

# Work Stress, Sense of Coherence, and Risk of Type 2 Diabetes in a Prospective Study of Middle-Aged Swedish Men and Women

ANNA-KARIN ERIKSSON, RPT, PHD<sup>1,2,3</sup>  
MAUREEN VAN DEN DONK, PHD<sup>4</sup>

AGNETA HILDING, LIC MED<sup>2</sup>  
CLAES-GÖRAN ÖSTENSON, MD, PHD<sup>2</sup>

**OBJECTIVE**—To investigate the prospective influence of work stress on type 2 diabetes (T2D).

**RESEARCH DESIGN AND METHODS**—This population-based cohort included 3,205 women and 2,227 men, aged 35–56 years, with baseline normal glucose tolerance measured with oral glucose tolerance test. At follow-up 8–10 years later, T2D was diagnosed in 60 women and 111 men. Work stress factors evaluated by questionnaire (i.e., demands, decision latitude, job strain, shift work, overtime work, and also sense of coherence) were studied in association with T2D. Odds ratios (ORs) and 95% CIs adjusted for age, education, BMI, physical activity, smoking, family history of diabetes, and psychological distress were calculated.

**RESULTS**—In women, low decision latitude was associated with T2D on its own (OR 2.4 [95% CI 1.1–5.2]) and combined with high demands: job strain (OR 4.2 [2.0–8.7]), adjusted for all available potential confounders. Also, shift work increased the risk of T2D in women (OR 2.2 [1.0–4.7]) when adjusted for age, education, and psychological distress, although this risk was diluted after multifactor adjustment (OR 1.9 [0.8–4.4]). In men, high work demands and high strain decreased the risk of T2D (OR 0.5 [0.3–0.9]) for both measures, as did an active job (high demands and high decision latitude, OR 0.4 [0.2–0.9]).

**CONCLUSIONS**—Work stress and shift work may contribute to the development of T2D in women. In men, the risk was decreased by high work demands, high strain, and an active job.

*Diabetes Care* 36:2683–2689, 2013

Work stress has been acknowledged as a risk factor for cardiovascular diseases, at least in men (1,2). The impact of work stress on the risk of type 2 diabetes (T2D) is still not widely studied, and the results are partially contradictory.

The role of psychosocial working conditions can be analyzed by applying the job strain model of Karasek (3), in which a combination of job demands and decision latitude (job control) at work measures the impact of stress on

the risk of disease. In our previous cross-sectional study of women in the Stockholm Diabetes Prevention Program (SDPP), low decision latitude was associated with T2D; however, job demand was not (4). In the Whitehall II Study and the Västerbotten Intervention Program (5,6), job strain/tense work was prospectively associated with an increased risk of T2D in women, while no association was observed in men. In contrast, job strain was unrelated to diabetes in the Nurses' Health Study II (7), which included only

women. In addition to psychosocial work stress, years of rotating night-shift work have been associated with a modestly increased risk of T2D (7,8). A potential association between psychosocial work stress and T2D has been suggested to involve dysregulation of neuroendocrine pathways that lead to visceral obesity and insulin resistance (9) or to be mediated through unfavorable health behaviors.

The hypothesis that psychosocial work stress increases the risk of T2D was not confirmed in a recent meta-analysis (10). The authors noticed that there are very few studies in this area available, and only one previously published study with both prospective design and assessment of diabetes status using fasting blood glucose or oral glucose tolerance test (OGTT) at both baseline and follow-up health examinations (5).

Against this background, we assessed prospectively in a population-based cohort of Swedish middle-aged men and women whether there is an association between self-reported stress factors at work (high demands, low decision latitude, job strain, shift work, and overtime work), and prediabetes and T2D 8–10 years later (measured with OGTT). In addition, we evaluated if sense of coherence (SOC) (11), which facilitates successful coping with stressors, influenced the risk of T2D.

## RESEARCH DESIGN AND METHODS

### Study population

This follow-up study included 2,227 men and 3,205 women with baseline normal glucose tolerance (NGT) in the SDPP, a prospective population-based cohort described in detail elsewhere (12). In brief, the SDPP baseline study group consists of 3,128 men and 4,821 women aged 35–56 years, characterized in 1992–1994 (men) or 1996–1998 (women) using questionnaires and OGTTs. Abnormal glucose regulation was defined according to the World Health Organization criteria from

From the <sup>1</sup>Department of Medicine, Clinical Epidemiology Unit, Karolinska Institutet, Stockholm, Sweden; the <sup>2</sup>Department of Molecular Medicine and Surgery, Endocrine and Diabetes Unit, Karolinska Institutet, Stockholm, Sweden; the <sup>3</sup>Department of Public Health Science, Division of Social Medicine, Karolinska Institutet, Stockholm, Sweden; and the <sup>4</sup>Dutch College of General Practitioners, Utrecht, the Netherlands. Corresponding author: Anna-Karin Eriksson, anna-karin.eriksson.2@ki.se.

Received 27 August 2012 and accepted 9 March 2013.

DOI: 10.2337/dc12-1738

This article contains Supplementary Data online at <http://care.diabetesjournals.org/lookup/suppl/doi:10.2337/dc12-1738/-/DC1>.

A.-K.E. and M.v.d.D. contributed equally to this study.

© 2013 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. See <http://creativecommons.org/licenses/by-nc-nd/3.0/> for details.

1999 (13). Participants were invited for a health examination after ~8 (women) to 10 (men) years of follow-up. The total follow-up study sample comprised 2,383 men and 3,329 women, representing 76.2 and 69.1%, respectively, of the baseline study population. Of the 2,227 men with baseline NGT who could be followed throughout this follow-up period, 255 developed prediabetes (impaired fasting glucose and/or impaired glucose tolerance), and 111 developed T2D. Of the 3,205 women with NGT, 181 developed prediabetes, and 60 developed T2D.

### Classification of work-related factors

Five questions on work demands and five questions on decision latitude were obtained from the Swedish version of the Karasek and Theorell demand-decision latitude questionnaire (14). The questionnaire lacked one of the original six items on decision latitude (i.e., Do you have the freedom to decide how your work should be performed?). Demand refers to the load of work a person experiences; decision latitude describes a person's skills and ability to master his/her work activities. An index on demand and decision latitude was created from scores that were obtained from a four-scale responding alternative: almost always, often, seldom, and never. The scores ranged from 1 to 4 points on each question. From the distribution of total scores among all respondents, cutoff groups were created from the upper, middle, and lower tertiles.

For job strain (job strain 1), the tertile with high demands and the tertile with low decision latitude were combined and regarded as exposed to job strain, whereas all others were regarded as unexposed (4). Furthermore, we used combinations of median split demands and decision latitude, such that job strain (job strain 2) was defined as low strain (low demands and high decision latitude), passive job (low demands and low decision latitude), active job (high demands and high decision latitude), and high strain (high demands and low decision latitude) (3).

Shift work was derived from one question, Do you do shift work?, with answer possibilities "yes" or "no." Overtime work was also derived from one question and divided into yes (answer categories "work overtime once or twice a week," "often work overtime," and "do not have regulated hours at all" combined) or no ("never work overtime").

Self-reported SOC was based on three questions that have been validated with

satisfactory results and are suggested to capture the essence of the three dimensions of SOC: sense of manageability, comprehensibility, and meaningfulness (15). An index was created from the three questions: 1) Do you usually see a solution to problems and difficulties that other people find hopeless? 2) Do you usually feel that the things that happen to you in your daily life are hard to understand? and 3) Do you usually feel that your daily life is a source of personal satisfaction? The responding alternative "yes, usually" scored three points, "yes, sometimes" scored two points, and "no" scored one point for the questions on meaningfulness and manageability; the question on comprehensibility was scored in the reverse order. The index of summed scores among all respondents was divided into categories: low (3–6 points), middle (7–7.5 points), and high (8 to 9 points) SOC.

### Classification of potential confounders

Potential confounders were assessed at baseline. Family history of diabetes was based on self-report and defined as known diabetes in at least one first-degree relative (parent or sibling) or at least two second-degree relatives (grandparents, uncles, or aunts), with diabetes onset generally at age >35 years (<6% were <35 years). Body height and weight were measured with subjects wearing light indoor clothes and no shoes. For analyses, BMI was divided into three groups (<25.0, 25.0–29.9, and  $\geq 30.0$  kg/m<sup>2</sup>). Waist circumference was measured in the lying position midway between the lower costal margin and iliac crest and divided into three categories: for women, <80, 80–87, and  $\geq 88$  cm, and for men, <94, 94–101, and  $\geq 102$  cm. Smoking habits were analyzed in three categories from information in the questionnaire: never, former, and current smoking. Physical activity during the last year was measured from a question with four response options—sedentary, moderately active, regular exercise, and regular exercise and training—and categorized as low or regular physical activity. Educational level was categorized into low (elementary school and junior high school), middle (high school, technical or vocational school), or high (university or college). Civil status was defined as whether subjects were married or living together with someone.

Psychological distress was divided into high, middle, and low based on a

summed index of five questions concerning symptoms of insomnia, apathy, anxiety, depression, and fatigue (12).

### Data analysis

Odds ratios (ORs) and corresponding 95% CIs were calculated using multiple logistic regression analysis. The outcome parameters were T2D and prediabetes. Individuals with NGT at follow-up were used as the control group. As independent parameters, we used stress factors at work: work demands, decision latitude, job strain, shift work, and overtime work and also SOC, as defined above. Only persons who were employed, self-employed, or temporarily sick-listed were requested to describe their work conditions. Thus, 95% of the women and 97% of the men answered these questions.

The crude model was adjusted for age. In a second model, we considered potential confounders mentioned above as follows: first, we checked whether a variable was associated with both the dependent and independent parameter by using  $\chi^2$  tests. If this was the case, a variable was considered a confounder and used in the final analyses if the OR in the exposure of interest changed the age-adjusted measure by at least 10%. From the potential confounders that we tested, educational level and psychological distress were the only measures that changed the age-adjusted ORs by >10%. Furthermore, in a third model, we adjusted also for all other available potential confounders. Waist circumference and BMI had similar influence on the estimates, so BMI was chosen to be included. All analyses were performed only on the individuals with data on all work stress parameters and potential confounders. We also adjusted the exposure of interest for the other work-related stress factors and SOC.

Analyses were done for men and women combined and separately. To evaluate if the associations differed in men and women, we studied effect modification in a combined estimate by including interaction terms between the studied work-related factors and gender. Comparison of continuous variables and categorical variables between two independent groups was assessed with ANOVA and the  $\chi^2$  test, respectively. The analyses were computed with the SAS Statistical Program version 9.1 (SAS Institute).

**RESULTS**—Overweight or obesity (BMI  $\geq 25$  kg/m<sup>2</sup>), family history of

diabetes, current smoking, low physical activity, and low educational level were more prevalent in men and women who developed abnormal glucose regulation (prediabetes or T2D) compared with those who still were having NGT at follow-up (Table 1). Civil status did not differ significantly between the groups. High psychological distress was more prevalent in men with abnormal glucose regulation compared with those with NGT, although not in women. Finally, subjects with abnormal glucose regulation were slightly older.

Results from univariate analyses for the association between work-related factors and covariates are shown in Supplementary Tables 1 and 2.

The difference in work-related factors at baseline between follow-up participants and nonparticipants was analyzed (Supplementary Table 3). In women, there was a lower proportion with job strain among participants compared with nonparticipants, and high SOC was more prevalent among participants than among nonparticipants. For men, no differences were observed. The distribution for other characteristics/potential confounders has been previously published (12).

Decision latitude, shift work, overtime work, and SOC were not associated with T2D when men and women were analyzed as one group and potential confounders were taken into consideration (Table 2). For work demands, a decreased risk was observed for the individuals in the middle group (OR 0.6 [95% CI 0.4–1.0] in the model adjusted for age, educational level, and psychological distress and 0.7 [0.4–1.0] in the model adjusted for age, educational level, family history of diabetes, BMI, physical activity, smoking, civil status, and psychological distress). Job strain 1 conferred an increased risk of developing T2D (OR 1.6 [1.0–2.6] and 1.6 [1.0–2.7] in the two models, respectively). An active job decreased the risk for T2D (OR 0.5 [0.3–0.9]) for both confounding models. When we included an interaction term between work-related factors and gender, this was significant only for job strain 1 ( $P = 0.008$ ).

Further, we estimated the risk for T2D associated with the different work-related factors in men and women separately. Women with low decision latitude at work had an increased risk of T2D compared with women with high decision latitude (OR 2.1 [95% CI 1.0–4.4] and OR 2.4 [1.1–5.2] in the two models, respectively) (Table 3). The risk was

**Table 1—Baseline characteristics according to glucose tolerance at follow-up in women and men**

	NGT	Prediabetes	T2D	P value
<b>Women</b>				
Total number	2,707	166	51	
Age (years)	47.3 ± 4.9	49.3 ± 4.0	49.2 ± 4.5	<0.001
<b>BMI (kg/m<sup>2</sup>)</b>				
<25.0	58.3 (1,577)	28.9 (48)	15.7 (8)	
25.0–29.9	33.1 (896)	42.8 (71)	39.2 (20)	
≥30.0	8.6 (234)	28.3 (47)	45.1 (23)	<0.001
Family history of diabetes	50.7 (1,373)	69.9 (116)	80.4 (41)	<0.001
<b>Smoking</b>				
Never	38.7 (1,049)	41.0 (68)	29.4 (15)	
Former	37.6 (1,017)	28.3 (47)	35.3 (18)	
Current	23.7 (641)	30.7 (51)	35.3 (18)	0.029
<b>Physical activity</b>				
Low	63.3 (1,714)	80.1 (133)	78.4 (40)	
Regular	36.7 (993)	19.9 (33)	21.6 (11)	<0.001
<b>Educational level</b>				
Low	28.0 (757)	37.4 (62)	45.1 (23)	
Middle	33.8 (916)	33.7 (56)	35.3 (18)	
High	38.2 (1,034)	28.9 (48)	19.6 (10)	0.002
<b>Civil status<sup>a</sup></b>				
No	16.5 (446)	16.3 (27)	19.6 (10)	
Yes	83.5 (2,261)	83.7 (139)	80.4 (41)	0.834
<b>Psychological distress</b>				
Low	15.7 (426)	9.6 (16)	21.6 (11)	
Middle	56.6 (1,531)	65.7 (109)	51.0 (26)	
High	27.7 (750)	24.7 (41)	27.4 (14)	0.088
<b>Men</b>				
Total number	1,724	239	98	
Age (years)	46.4 ± 4.9	47.2 ± 4.8	47.5 ± 4.7	0.006
<b>BMI (kg/m<sup>2</sup>)</b>				
<25.0	48.0 (828)	25.1 (60)	22.5 (22)	
25.0–29.9	44.8 (772)	54.8 (131)	57.1 (56)	
≥30.0	7.2 (124)	20.1 (48)	20.4 (20)	<0.001
Family history of diabetes	47.7 (823)	61.9 (148)	72.5 (71)	<0.001
<b>Smoking</b>				
Never	42.6 (734)	33.5 (80)	29.6 (29)	
Former	35.6 (614)	38.5 (92)	28.6 (28)	
Current	21.8 (376)	28.0 (67)	41.8 (41)	<0.001
<b>Physical activity</b>				
Low	59.9 (1,033)	65.7 (157)	70.4 (69)	
Regular	40.1 (691)	34.3 (82)	29.6 (29)	0.035
<b>Educational level</b>				
Low	31.1 (536)	34.3 (82)	40.8 (40)	
Middle	45.7 (788)	46.0 (110)	45.9 (45)	
High	23.2 (400)	19.7 (47)	13.3 (13)	0.085
<b>Civil status<sup>a</sup></b>				
No	12.2 (211)	13.4 (32)	19.4 (19)	
Yes	87.8 (1,513)	86.6 (207)	80.6 (79)	0.112
<b>Psychological distress</b>				
Low	35.4 (610)	30.5 (73)	25.5 (25)	
Middle	53.5 (923)	49.4 (118)	51.0 (50)	
High	11.1 (191)	20.1 (48)	23.5 (23)	<0.001

Continuous data are expressed as mean ± SD and categorical data as percent (number). Statistical analyses are performed by ANOVA or  $\chi^2$  test where appropriate. <sup>a</sup>Married or living together with someone.

**Table 2—OR and 95% CI for T2D in association with work-related factors and SOC in the whole study group, women and men combined**

	NGT (n)	n	T2D		
			OR (95% CI)	OR (95% CI)*	OR (95% CI)**
<b>Work demands</b>					
Low	1,338	63	1.0	1.0	1.0
Middle	1,665	43	0.6 (0.4–0.9)	0.6 (0.4–1.0)	0.7 (0.4–1.0)
High	1,428	43	0.7 (0.5–1.0)	0.7 (0.5–1.1)	0.7 (0.5–1.1)
			<i>P</i> = 0.208	<i>P</i> = 0.216	<i>P</i> = 0.241
<b>Decision latitude</b>					
High	1,286	32	1.0	1.0	1.0
Middle	1,585	46	1.0 (0.7–1.6)	0.9 (0.6–1.4)	1.0 (0.6–1.6)
Low	1,560	71	1.6 (1.0–2.4)	1.2 (0.8–1.9)	1.3 (0.8–2.1)
			<i>P</i> = 0.055	<i>P</i> = 0.078	<i>P</i> = 0.064
<b>Job strain 1</b>					
High demands/low decision latitude					
No	4,059	128	1.0	1.0	1.0
Yes	372	21	1.8 (1.1–2.9)	1.6 (1.0–2.6)	1.6 (1.0–2.7)
			<i>P</i> = 0.009	<i>P</i> = 0.014	<i>P</i> = 0.008
<b>Job strain 2</b>					
Low strain	941	34	1.0	1.0	1.0
Passive job	1,432	53	0.8 (0.6–1.4)	0.7 (0.5–1.2)	0.8 (0.5–1.3)
Active job	1,093	20	0.5 (0.3–0.8)	0.5 (0.3–0.9)	0.5 (0.3–0.9)
High strain	965	42	1.0 (0.6–1.6)	0.8 (0.5–1.3)	0.8 (0.5–1.4)
			<i>P</i> = 0.079	<i>P</i> = 0.111	<i>P</i> = 0.120
<b>Shift work</b>					
No	3,996	130	1.0	1.0	1.0
Yes	435	19	1.3 (0.8–2.1)	1.2 (0.7–1.9)	1.1 (0.6–1.9)
			<i>P</i> = 0.081	<i>P</i> = 0.084	<i>P</i> = 0.120
<b>Overtime work</b>					
No	1,434	47	1.0	1.0	1.0
Yes	2,997	102	0.9 (0.6–1.2)	0.9 (0.7–1.4)	0.9 (0.6–1.3)
			<i>P</i> = 0.654	<i>P</i> = 0.591	<i>P</i> = 0.685
<b>SOC</b>					
High	2,325	68	1.0	1.0	1.0
Middle	1,332	47	1.2 (0.8–1.8)	1.1 (0.7–1.6)	1.0 (0.7–1.6)
Low	774	34	1.7 (1.1–2.6)	1.3 (0.8–2.1)	1.3 (0.8–2.0)
			<i>P</i> = 0.213	<i>P</i> = 0.175	<i>P</i> = 0.156

All analyses are controlled for age (35–40, 41–46, 47–51, and 52–56 years) and gender. *P* values are for the interaction term between gender and the work-related factor. \*Adjusted for educational level (high, middle, and low) and psychological distress (low, middle, and high). \*\*Adjusted for educational level (high, middle, and low), psychological distress (low, middle, and high), family history of diabetes (no, yes), BMI (<25.0, 25.0–29.9, and ≥30.0 kg/m<sup>2</sup>), physical activity (high, low), smoking (never, former, and current), and civil status (married or living with someone; no, yes).

three- and fourfold increased when low decision latitude was combined with high demands (job strain) (OR 3.7 [1.9–7.4] and OR 4.2 [2.0–8.7]). When job strain was defined as passive job, active job, or high strain compared with low strain, only a high-strain job was associated with T2D in the crude model. This association was no longer significant after adjustment for confounders. We also found a positive association between shift work and T2D in women (OR 2.2 [1.0–4.7] adjusted for age, education, and psychological

distress). However, shift work seemed not associated with T2D once all potential confounders were accounted for (OR 1.9 [0.8–4.4]), mainly due to the influence of BMI. There was no association among work demands, overtime work, or SOC and incidence of T2D in women. The results did not change after mutual adjustment for the other work-related stress factors and SOC (results not shown).

In men, high work demands decreased the risk of T2D when compared with low work demands (OR 0.5 [95% CI

0.3–0.9] for both confounding models) (Table 4). Also, having an active job was associated with a 60% decreased risk of T2D compared with having a low-strain job (OR 0.4 for both confounding models [95% CIs 0.2–0.8 and 0.2–0.9, respectively]). In addition, a high-strain job was associated with a decreased risk of T2D (OR 0.5 [0.3–0.9] for both models). An increased risk for T2D observed for the crude estimate of SOC was no longer significant when potential confounders were taken into consideration. The main reason for this was the inclusion of psychological distress in the model. Decision latitude, shift work, and overtime work were not associated with T2D in men. Again, the results did not materially change after mutual adjustment for other stress factors at work and SOC.

In addition, we studied the associations between stress factors at work and SOC on the incidence of prediabetes. However, there were no associations found (Supplementary Tables 4–6).

**CONCLUSIONS**—The results of this study indicate that the risk of T2D is influenced by stress factors at work in middle-aged women and men. In women, low decision latitude predicted T2D, especially when combined with high work demands (high job strain). Furthermore, shift work increased the risk of T2D in women, although this association disappeared when all available confounders were taken into consideration. In men, the risk of T2D was decreased by high work demands, an active job, and a high-strain job.

When the influence of stress factors at work and SOC was studied on the incidence of prediabetes, no associations were found in either men or women. Consequently, it is possible that these factors are not having an effect on the early development of abnormal glucose regulation.

In a recent meta-analysis compiling the available literature in this area (10), it was reported that an association between work psychosocial stress and T2D could not be confirmed. However, the designs of the original studies were heterogeneous with regard to adjustments for confounders and covariates. Also, whereas a small number of cases may contribute to results being due to chance, the increased risk observed in women in some of the studies was possibly diluted when combined with men. Only one of the included original studies was, as in our study, based on prospective data and with formal

**Table 3—OR and 95% CI for T2D in association with work-related factors and SOC in women**

	NGT (n)	n	T2D		
			OR (95% CI)	OR (95% CI)*	OR (95% CI)**
<b>Work demands</b>					
Low	727	18	1.0	1.0	1.0
Middle	1,124	14	0.5 (0.3–1.1)	0.6 (0.3–1.2)	0.6 (0.3–1.2)
High	856	19	0.9 (0.5–1.8)	1.2 (0.6–2.3)	1.0 (0.5–2.0)
<b>Decision latitude</b>					
High	890	11	1.0	1.0	1.0
Middle	934	11	1.0 (0.4–2.3)	0.8 (0.4–2.0)	0.9 (0.4–2.2)
Low	883	29	2.7 (1.3–5.4)	2.1 (1.0–4.4)	2.4 (1.1–5.2)
<b>Job strain 1</b>					
High demands/low decision latitude					
No	2,497	39	1.0	1.0	1.0
Yes	210	12	3.7 (1.9–7.2)	3.7 (1.9–7.4)	4.2 (2.0–8.7)
<b>Job strain 2</b>					
Low strain	664	10	1.0	1.0	1.0
Passive job	819	17	1.4 (0.6–3.0)	1.1 (0.5–2.5)	1.2 (0.5–2.6)
Active job	713	7	0.6 (0.2–1.7)	0.8 (0.3–2.0)	0.6 (0.2–1.8)
High strain	511	17	2.2 (1.0–4.9)	2.1 (0.9–4.8)	2.1 (0.9–4.8)
<b>Shift work</b>					
No	2,489	43	1.0	1.0	1.0
Yes	218	8	2.3 (1.1–5.0)	2.2 (1.0–4.7)	1.9 (0.8–4.4)
<b>Overtime work</b>					
No	1,029	20	1.0	1.0	1.0
Yes	1,678	31	1.0 (0.5–1.7)	1.1 (0.6–2.0)	1.0 (0.6–1.9)
<b>SOC</b>					
High	1,388	22	1.0	1.0	1.0
Middle	795	19	1.6 (0.8–2.9)	1.5 (0.8–2.8)	1.5 (0.8–2.9)
Low	524	10	1.2 (0.6–2.6)	1.2 (0.5–2.6)	1.2 (0.5–2.8)

All analyses are controlled for age (35–40, 41–46, 47–51, and 52–56 years). \*Adjusted for educational level (high, middle, and low) and psychological distress (low, middle, and high). \*\*Adjusted for educational level (high, middle, and low), psychological distress (low, middle, and high), family history of diabetes (no, yes), BMI (<25.0, 25.0–29.9, and  $\geq 30.0$  kg/m<sup>2</sup>), physical activity (high, low), smoking (never, former, and current), and civil status (married or living with someone; no, yes).

assessment of T2D by OGTT at both baseline and follow-up (5).

Our finding that job strain is associated with an increased risk of T2D in women, but not in men, is in accordance with two other prospective studies: similar results were also found in the Västerbotten Intervention Program (6) and the Whitehall II Study (5). The only study that published prospective data in women and did not find an association between job strain and risk of T2D was the Nurses' Health Study II (7). The discrepancy might be due to the fact that the Nurses' Health Study II included a selected occupational group, which may experience a lower variation in job strain than the populations studied in the other prospective studies. In a Japanese study of male industrial workers (16), job strain did not increase the risk of T2D. In

contrast, another measure of work stress, effort–reward imbalance, has been associated with T2D in men, while no association was observed in women (17). When job strain in our study was defined in four groups, as low strain, passive job, active job, or high strain, the influence of a high-strain job (high demands and low decision latitude) in women was attenuated. This is probably explained by the fact that median splits were used in this analysis, implying that the contrast between the exposure groups became less pronounced.

When analyzing the individual components of job strain, namely work demands and decision latitude, work demands were not a crucial work stress factor influencing the risk of T2D in women. Instead, it was low decision latitude that increased the risk of T2D. This is in line with the results from the

Västerbotten Intervention Program (6) and with the previous literature on, for instance, coronary heart disease, in which lack of control/low decision latitude over the job's demands has been shown to be the important factor. An increased risk with a demanding job often appears only in combination with low control/decision latitude (18).

High work demands, high strain, and an active job (high demands and high decision latitude, according to median splits) conferred a protective effect on T2D risk in men. According to the job strain model, an active job entails work situations that often are intensively demanding and involve the workers in activities over which they feel a large amount of control and also the freedom to use all available skills. This leads to a state of positive activity that facilitates development and learning (18). At the same time, it could be proposed that the result of a decreased risk of T2D associated with an active job reflects a “healthy worker effect,” which would mean that only individuals with the resource of strong health will have jobs characterized by high demands in combination with high decision latitude. Also, it may be noted that a decreased risk of T2D associated with an active job was not observed in women.

For overtime work, we could not see any association with the development of T2D in either women or men. Working overtime has been associated with a slightly increased risk of developing T2D (7), and in a study in Japanese industrial workers, >50 h overtime per month gave a 3.7 times higher risk compared with those working 0–25 h per month (16). In contrast, another Japanese study found a protective effect of overtime work on the risk of impaired glucose tolerance or T2D in Japanese male office workers (19).

There was an increased risk of T2D associated with shift work in women in the current study. At the same time, when the estimate adjusted for age, education, and psychological distress was further adjusted for the other potential confounders, the association became attenuated and nonsignificant, mainly due to the influence of BMI. Likewise, in The Nurses' Health Study II (7), a positive association between years of rotating night-shift work was found that disappeared after correction for BMI. However, in their updated analysis, it was concluded that BMI only partly explained the relationship (8). Shift

Table 4—OR and 95% CI for T2D in association with work-related factors and SOC in men

	NGT (n)	n	T2D		
			OR (95% CI)	OR (95% CI)*	OR (95% CI)**
<b>Work demands</b>					
Low	611	45	1.0	1.0	1.0
Middle	541	29	0.7 (0.4–1.2)	0.7 (0.4–1.1)	0.8 (0.5–1.3)
High	572	24	0.6 (0.3–1.0)	0.5 (0.3–0.9)	0.5 (0.3–0.9)
<b>Decision latitude</b>					
High	396	21	1.0	1.0	1.0
Middle	651	35	1.0 (0.6–1.7)	0.9 (0.5–1.5)	1.0 (0.5–1.7)
Low	677	42	1.2 (0.7–2.0)	0.9 (0.5–1.6)	0.9 (0.5–1.7)
<b>Job strain 1</b>					
High demands/low decision latitude					
No	1,562	89	1.0	1.0	1.0
Yes	162	9	1.0 (0.5–2.1)	0.9 (0.4–1.8)	0.8 (0.4–1.7)
<b>Job strain 2</b>					
Low strain	277	24	1.0	1.0	1.0
Passive job	613	36	0.7 (0.4–1.1)	0.6 (0.3–1.0)	0.6 (0.3–1.1)
Active job	380	13	0.4 (0.2–0.8)	0.4 (0.2–0.8)	0.4 (0.2–0.9)
High strain	454	25	0.6 (0.3–1.1)	0.5 (0.3–0.9)	0.5 (0.3–0.9)
<b>Shift work</b>					
No	1,507	87	1.0	1.0	1.0
Yes	217	11	0.9 (0.5–1.7)	0.9 (0.4–1.7)	0.8 (0.4–1.7)
<b>Overtime work</b>					
No	405	27	1.0	1.0	1.0
Yes	1,319	71	0.8 (0.5–1.3)	0.9 (0.5–1.4)	0.9 (0.5–1.4)
<b>SOC</b>					
High	937	46	1.0	1.0	1.0
Middle	537	28	1.1 (0.7–1.8)	0.9 (0.6–1.5)	0.8 (0.5–1.4)
Low	250	24	2.0 (1.2–3.3)	1.4 (0.8–2.5)	1.4 (0.8–2.5)

All analyses are controlled for age (35–40, 41–46, 47–51, and 52–56 years). \*Adjusted for educational level (high, middle, and low) and psychological distress (low, middle, and high). \*\*Adjusted for educational level (high, middle, and low), psychological distress (low, middle, and high), family history of diabetes (no, yes), BMI (<25.0, 25.0–29.9, and ≥30.0 kg/m<sup>2</sup>), physical activity (high, low), smoking (never, former, and current), and civil status (married or living with someone; no, yes).

work has adverse health effects, including cardiovascular disease (20). Shift work induces disturbed sleep (21), which in turn has been found to increase the risk for T2D (12,22,23), and interferes with the normal synchrony between the light–dark cycle, sleeping, and eating, which may influence the function of the endocrine system (24). A relation among shift work/sleep disturbances, insulin resistance, and T2D may well be mediated through adiposity or weight gain influenced either by disturbances of the hormone systems or by changed dietary and exercise patterns (24).

Finally, we could not confirm previous cross-sectional results in the SDPP of an association between low SOC and T2D in women (4). Also, low SOC did not predict T2D in men when potential confounders, above all psychological distress, were taken into account. It is not unlikely

that the measures of SOC and psychological distress may share some components or to some extent capture similar conditions. To our knowledge, there is only one other prospective study that examined the association between SOC and T2D (25). That study included men in a forest-industry corporation, and the diagnosis of diabetes was prescription-based (25). Partly in line with our results, a weak SOC was associated with an increased risk of diabetes.

In this study, the observed risk for T2D differed between men and women according to the interaction terms for job strain. It may be speculated that the different effects of work stress in men and women on T2D are partly due to different opportunities for recovering from high work-stress levels. It has been suggested that the lack of restitution may be a greater health problem than the absolute levels of stress (26). In studies

of Swedish white-collar workers, it has been shown that men and women at the same occupational level respond equally to stress at work. In contrast, after work, the stress levels of men were more rapidly reduced, while those of women remained elevated (26–28). The greater amount of unpaid work connected to household responsibilities and child care may be a contributing factor to sustained stress levels in women (29,30). Even though Swedish men have increased their household work hours and women decreased theirs since 1974, women’s weekly hours of house work were more than double that of men in 2000 in the age-group 18–74 years (31). In our study of middle-aged individuals, we were not able to measure the amount of household work or stress levels after work in either men or women.

Strengths of this study include the prospective design and the use of OGTTs at both the baseline and follow-up health examinations to define T2D. We were able to follow individuals free of disease (i.e., those characterized with NGT at baseline), implying that reversed causality was not likely. The cohort includes both men and women, which provides the opportunity to display separate estimates. We had information on many established risk factors for T2D, such as family history of diabetes, BMI, smoking, and physical inactivity, as well as education, civil status, and psychological distress, and could therefore adjust for these potential confounders. We found some differences between participants and nonparticipants regarding work stress-related factors and potential confounders. However, the differences were small, and if they had any influence, the present results would probably have been underestimated. Nonresponse bias, which is regarded to be a problem in observational studies, has been reported to be minimal in the studied cohort (12,32). A limitation is that we were not able to perform more detailed exposure analyses on overtime or shift work due to the small number of T2D cases.

In conclusion, work stress may contribute to the development of T2D, especially in women. Whether this is due solely to women’s work situation or is an accumulation effect from work stress and stress in the home situation, leading to lack of opportunity for recovery, remains an interesting question.

**Acknowledgments**—This study was supported by grants from Stockholm County

Council, Swedish Council of Working Life and Social Research, Novo Nordisk Scandinavia, and Swedish Diabetes Association. No other potential conflicts of interest relevant to this article were reported.

A.-K.E. and M.v.d.D. researched data and wrote the manuscript. A.H. researched data and reviewed the manuscript. C.-G.Ö. designed the study and reviewed the manuscript. C.-G.Ö. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

The authors thank the nurses, technicians, and other staff members at the health care centers and the laboratory who carried out the OGTTs and other measurements.

## References

- Karasek R, Baker D, Marxer F, Ahlborn A, Theorell T. Job decision latitude, job demands, and cardiovascular disease: a prospective study of Swedish men. *Am J Public Health* 1981;71:694–705
- Belkic KL, Landsbergis PA, Schnall PL, Baker D. Is job strain a major source of cardiovascular disease risk? *Scand J Work Environ Health* 2004;30:85–128
- Karasek RA. Job demands, job decision latitude, and mental strain: implications for job redesign. *Adm Sci Q* 1979;24:285–307
- Agardh EE, Ahlborn A, Andersson T, et al. Work stress and low sense of coherence is associated with type 2 diabetes in middle-aged Swedish women. *Diabetes Care* 2003;26:719–724
- Heraclides A, Chandola T, Witte DR, Brunner EJ. Psychosocial stress at work doubles the risk of type 2 diabetes in middle-aged women: evidence from the Whitehall II study. *Diabetes Care* 2009;32:2230–2235
- Norberg M, Stenlund H, Lindahl B, Andersson C, Eriksson JW, Weinehall L. Work stress and low emotional support is associated with increased risk of future type 2 diabetes in women. *Diabetes Res Clin Pract* 2007;76:368–377
- Kroenke CH, Spiegelman D, Manson J, Schernhammer ES, Colditz GA, Kawachi I. Work characteristics and incidence of type 2 diabetes in women. *Am J Epidemiol* 2007;165:175–183
- Pan A, Schernhammer ES, Sun Q, Hu FB. Rotating night shift work and risk of type 2 diabetes: two prospective cohort studies in women. *PLoS Med* 2011;8:e1001141
- Rosmond R, Björntorp P. The hypothalamic-pituitary-adrenal axis activity as a predictor of cardiovascular disease, type 2 diabetes and stroke. *J Intern Med* 2000;247:188–197
- Cosgrove MP, Sargeant LA, Caleyachetty R, Griffin SJ. Work-related stress and Type 2 diabetes: systematic review and meta-analysis. *Occup Med (Lond)* 2012;62:167–173
- Antonovsky A. *Unraveling the Mystery of Health: How People Manage Stress and Stay Well*. San Francisco, Jossey-Bass, 1987
- Eriksson AK, Ekblom A, Granath F, Hilding A, Efendic S, Ostenson CG. Psychological distress and risk of pre-diabetes and Type 2 diabetes in a prospective study of Swedish middle-aged men and women. *Diabet Med* 2008;25:834–842
- World Health Organization. *Definition, Diagnosis and Classification of Diabetes Mellitus and Its Complications. Report of a WHO Consultation. Part 1. Diagnosis and Classification of Diabetes Mellitus*. Geneva, World Health Organization, 1999
- Karasek RA, Theorell T, Schwartz JE, Schnall PL, Pieper CF, Michela JL. Job characteristics in relation to the prevalence of myocardial infarction in the US Health Examination Survey (HES) and the Health and Nutrition Examination Survey (HANES). *Am J Public Health* 1988;78:910–918
- Lundberg U, Nyström Peck M. A simplified way of measuring sense of coherence. *Eur J Public Health* 1995;5:56–59
- Kawakami N, Araki S, Takatsuka N, Shimizu H, Ishibashi H. Overtime, psychosocial working conditions, and occurrence of non-insulin dependent diabetes mellitus in Japanese men. *J Epidemiol Community Health* 1999;53:359–363
- Kumari M, Head J, Marmot M. Prospective study of social and other risk factors for incidence of type 2 diabetes in the Whitehall II study. *Arch Intern Med* 2004;164:1873–1880
- Karasek R, Theorell T. *Healthy Work: Stress, Productivity and Reconstruction of Working Life*. New York, Basic Books, 1990
- Nakanishi N, Nishina K, Yoshida H, et al. Hours of work and the risk of developing impaired fasting glucose or type 2 diabetes mellitus in Japanese male office workers. *Occup Environ Med* 2001;58:569–574
- Knutsson A. Health disorders of shift workers. *Occup Med (Lond)* 2003;53:103–108
- Åkerstedt T, Wright KP, Jr. Sleep loss and fatigue in shift work and shift work disorder. *Sleep Med Clin* 2009;4:257–271
- Mallon L, Broman J-E, Hetta J. High incidence of diabetes in men with sleep complaints or short sleep duration: a 12-year follow-up study of a middle-aged population. *Diabetes Care* 2005;28:2762–2767
- Kawakami N, Takatsuka N, Shimizu H. Sleep disturbance and onset of type 2 diabetes. *Diabetes Care* 2004;27:282–283
- Kivimäki M, Batty GD, Hublin C. Shift work as a risk factor for future type 2 diabetes: evidence, mechanisms, implications, and future research directions. *PLoS Med* 2011;8:e1001138
- Kouvonen AM, Väänänen A, Woods SA, Heponiemi T, Koskinen A, Toppinen-Tanner S. Sense of coherence and diabetes: a prospective occupational cohort study. *BMC Public Health* 2008;8:46
- Lundberg U. Stress hormones in health and illness: the roles of work and gender. *Psychoneuroendocrinology* 2005;30:1017–1021
- Frankenhaeuser M, Lundberg U, Fredrikson M, et al. Stress on and off the job as related to sex and occupational status in white-collar workers. *J Organ Behav* 1989;10:321–346
- Lundberg U, Frankenhaeuser M. Stress and workload of men and women in high-ranking positions. *J Occup Health Psychol* 1999;4:142–151
- Lundberg U, Mårdberg B, Frankenhaeuser M. The total workload of male and female white collar workers as related to age, occupational level, and number of children. *Scand J Psychol* 1994;35:315–327
- Berntsson L, Lundberg U, Krantz G. Gender differences in work-home interplay and symptom perception among Swedish white-collar employees. *J Epidemiol Community Health* 2006;60:1070–1076
- Evertsson M, Neremo M. Dependence within families and the division of labor: comparing Sweden and the United States. *J Marriage Fam* 2004;66:1272–1286
- Eriksson A-K, Ekblom A, Hilding A, Östenson C-G. The influence of non-response in a population-based cohort study on type 2 diabetes evaluated by the Swedish Prescribed Drug Register. *Eur J Epidemiol* 2012;27:153–162