Prevalence and Risk Factors for Urinary Incontinence in Women With Type 2 Diabetes and Impaired Fasting Glucose

Findings from the National Health and Nutrition Examination Survey (NHANES) 2001–2002

JEANETTE S. BROWN, MD[1]
ERIC VITTINGHOFF, PHD[1]
FENG LIN, MS[1]
LEROY M. NYBERG, MD, PHD[2]
JOHN W. KUSEK, PHD[2]
ALKA M. KANAYA, MD[1]

OBJECTIVE — Diabetes is associated with increased risk of urinary incontinence. It is unknown whether women with pre-diabetes, or impaired fasting glucose (IFG), have increased prevalence of incontinence. We determined the prevalence of, and risk factors for, incontinence among U.S. women with diabetes and IFG.

RESEARCH DESIGN AND METHODS — The 2001–2002 National Health and Nutrition Examination Survey measured fasting plasma glucose and obtained information about diabetes and urinary incontinence among 1,461 nonpregnant adult women. Self-reported weekly or more frequent incontinence, both overall and by type (urge and stress), was our outcome.

RESULTS — Of the 1,461 women, 17% had diabetes and 11% met criteria for IFG. Prevalence of weekly incontinence was similar among women in these two groups (35.4 and 33.4%, respectively) and significantly higher than among women with normal fasting glucose (16.8%); both urge and stress incontinence were increased. In addition to well-recognized risk factors including age, weight, and oral estrogen use, two microvascular complications caused by diabetes, specifically macroalbuminuria and peripheral neuropathic pain, were associated with incontinence.

CONCLUSIONS — Physicians should be alert for incontinence, an often unrecognized and therefore undertreated disorder, among women with diabetes and IFG, in particular those with microvascular complications. The additional prospect of improvements in their incontinence may help motivate some high-risk women to undertake difficult lifestyle changes to reduce their more serious risk of diabetes and its sequelae.

Diabetes Care **29:1307–1312, 2006**

Urinary incontinence, present in nearly 50% of middle-aged and older women, results in psychological stress and social isolation and has a profound effect on quality of life (1). The costs are substantial, up to $32 billion per year in the U.S., and greater than the annual direct costs for breast, ovarian, cervical, and uterine cancers combined (2,3).

Type 2 diabetes also is a common and costly disorder. While ~17 million adults in the U.S. have diabetes, another 43 million adults are estimated to have "pre-diabetes," or impaired fasting glucose (IFG) (4,5). Recent evidence strongly suggests that urinary incontinence is a common complication, from 50 to 200% more common among women with type 2 diabetes than among women with normal glucose levels (6–8). However, no studies have determined whether women with IFG are also at higher risk of incontinence.

While it is known that incontinence is more common in women with diabetes, mechanisms by which type 2 diabetes may contribute to its development or severity are not well defined. A likely etiology for incontinence is microvascular damage, similar to the disease process involved in development of retinopathy, nephropathy, and peripheral neuropathy. Accordingly, duration of diabetes (7,8), insulin treatment (6), peripheral neuropathy (8), and retinopathy (8) have been shown to be important risk factors for incontinence among women with diabetes. Less is known about risk factors specific to urge and stress incontinence among women with type 2 diabetes, even though these clearly differ in clinical presentation and response to treatment.

We conducted a cross-sectional analysis using data from the 2001–2002 National Health and Nutrition Examination Survey (NHANES). Our goal was to estimate prevalence and identify risk factors for urinary incontinence among women with pre-diabetes or diabetes. We were able to evaluate a broad range of incontinence risk factors, while controlling for potential confounding variables.

RESEARCH DESIGN AND METHODS

— The 2001–2002 NHANES is a nationally representative probability sample of noninstitutionalized civilians. Using self-reported race/ethnicity, participants were identified using a complex, stratified, multistage probability cluster design that oversampled non-Hispanic blacks, Mexican Americans, individuals

From the [1]UCSF Women's Health Clinical Research Center, University of California, San Francisco, California; and the [2]National Institute of Diabetes, Digestive, and Kidney Diseases, National Institutes of Health, Bethesda, Maryland.

Address correspondence and reprint requests to Jeanette S. Brown, MD, Department of Obstetrics, Gynecology and Reproductive Sciences, UCSF Women's Health Clinical Research Center, 1635 Divisadero St., Suite 600, San Francisco, CA 94115. E-mail: brownj@obgyn.ucsf.edu.

Received for publication 14 December 2005 and accepted in revised form 10 March 2006.

Abbreviations: IFG, impaired fasting glucose; NHANES, National Health and Nutrition Examination Survey.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

DOI: 10.2337/dc05-2463

aged ≥60 years, and low-income individuals so that nationally representative estimates of health could be generated in these population groups. Among the sample of 2,531 nonpregnant adult women who were ≥20 years of age, we excluded 213 who did not undergo the NHANES physical examination, 171 who had incomplete urinary incontinence information, and another 686 women without a known diagnosis of diabetes who had not fasted for at least 8 h before their laboratory tests. After these exclusions, a total of 1,461 (57.7%) women remained in our analysis sample. Women in our study population did not differ in age, race, parity, BMI, and estrogen use compared with the women who were excluded. Our primary analyses of risk factors for incontinence was conducted in the subsample of 164 women with IFG and 246 women with diabetes.

Diabetes was defined by a self-report of diabetes or if fasting plasma glucose level was ≥126 mg/dl (9). IFG was defined as fasting plasma glucose between 100 and 125 mg/dl (10). The remaining women, with fasting glucose <100 mg/dl, were classified as having normal glucose levels. NHANES ascertains self-reported diabetes duration, use of oral hypoglycemic medications, use of insulin, and history of physician-diagnosed retinopathy. Additionally, all participants were questioned about symptoms of peripheral neuropathy over the past 3 months, including "numbness or loss of feeling in your hands or feet other than from your hands or feet falling asleep," and "a painful sensation or tingling in your hands or feet. . . not including normal foot aches from standing or walking for long periods." Participants were also asked whether they ever had an ulcer or sore on their leg or foot that took >4 weeks to heal. HbA_{1c} (A1C) level was measured from blood specimens on all participants by the Primus automated high-performance liquid chromatography analyzer (Primus, Kansas City, MO). A random urine sample was obtained from all participants during the survey. Urinary albumin concentration (in micrograms per milliliter) was measured by solid-phase fluorescent immunoassay (11) (Sequoia-Turner, Mountain View, CA), and urinary creatinine concentration (in milligrams per milliliter) was measured by the modified kinetic method of Jaffé (Beckman Instruments, Brea, CA). Microalbuminuria was defined as a urinary albumin-to-creatinine ratio of 30–300 mg/g and macroalbuminuria as an albumin-to-creatinine ratio >300 mg/g. All laboratory tests were collected at a single examination, and details about the laboratory procedures of all these tests are published elsewhere (12).

Urinary incontinence was determined by a self-administered questionnaire based on validated instruments used in previous studies (13). The sequence of incontinence questions began with "[d]uring the past 12 months have you leaked or lost control of even a small amount of urine. . . ," followed by "with an activity like coughing, lifting, or exercise?" (stress incontinence) and "with an urge or pressure to urinate and could not get to the toilet fast enough?" (urge incontinence). Frequency for each type of incontinence was ascertained as every day, a few times a week, a few times a month, or a few times a year. The primary outcome of interest was weekly or more frequent incontinence. We also examined the level of bother of incontinence and the effect of incontinence on the participant's quality of life. Participants were asked about the degree of worry created by urine leakage and the affect of urine leakage on day-to-day activities during the previous 12 months. These questions were categorized as "not at all" or "only a little" versus "somewhat," "very much," or "greatly."

Statistical analysis

Data were analyzed using Stata (version 8; Stata, College Station, TX) programs specialized for complex survey data. These procedures accommodate sampling weights, as well as compute SEs and use modified hypothesis tests that account for stratification and clustering of the multistage NHANES sampling design. The sampling weights are inversely proportional to the probability of selection into the sample and are therefore interpretable as the number of individuals in the target population that each sample participant is estimated to represent. Moreover, the weights are corrected to sum-to-subpopulation totals by region and demographic subgroup, based on the U.S. Census. Thus, the national prevalence of incontinence among women with diabetes was estimated by a weighted proportion; specifically, it was estimated by the number of diabetic women in the population with incontinence (sum of weights for sampled women classified as having diabetes who report incontinence) divided by the number of women in the target population with diabetes (sum of weights for sampled women in this category).

We assessed heterogeneity in the prevalence of urinary incontinence across women with normal fasting glucose, women with IFG, and women with diabetes using a χ^2 test with correction for the survey design. Risk factors for urinary incontinence were assessed using logistic regression models suitable for complex survey data, which accommodate the sampling weights and use "robust" SEs and modified *t* tests with degrees of freedom equal to the number of primary sampling units, minus the number of strata. We performed separate models for women with diabetes and IFG and then a combined model pooling these two populations. Model derivation began with a list of predictors determined a priori, with final multivariable models selected by backward deletion, retaining risk factors that remained significant at $P < 0.15$ after adjustment. Age, BMI, and parity were included by default in these models. Correlations between predictors were generally <0.4, indicating that collinearity did not adversely affect our estimates. We found no persuasive evidence of an interaction between various risk factors and glucose group.

RESULTS — Of the 1,461 women in our analysis, 246 (16.8%) were classified with diabetes and another 164 (11.2%) met criteria for IFG. The overall prevalence of weekly or more frequent incontinence was similar among women with diabetes and IFG (35.4 and 33.4%, respectively) and significantly higher than among women with normal fasting glucose (16.8%) (Table 1). Similarly, both urge and stress incontinence were significantly more common among diabetic and pre-diabetic women ($P < 0.001$). Furthermore, among women with incontinence, women with diabetes were more likely to report being bothered by their incontinence symptoms, while both diabetic and pre-diabetic women felt that incontinence affected their daily activities significantly more than nondiabetic women. Adjustment for BMI did not attenuate the difference among the three glucose subgroups.

Table 2 shows the characteristics of the women with normal glucose, IFG, and diabetes. Women with diabetes were more likely to be of ethnic minority background and have a higher BMI and waist circumference than those without diabetes. As expected, women with diabetes were more likely to report peripheral neuropathy symptoms, foot ulcers, hyperten-

Table 1—*Prevalence of urinary incontinence by glucose subgroups, NHANES 2001–2002*

	Normal glucose	IFG	Diabetes	*P**
n	1,051	164	246	
≥Weekly incontinence (%)	16.8	33.4	35.4	<0.001
≥Weekly urge incontinence (%)	7.7	24.6	26.4	<0.001
≥Weekly stress incontinence (%)	14.4	31.2	30.2	<0.001
Bothersome incontinence (%)†	18.2	24.7	31.3	0.01
Incontinence affect on daily activities (%)†	4.9	14.0	12.6	<0.001

**P* value by modified Pearson χ^2 test; †report of "somewhat," "very much," or "greatly" versus "not at all" or "only a little," as the reference category among women with ≥weekly incontinence.

sion, stroke, and claudication. Mean A1C level was 7.3% in diabetic women compared with 5.7% in women with IFG. As expected, higher proportions of women with diabetes had micro- and macroalbuminuria than women with IFG or normal glucose. Almost half of all diabetic women reported fair or poor overall health status compared with only a quarter of women with IFG and 18% of normoglycemic women.

In multivariate logistic models, peripheral neuropathy pain, a marker of microvascular disease, was independently associated with any weekly incontinence among women with diabetes, while macroalbuminuria was close to criteria for statistical significance (Table 3). Past history of hysterectomy was the only other significant risk factor among diabetic women. Among women with IFG, microalbuminuria was strongly associated with increased odds of incontinence, as were other well-established risk factors for incontinence. Since we were limited with small numbers of outcomes in each population with abnormal glucose, and since the estimated prevalence of incontinence was similar among women with diabetes and IFG, we pooled these two populations. A multivariate model in this combined population showed that both macroalbuminuria and neuropathic pain are associated with incontinence (Table 3).

We also constructed separate models for weekly stress incontinence and urge incontinence. Results of these models within the diabetes and IFG populations, both separately and combined, were similar to the models for any weekly incontinence. For urge incontinence, macroalbuminuria (OR 6.63 [95% CI 1.14–38.51]) and a history of foot ulcer (19.16 [0.89–411.01]) were associated with incontinence among diabetic women, whereas neuropathic pain was not significant. For women with IFG, presence of microalbuminuria was associated with significantly increased odds of both stress (6.83 [1.21–38.42]) and urge (7.45 [1.59–34.98]) incontinence.

CONCLUSIONS — In the NHANES 2001–2002 sample, one out of three women with IFG or diabetes reported weekly or more frequent urinary incontinence. We estimate that ~12.7 million women have weekly incontinence in the U.S., including ~1.9 million women (95% CI 1.3–2.5) with IFG and another 2.5 million women with diabetes (2.1–2.9). Compared with nondiabetic women, those with diabetes and prediabetes have a threefold increased prevalence of urge incontinence and twice the prevalence of stress incontinence. Nearly 60% of women with diabetes and weekly incontinence considered their incontinence bothersome, and ~20% reported that it interfered with their daily activities; this was two times more frequent than that reported by incontinent women without diabetes.

Increased prevalence of urinary incontinence among women with diabetes has been previously reported in cross-sectional analyses (7,8,14). However, no studies have examined whether women with IFG, or pre-diabetes, also have increased prevalence of incontinence. Since some diabetes complications are observed before the diagnosis of diabetes (15), we hypothesized that the prevalence of urinary incontinence may also be increased among pre-diabetic patients. We found a strikingly similar prevalence of incontinence, both overall and by type, among the pre-diabetic and diabetic women in NHANES. While the difference in prevalence among the glucose subgroups may be accounted for by several shared risk factors (BMI, parity, hysterectomy status, and hormone therapy use), these risk factors continued to be independently associated within each glucose subgroup.

We also found that microvascular complications, specifically peripheral neuropathic pain and macroalbuminuria, were associated with increased risk of weekly incontinence in diabetic women. These associations suggest that incontinence may indeed be another microvascular complication, possibly through disturbances of the nerve supply to the urethral sphincter and bladder, causing sphincter damage and involuntary bladder contractions resulting in incontinence (8,16). Thus, our findings suggest that therapies for microvascular complications of diabetes may be beneficial in the prevention or treatment of urinary incontinence. Although we did not find that A1C or blood pressure were related to incontinence, therapies that improve glycemic and blood pressure control may be useful for incontinence because both improved microvascular complications in the U.K. Prospective Diabetes Study (17,18). This hypothesis should be testable in the ongoing Action to Control Cardiovascular Risk in Diabetes trial.

Our finding of a similarly high prevalence of incontinence among women with pre-diabetes and those with diabetes suggests that incontinence may be an earlier consequence of hyperglycemia than other microvascular complications. Surprisingly, microalbuminuria was associated with increased odds of incontinence among women with IFG. Hyperglycemia and hyperinsulinemia, which are both related to obesity, may be present before diabetes diagnosis and contribute to the risk of micro- and macrovascular disease.

Importantly, we found increasing weight was significantly associated with incontinence, similar to the association found among women without diabetes (6). Weight reduction has recently been shown to improve incontinence in moderately obese women (19). The likely mechanism is that decreasing abdominal weight reduces intra-abdominal and intravesicular pressure, as well as urethral mobility. We have previously found that intensive lifestyle change resulting in weight loss decreased prevalence of incontinence among women with prediabetes who were enrolled in the Diabetes Prevention Program (20). We are currently investigating whether weight loss among women with type 2 diabetes is also associated with decreased incontinence in the Look AHEAD (Action for Health in Diabetes) study (21). Fur-

Table 2—*Characteristics of women with IFG and diabetes in NHANES 2001–2002*

Characteristic	Normal glucose	IFG	Diabetes	*P*
n	1,051	164	246	
Age (years)	44.0 ± 0.8	58.0 ± 1.1	60.2 ± 1.5	
20–29	195 (18.5)	4 (2.4)	7 (2.8)	<0.001
30–39	195 (18.5)	14 (8.5)	17 (6.9)	
40–49	226 (21.5)	23 (14.0)	28 (11.4)	
50–59	147 (14.0)	26 (15.8)	40 (16.3)	
60–69	131 (12.5)	40 (24.4)	70 (28.4)	
70–79	84 (8.0)	29 (17.7)	48 (19.5)	
≥80	73 (6.9)	28 (17.1)	36 (14.6)	
Race				
Non-Hispanic white	565 (53.8)	90 (54.9)	104 (42.3)	0.24
Non-Hispanic black	188 (17.9)	31 (18.9)	59 (24.0)	
Mexican American	225 (21.4)	32 (19.5)	65 (26.4)	
BMI (kg/m^2)	27.4 ± 0.3	30.7 ± 0.8	32.5 ± 0.7	<0.001
Waist circumference (cm)	90.7 ± 0.7	100.0 ± 1.8	105.9 ± 1.4	<0.001
Current smoker	221 (21.1)	27 (16.5)	35 (14.2)	0.13
Systolic blood pressure ≥140 mmHg	196 (19.0)	61 (37.9)	89 (38.9)	<0.001
Diastolic blood pressure ≥90 mmHg	50 (4.8)	7 (4.3)	15 (6.5)	0.75
Reproductive factors				
Parity				
0	190 (18.2)	21 (13.0)	29 (12.4)	<0.001
1	154 (14.8)	17 (10.5)	28 (12.0)	
2	276 (26.5)	44 (27.3)	39 (16.7)	
3	209 (20.1)	33 (20.5)	36 (15.4)	
4	99 (9.5)	13 (8.1)	41 (17.6)	
≥5	113 (10.8)	33 (20.5)	60 (25.7)	
Hysterectomy	247 (23.5)	63 (38.6)	102 (41.5)	<0.001
Menopausal status	489 (47.4)	125 (78.1)	188 (81.4)	<0.001
Current hormone therapy use	134 (12.9)	30 (18.7)	36 (15.7)	0.07
Diabetes characteristics				
Diabetes duration (years)				
<5	NA	NA	56 (22.8)	
5–9			45 (18.3)	
10–14			31 (12.6)	
15–19			20 (8.1)	
≥20			49 (19.9)	
Diabetes medication used				
Oral agent	NA	NA	147 (68.1)	
Insulin	NA	NA	55 (22.4)	
Retinopathy	NA	NA	49 (22.9)	
Peripheral neuropathy symptoms				
Numbness	138 (20.9)	34 (23.3)	81 (36.5)	0.01
Pain	150 (22.7)	38 (26.0)	83 (37.4)	0.005
Leg or foot ulcer	19 (2.9)	4 (2.7)	11 (4.9)	0.25
A1C (%)	5.2 ± 0.0	5.7 ± 0.0	7.3 ± 0.2	<0.001
No albuminuria (<30 mg/g)	945 (90.9)	138 (86.8)	158 (67.2)	<0.001
Microalbuminuria (30–300 mg/g)	88 (8.5)	19 (11.9)	55 (23.4)	
Macroalbuminuria (>300 mg/g)	6 (0.6)	2 (1.3)	22 (9.4)	
Other medical conditions				
Arthritis	273 (26.0)	80 (48.8)	104 (42.4)	<0.001
Hypertension	222 (21.2)	77 (46.9)	140 (56.9)	<0.001
Emphysema	13 (1.2)	5 (3.1)	6 (2.4)	0.05
Asthma	118 (11.2)	15 (9.1)	28 (11.4)	0.93
Stroke	33 (3.1)	5 (3.0)	14 (5.7)	0.007
Claudication	167 (25.3)	50 (34.2)	100 (45.1)	<0.001

Continued on following page

Table 2—*Continued*

Characteristic	Normal glucose	IFG	Diabetes	*P*
Overall health status				
Excellent/very good	531 (50.6)	60 (36.6)	45 (18.3)	<0.001
Good	334 (31.8)	59 (36.0)	86 (34.9)	
Fair/poor	185 (17.6)	45 (27.4)	115 (46.7)	
Standing up from an armless chair				
No difficulty	302 (28.7)	73 (44.5)	112 (45.5)	<0.001
Some difficulty	72 (6.8)	28 (17.1)	49 (19.9)	
Much difficulty	21 (2.0)	8 (4.8)	17 (6.9)	
Unable to do	15 (1.4)	4 (2.4)	9 (3.7)	
Any current diuretic use	99 (9.4)	40 (24.4)	67 (27.2)	<0.001

Data are means ± SE or *n* (%) unless otherwise indicated. *P* value by Pearson χ^2 test or adjusted Wald test. NA, not applicable.

thermore, it has been suggested that the prospect of improved incontinence may motivate overweight and obese women to lose weight (19). If this proves accurate, then preventing or improving incontinence may help motivate women with pre-diabetes or diabetes to undertake difficult lifestyle modifications that reduce diabetes incidence by 40–60% and may also prevent complications associated with diabetes (20,22).

Similar to other earlier reports of risk factors for incontinence among women without diabetes (7), we found that oral hormone therapy is an important risk factor for incontinence among women with pre-diabetes and diabetes. Women currently using oral estrogens were at a threefold increased risk of incontinence. Recent large, randomized trials of hormone therapy have found that standard doses of oral estrogen increase both incidence and severity of incontinence (13,23). When women with pre-diabetes and diabetes consider starting or stopping hormone therapy, they should be informed of the increased risk of incontinence.

Hysterectomy is the most common major gynecologic surgery in the U.S. Approximately 40% of older women have had a hysterectomy, of which 90% are performed for benign conditions and most are elective. Among nondiabetic women, hysterectomy is associated with a 40–60% increased risk of incontinence (24). We found that among women with pre-diabetes and diabetes, hysterectomy is associated with a nearly threefold increased risk of incontinence. Thus, we recommend that women with pre-diabetes and diabetes considering hysterectomy receive counseling regarding the potential long-term adverse effects of incontinence.

Some risk factors, in particular microvascular complications, increasing weight, and oral estrogen use, are associated with both urge and stress incontinence, suggesting that interventions addressing these risk factors may improve both types of incontinence. In contrast, age was associated only with urge incontinence. Similar to our findings, large observational studies have found urge incontinence associated with advancing age (6). As the population ages, both diabetes and urge incontinence will markedly increase in prevalence. Clinical outcomes of common treatments for incontinence in women with pre-diabetes and diabetes have not been critically examined, and randomized controlled trials are needed to assess the efficacy and safety of conservative, pharmacologic, and surgical treatments.

While this NHANES survey included a population-based sample of women with a wide age range, we were limited in the definition of the glucose categories.

Table 3—*Multivariate models for any weekly urinary incontinence among women with either IFG or diabetes, or within each abnormal glucose population*

	IFG only		Diabetes only		Combined population*	
	n/N (%)	OR (95% CI)	*n/N* (%)	OR (95% CI)	*n/N* (%)	OR (95% CI)
Diabetes complications						
Albuminuria						
None	99/296 (33)	1.0	99/296 (33)	1.0	99/296 (33)	1.0
Microalbuminuria	30/74 (40)	7.45 (1.59–34.98)	30/74 (40)	0.98 (0.36–2.71)	30/74 (40)	1.71 (0.60–4.87)
Macroalbuminuria	13/24 (54)	—	13/24 (54)	3.82 (0.95–15.33)	13/24 (54)	8.29 (2.32–29.68)
Neuropathic pain (yes/no)	—	—	65/121 (54)	2.37 (1.27–4.42)	65/121 (54)	2.23 (1.33–3.73)
Age (per 5 years)	NA	1.30 (1.06–1.60)	NA	1.19 (0.96–1.48)	NA	1.22 (1.06–1.42)
Parity (any children vs. none)	127/344 (37)	2.31 (0.81–6.63)	127/344 (37)	2.65 (0.61–11.52)	127/344 (37)	2.12 (0.69–6.49)
BMI (kg/m^2)	NA	1.10 (1.01–1.19)	NA	1.05 (0.97–1.14)	NA	1.06 (1.01–1.12)
Current oral estrogen use (yes/no)	35/66 (64)	7.13 (1.05–48.25)	—	—	35/66 (53)	3.04 (1.11–8.28)
Hysterectomy (yes/no)	81/165 (49)	5.46 (2.53–11.77)	81/165 (49)	2.29 (1.01–5.20)	81/165 (49)	2.94 (1.55–5.60)

n/N (%), unweighted prevalence of incontinence for each covariate level among the total women with this outcome. Covariates with no values were eliminated in our backward selection of models since they were deemed not significant ($P > 0.15$). *Adjusted for diabetes status. NA, not applicable.

The American Diabetes Association has recommended the use of a fasting plasma glucose value ≥126 mg/dl, confirmed by repeat testing on another day, as being indicative of diabetes (15). We were limited to a single fasting glucose measurement for the diagnosis of diabetes or IFG, so our study may have misclassified some women with diabetes who may have had IFG, or even normal fasting glucose, on repeat testing. Frequency and type of incontinence were included in the questions for the NHANES; however, severity of incontinence could not be determined and length of time of incontinence symptoms was not present.

In conclusion, prevalence of incontinence is comparably elevated among women with pre-diabetes and diabetes, as compared with women with normal glucose levels. Furthermore, incontinence is more bothersome and has a greater effect on daily activities in this population. Physicians should be alert for incontinence, which is often unrecognized and therefore undertreated, among women with diabetes and IFG, in particular those with microvascular complications. The prospect of improved incontinence may help motivate women to undertake difficult lifestyle changes that have been shown to reduce the risk of diabetes and its sequelae. Therapies with the potential to improve or prevent incontinence in this population are weight loss, stopping hormone therapy, and therapies that improve or prevent microvascular disease, including glycemic control and blood pressure control.

Acknowledgments— This research was supported in part by a National Institute of Diabetes, Digestive, and Kidney Diseases K-24 Mid-Career Investigator Award in Patient Oriented Research (PA-98-053 to J.S.B.).

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