case analysis was performed to compare with the analysis based on imputed data.

2.5.3 | Post hoc analyses

Of participants in the 7-year follow-up, 34.9% did not participate in the maternal follow-up. To account for the nonparticipation, we repeated the main analysis using inverse probability of censoring weights[20] (additional information is available in the Supporting Information).

Studies have shown high specificity, but low sensitivity for self-reported categorical BMI (specificity 0.99, sensitivity 0.66 for BMI at or above 30 kg/m^2[21]). We therefore conducted a probabilistic bias analysis[22] to explore how misclassification of weight could affect our findings (additional information is available in the Supporting Information).

In a sensitivity analysis to address potential confounding, we additionally adjusted for multiple births. Also, to investigate the impact of different outcome definitions, we repeated the main analysis with a broader definition of urinary incontinence, including women who had reported “rarely” experiencing symptoms.

All analyses were done using Stata (version 17.0, StataCorp).

3 | RESULTS

The study sample included 27 254 parous women at a mean age of 37.7 years at 7-year follow-up (SD 4.2), and 44.2 years at maternal follow-up (SD 4.4). A majority (89.4%) had two or more children. Most of the women had BMI below 25.0 (19 009 women, corresponding to 69.7%). BMI at or above 30.0 kg/m^2 was seen in 2314 women (8.5%), waist circumference at or above 88.0 cm in 8001 women (29.4%). Compared with women with a

TABLE 1 Participant characteristics by BMI and waist circumference at 7-year follow-up.

	BMI and waist circumference at 7-year follow-up					
	BMI <25.0	**BMI 25.0–29.9**	**BMI ≥30.0**	**WC <80.0 cm**	**WC 80.0–87.9 cm**	**WC ≥88.0**
n	19 009 (69.7%)	5931 (21.8%)	2314 (8.5%)	10 808 (39.7%)	8445 (31.0%)	8001 (29.4%)
Background						
Age						
<30	300 (1.6%)	117 (2.0%)	69 (3.0%)	195 (1.8%)	114 (1.3%)	177 (2.2%)
30–34	3893 (20.5%)	1318 (22.2%)	537 (23.2%)	2283 (21.1%)	1698 (20.1%)	1767 (22.1%)
35–39	8571 (45.1%)	2553 (43.0%)	1008 (43.6%)	4886 (45.2%)	3800 (45.0%)	3446 (43.1%)
≥40	6245 (32.9%)	1943 (32.8%)	700 (30.3%)	3444 (31.9%)	2833 (33.5%)	2611 (32.6%)
Socioeconomic position						
Low	951 (5.3%)	432 (7.7%)	229 (10.5%)	497 (4.9%)	460 (5.7%)	655 (8.7%)
Middle	5413 (30.1%)	2142 (38.1%)	948 (43.5%)	2915 (28.5%)	2570 (32.1%)	3018 (39.9%)
High	11 634 (64.6%)	3049 (54.2%)	1000 (45.9%)	6805 (66.6%)	4983 (62.2%)	3895 (51.5%)
Missing	1011	308	137	591	432	433
Reproductive factors						
Number of vaginal births	2.0 (0.9)	1.9 (1.0)	1.8 (1.1)	2.0 (0.9)	2.0 (1.0)	1.9 (1.0)
Number of cesarean sections	0.3 (0.6)	0.4 (0.7)	0.5 (0.8)	0.3 (0.6)	0.3 (0.7)	0.4 (0.7)
Postmenopausal	423 (2.3%)	156 (2.8%)	72 (3.3%)	219 (2.1%)	216 (2.7%)	216 (2.9%)
Missing	973	347	157	534	477	466
Health/lifestyle						
Chronic illness[a]	508 (4.3%)	262 (6.9%)	186 (12.0%)	269 (4.1%)	255 (4.8%)	432 (8.1%)
Missing	7083	2146	769	4215	3130	2653
Physical activity, min/week						
None	10 567 (58.6%)	3550 (63.1%)	1453 (66.5%)	5878 (57.4%)	4820 (60.1%)	4872 (64.3%)
1–180	5917 (32.8%)	1678 (29.8%)	604 (27.6%)	3356 (32.8%)	2599 (32.4%)	2244 (29.6%)
>180	1540 (8.5%)	402 (7.1%)	129 (5.9%)	1001 (9.8%)	604 (7.5%)	466 (6.1%)
Missing	985	301	128	573	422	419
Current smoking	2606 (13.8%)	885 (15.0%)	340 (14.8%)	1432 (13.4%)	1147 (13.7%)	1252 (15.8%)
Missing	165	42	21	91	77	60
Alcohol use[b]						
None	5757 (30.4%)	2384 (40.3%)	1229 (53.3%)	3251 (30.2%)	2710 (32.2%)	3409 (42.8%)
Within recommendations	12 972 (68.5%)	3482 (58.9%)	1059 (46.0%)	7408 (68.7%)	5626 (66.8%)	4479 (56.2%)
Above recommendations	217 (1.1%)	49 (0.8%)	16 (0.7%)	118 (1.1%)	87 (1.0%)	77 (1.0%)
Missing	63	16	10	31	22	36

Abbreviations: BMI, body mass index; WC, waist circumference.

[a]Any of chronic obstructive pulmonary disorder, diabetes, hypertension, or other cardiovascular disease diagnosed by a physician.

[b]Classified according to recommendations from the Danish Health Authority. At the time of follow-up, these recommendations entailed that women should not drink more than 14 units per week.

BMI below 25 kg/m^2, women with BMI above 30 kg/m^2 were younger, more likely to be of lower sociooccupational status and to have a chronic illness, and less likely to drink alcohol (Table 1). The same patterns were seen when comparing women with a waist circumference below 80 cm and above 88 cm. In addition, women in the high waist circumference group were more likely to smoke.

The mean ICIQ-FLUTS score at maternal follow-up was 2.1 (SD 2.2) (Table 2), increasing with higher BMI or waist circumference. The estimates of associations were similar when comparing half a standard deviation increase in BMI to half a standard deviation increase in waist circumference (adjusted mean difference 0.14). In our data set, half a standard deviation increase in BMI and waist circumference corresponded to an increase in weight of about 5–6 kg.

Any urinary incontinence was reported by 8736 women (32.1%). The most common urinary incontinence subtype was SUI, reported by 5689 women (20.9%). MUI was reported by 2352 (8.6%), and UUI by 661 (2.4%) women. The risk of all three subtypes increased with higher BMI or waist circumference, but the estimates of association were highest for MUI (adjusted RR 1.10 and 1.12 for ½ SD increase in BMI and waist circumference, respectively). Continuous measures of BMI and waist circumference appeared equally predictive of presence of urinary incontinence and its subtypes. This was also seen when categorizing BMI and waist circumference by SD to compare women at or below −1SD with women at or above +1SD (any urinary incontinence: adjusted RR 1.54, 95% CI 1.40;1.70 for BMI and 1.50, 95% CI 1.38;1.64 for waist circumference). Using the BMI categories defined by the World Health Organization, excess risk of all subtypes of urinary incontinence was present in both women with overweight and obesity compared to women with normal weight with risk increasing across the two obesity categories. A similar pattern was seen for waist circumference across the high categories "80.0–87.9 cm" and "above 87.9 cm" compared to women with lower waist circumference, except for UUI where an increased risk was first observed above 87.9 cm.

When using splines to allow for nonlinear relationships, we saw the steepest increase in ICIQ-FLUTS score, and risk of any incontinence and MUI, until BMI 30 kg/m^2, after which the increase was smaller in magnitude (Figure 2). For UUI, the estimates were imprecise, but the increase appeared to be steepest towards the higher BMI-values. The prevalence of SUI only increased with higher BMI until BMI 28 kg/m^2 and then gradually fell to comparable levels as in women with normal BMI, however with wide confidence intervals. The same patterns were seen for waist circumference, where the steepest increase was seen until 95 cm, after which the increase was less steep for ICIQ-FLUTS score, any incontinence and MUI, and the risk appeared to decline for SUI (Figure 3).

All sensitivity analyses found similar results to the main analysis (Supporting Information: Tables S1–S3).

When accounting for nonparticipation, results were likewise similar to the main analysis (Supporting Information: Table S4). However, misclassification of BMI could have biased the results toward no association by up to 33%.

Additional adjustment for multiple births did not alter the results (data not shown). When including women with rare symptoms of urinary incontinence, all estimates of association were attenuated (Supporting Information: Table S5). BMI and waist circumference remained equally predictive of urinary incontinence.

4 | DISCUSSION

In this cohort of 27 254 Danish mothers, obesity was associated with self-reported urinary incontinence symptoms in midlife, and with the presence of any urinary incontinence, SUI, UUI, and MUI. The associations were stronger for UUI and MUI than for SUI. Regarding measures of obesity, self-reported BMI and waist circumference were equally predictive of urinary incontinence.

Our findings on the association between obesity and urinary incontinence are in line with previous research.[4] Also, in accordance with previous studies,[3] SUI was the most common urinary incontinence subtype in our cohort. The prevalence of SUI did not appear to increase with higher BMI and waist circumference in the same manner as the other urinary incontinence subtypes. Opposite, the prevalence appeared to begin a slight decline after BMI 28 kg/m^2, or waist circumference 95 cm. This could be explained by the mutual exclusivity of the urinary incontinence subtypes. Hence, women with a higher BMI or waist circumference may have experienced the more severe MUI that includes symptoms of SUI. Another hypothesis could be a threshold effect of obesity and intra-abdominal pressure on SUI.[23] Since we only inquired about frequency of SUI, women with high BMI or waist circumference may have experienced more substantial leaks than women with normal weight. However, few women in our study had BMI above 40 kg/m^2, or waist circumference above 120 cm, so we were unable to assess if the small decline in SUI prevalence continued at higher BMI and waist circumference.

High intra-abdominal pressure might explain the observed higher risk of urinary incontinence in women with high BMI and waist circumference compared with women with normal BMI and waist circumference. Theoretically, high intra-abdominal pressure strains the pelvic floor muscles, leading to overt structural damage or neurologic dysfunction, resulting in a predisposition to urinary incontinence.[24] Thus, an added focus on obesity may be beneficial in reducing urinary incontinence

TABLE 2 Urinary incontinence by BMI and waist circumference at 7-year follow-up.

	BMI				Waist circumference			
	Continuous	Categorical			Continuous	Categorical		
	per ½ SD increase	<25.0	25.0–29.9	≥30.0	per ½ SD increase	<80.0 cm	80.0–87.9 cm	≥88.0 cm
ICIQ-FLUTS score[a]								
Mean (sd)	2.1 (2.2)	2.0 (2.1)	2.3 (2.3)	2.8 (2.6)	2.1 (2.2)	1.9 (2.0)	2.1 (2.2)	2.5 (2.4)
Crude mean difference (95% CI)	0.12 (0.11;0.14)	Reference	0.30 (0.23;0.36)	0.78 (0.69;0.88)	0.13 (0.12;0.14)	Reference	0.23 (0.17;0.29)	0.57 (0.51;0.64)
Adjusted[b] mean difference (95% CI)	0.14 (0.13;0.15)	Reference	0.34 (0.28;0.40)	0.88 (0.78;0.97)	0.14 (0.13;0.16)	Reference	0.23 (0.17;0.30)	0.62 (0.55;0.68)
Any urinary incontinence								
n (%)	8736 (32.1%)	5703 (30.0%)	2105 (35.5%)	928 (40.1%)	8736 (32.1%)	3035 (28.1%)	2663 (31.5%)	3038 (38.0%)
Crude RR (95% CI)	1.05 (1.04;1.06)	Reference	1.18 (1.13;1.24)	1.34 (1.25;1.43)	1.06 (1.05;1.07)	Reference	1.12 (1.07;1.18)	1.35 (1.29;1.42)
Adjusted[b] RR (95% CI)	1.06 (1.05;1.07)	Reference	1.20 (1.14;1.26)	1.38 (1.29;1.49)	1.07 (1.06;1.08)	Reference	1.13 (1.07;1.19)	1.37 (1.31;1.45)
Stress urinary incontinence								
n (%)	5689 (20.9%)	3829 (20.1%)	1328 (22.4%)	532 (23.0%)	5689 (20.9%)	2067 (19.1%)	1738 (20.6%)	1884 (23.5%)
Crude RR (95% CI)	1.03 (1.01;1.04)	Reference	1.11 (1.04;1.18)	1.14 (1.04;1.25)	1.04 (1.02;1.05)	Reference	1.08 (1.01;1.15)	1.23 (1.16;1.31)
Adjusted[b] RR (95% CI)	1.03 (1.02;1.05)	Reference	1.13 (1.06;1.20)	1.18 (1.08;1.30)	1.04 (1.03;1.05)	Reference	1.08 (1.02;1.16)	1.26 (1.18;1.34)
Urgency urinary incontinence								
n (%)	661 (2.4%)	415 (2.2%)	169 (2.8%)	77 (3.3%)	661 (2.4%)	239 (2.2%)	193 (2.3%)	229 (2.9%)
Crude RR (95% CI)	1.08 (1.05;1.12)	Reference	1.31 (1.09;1.56)	1.52 (1.20;1.94)	1.07 (1.03;1.11)	Reference	1.03 (0.85;1.25)	1.29 (1.08;1.55)
Adjusted[b] RR (95% CI)	1.08 (1.05;1.12)	Reference	1.29 (1.08;1.55)	1.50 (1.17;1.93)	1.07 (1.03;1.11)	Reference	1.02 (0.84;1.23)	1.27 (1.06;1.53)
Mixed urinary incontinence								
n (%)	2352 (8.6%)	1438 (7.6%)	598 (10.1%)	316 (13.7%)	2352 (8.6%)	720 (6.7%)	722 (8.5%)	910 (11.4%)
Crude RR (95% CI)	1.09 (1.07;1.11)	Reference	1.33 (1.21;1.47)	1.81 (1.60;2.04)	1.11 (1.10;1.13)	Reference	1.28 (1.16;1.42)	1.71 (1.55;1.88)
Adjusted[b] RR (95% CI)	1.10 (1.08;1.12)	Reference	1.36 (1.24;1.50)	1.91 (1.68;2.16)	1.12 (1.10;1.14)	Reference	1.28 (1.16;1.42)	1.74 (1.57;1.92)

Abbreviations: BMI, body mass index; CI, confidence interval; RR, risk ratio.

[a]Symptoms of urinary incontinence on a scale from 0–20 with higher scores representing more severe symptoms.

[b]Adjusted for age, number of cesarean sections, number of vaginal births, chronic illness, smoking, and alcohol use at 7-year follow-up, plus socioeconomic position, and physical activity at the index pregnancy.

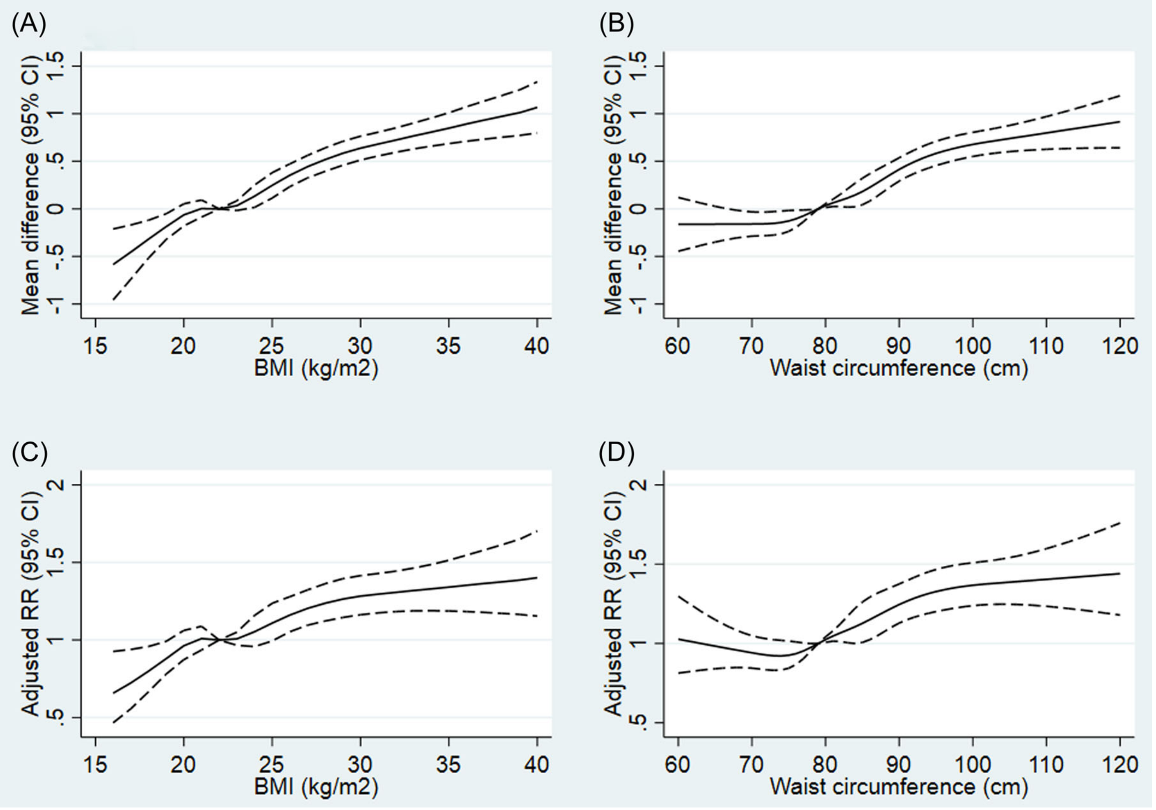

FIGURE 2 Restricted cubic splines of the association between BMI and waist circumference at 7-year follow-up and urinary incontinence. Panel (A) BMI and incontinence symptom score, panel (B) waist circumference and incontinence symptom score, panel (C) BMI and any urinary incontinence, panel (D) waist circumference and any urinary incontinence. BMI truncated at 40 kg/m^2 and WC at 120 cm due to few observations at higher values. BMI, body mass index; CI, confidence interval; RR, risk ratio; WC, waist circumference.

among women. During pregnancy, women should be informed about their increased risk of urinary incontinence with high BMI or waist circumference after delivery. The information should also include guidance about healthy weight loss after delivery, if needed.

Contrary to theoretical considerations[5] and one previous study,[6] we found BMI and waist circumference to be equally predictive of urinary incontinence. A difference between the present and previous study is the present study's analysis of BMI and waist circumference on the same scale, half a standard deviation, allowing for a more precise comparison. Furthermore, this study used self-reported, rather than health care provider measured, weight and waist circumference. Waist circumference may be more difficult to measure than weight, resulting in more misclassification of waist circumference than BMI. However, we have not identified any studies on the validity of self-reported waist circumference with a cut-off at 88 cm, nor any studies comparing the validity of self-reported BMI and waist circumference. Our finding of self-reported BMI and waist circumference being equally predictive of urinary incontinence, may not apply to settings where the measurements are carried out by health care professionals, but the findings indicate that both self-reported BMI and waist circumference are useful in predicting the risk of urinary incontinence and targeting preventive care.

Strengths of the study include a large general population of women with information on several potential confounders and the use of a validated questionnaire for urinary incontinence symptoms. Some limitations are worth noting. First, weight and waist circumference were self-reported, and therefore subjective, leading to a potential for underreporting. Given the prospective nature of this study, any misclassification was likely to be nondifferential. Based on estimates of sensitivity and specificity from previous studies, our results could have been biased towards the null by 12% to 33%. Second, nonparticipation in either the 7-year—or maternal follow-up was substantial, and women with normal BMI were more likely to participate in the maternal follow-up,[25] where the outcome was known to the participants. Although previous studies based on the same cohort have shown little impact on the internal validity,[7] such nonparticipation could be associated with

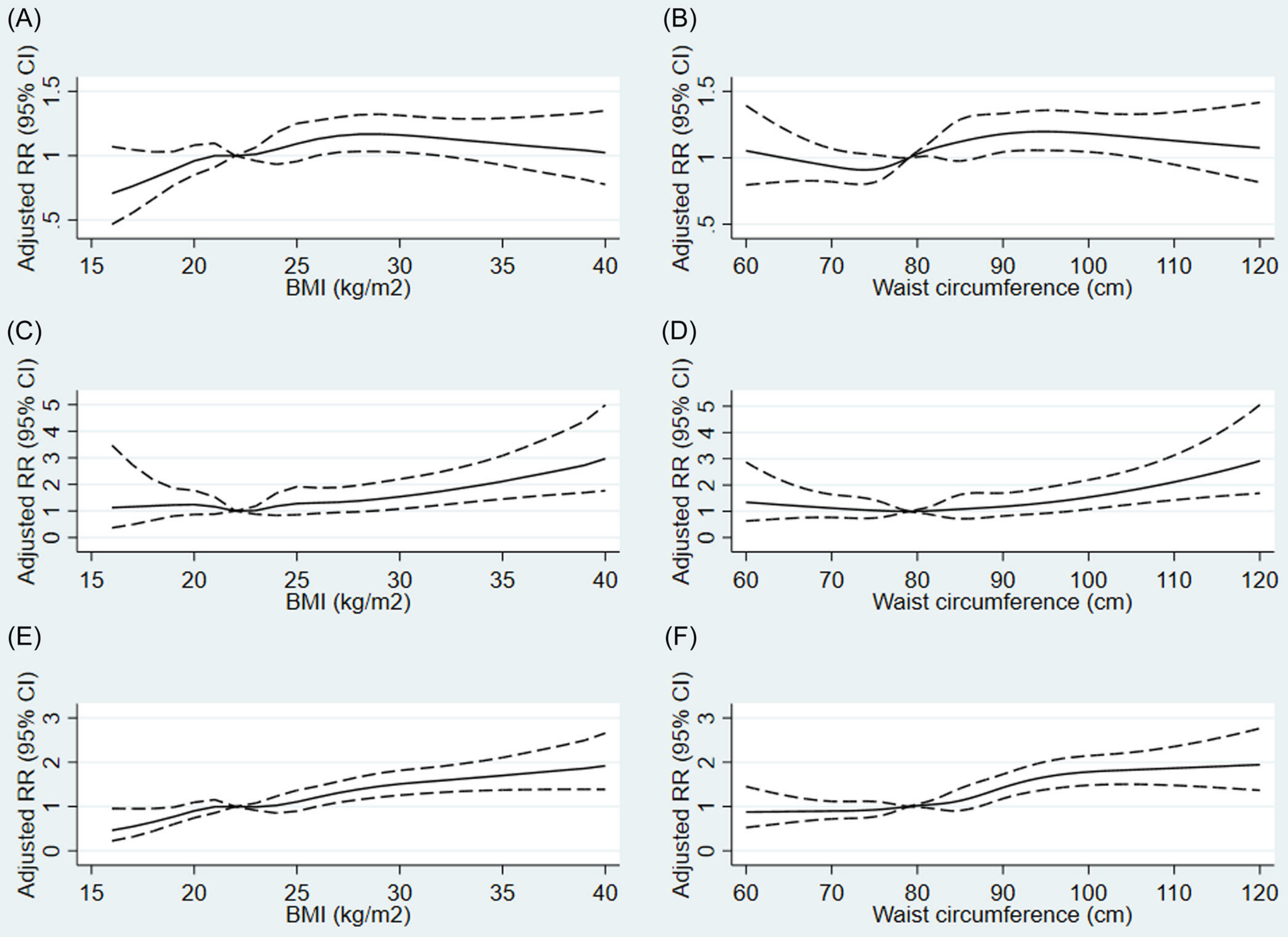

FIGURE 3 Restricted cubic splines of the association between BMI and waist circumference at 7-year follow-up and subtypes of urinary incontinence. Panel (A) BMI and stress urinary incontinence, panel (B) waist circumference and stress urinary incontinence, panel (C) BMI and urge urinary incontinence, panel (D) waist circumference and urge urinary incontinence, panel (E) BMI and mixed urinary incontinence, panel (F) waist circumference and mixed urinary incontinence. BMI truncated at 40 kg/m^2 and WC at 120 cm due to few observations at higher values. BMI, body mass index; CI, confidence interval; RR, risk ratio; WC, waist circumference.

both exposure and outcome. Reassuringly, results were largely unchanged when we repeated our analysis using inverse probability of censoring weights. Third, we had little information on the severity of the urinary incontinence symptoms. However, when comparing different outcome classifications, high BMI and weight circumference were better predictors of more frequent incontinence than of rare incontinence. Residual confounding cannot be ruled out. We adjusted for number of births, not number of pregnancies. Furthermore, we were unable to account for potential confounding from diet.

In conclusion, symptoms of urinary incontinence, and the risk of any urinary incontinence, SUI, UUI, and MUI increased with higher BMI and waist circumference. Self-reported BMI and waist circumference were equally predictive of urinary incontinence symptoms.

AUTHOR CONTRIBUTIONS

All authors designed the research; Sarah Hjorth performed statistical analysis and wrote the paper. All other authors critically revised the paper. All authors read and approved the final manuscript and are responsible for the final content.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data described in the manuscript, code book, and analytic code will be made available upon request pending application to and approval from the DNBC steering committee and a Danish local data protection office.

ETHICS STATEMENT

The DNBC was initially approved by the Committee on Biomedical Research Ethics (reference no. [KF] 01-471/94), and all participants gave written, informed consent. The present study was approved by the Danish Data Protection Agency (approval no. 2014-41-2848).

ORCID

Sarah Hjorth http://orcid.org/0000-0003-2841-5868

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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