Work Stress and Low Sense of Coherence Is Associated With Type 2 Diabetes in Middle-Aged Swedish Women

Epidemiology/Health Services/Psychosocial Research

ORIGINAL ARTICLE

Emilie E. Agardh, RN, MPH
Anders Ahlbom, PhD
Tomas Andersson, BSc
Suad Efendic, MD, PhD
Valdemar Grill, MD, PhD
Johan Hallqvist, MD, PhD
Anders Norman, MD
Claes-Göran Östenson, MD, PhD

OBJECTIVE — The risk of type 2 diabetes is suggested to be increased for individuals exposed to stress. We analyzed the association of work stress by high demands, low decision latitude, and job strain (combination of high demands and low decision latitude) with type 2 diabetes. We also studied low sense of coherence (SOC) (a factor for successful coping with stressors) in association with type 2 diabetes. Finally, we investigated the combination of SOC and demands or SOC and decision latitude in association with the disease.

RESEARCH DESIGN AND METHODS — This cross-sectional study recruited 4,821 healthy Swedish women (aged 35–56 years) residing in five municipalities in the Stockholm area. An oral glucose tolerance test identified 52 women with type 2 diabetes. Relative risks (RRs) with 95% CIs were estimated in a logistic multiple regression analysis.

RESULTS — No association was found between high demands and type 2 diabetes (RR 1.1 [CI 0.5–2.2]). Low decision latitude was associated with type 2 diabetes with a RR of 2.2 (1.0–4.8). The RR of type 2 diabetes with low SOC was 3.7 (1.2–11.2). The combination of low SOC and low decision latitude was associated with type 2 diabetes with a RR of 2.6 (1.2–5.7). Homeostasis model assessment revealed an association of 4.2 (1.2–15.0) between low SOC and insulin resistance.

CONCLUSIONS — This study provided new evidence that stress factors such as low decision latitude at work and low SOC were associated with type 2 diabetes in middle-aged Swedish women. Diabetes Care 26:719–724, 2003

A n activation of the hypothalamo-pituitary-adrenal (HPA) axis and the central sympathetic system has been proposed to be responsible for the development of endocrine perturbations, leading to obesity and type 2 diabetes. Hence, psychosocial stress causes insulin resistance via psychoendocrine pathways (1,2). In addition, increased levels of stress hormones, e.g., catecholamines and glucocorticoids, may impair insulin secretion (3). The risk is specifically evident in genetically susceptible individuals exposed to perceived environmental psychosocial stress (2). A job stress model, the psychological demand-decision latitude model, introduced by Karasek and colleagues (4,5), has been developed for measuring the impact of work stress on the risk of illness. The combination of high demands and low decision latitude, referred to as job strain, increases the risk of coronary heart disease (5–7). Another parameter, sense of coherence (SOC), developed by Antonovsky (8), is suggested to be an important factor in successful coping with stressors and also for maintenance of health. A person with low SOC is more likely to deal unsuccessfully with stressors (8,9). However, to our knowledge there is no published study on the significance of work stress or SOC in association with type 2 diabetes. The aim of our study was to examine the association of self-reported high demands, low decision latitude, job strain, and low SOC with type 2 diabetes in middle-aged Swedish women. Furthermore, the combination of SOC and demands or SOC and decision latitude was studied.

RESEARCH DESIGN AND METHODS

Selection
The present part of the baseline study of the Stockholm Diabetes Prevention Program consists of 4,821 Swedish women, born between 1942 and 1961, residing within five municipalities, Sigtuna, Upplands Vasby, Värmdö, Upplands Bro, and Tyreso, situated on the outskirts of Stockholm. The women were identified through the Stockholm County Council register, and the data collection was carried out between 1996 and 1998.

The selection of subjects was performed in a two-step procedure (Fig. 1). First, a short questionnaire containing questions about country of birth, diabetes diagnosis, and family history of diabetes (FHD) was sent to all women living within the five municipalities in the appropriate age-groups (35–56 years). From a total of 19,416 postal questionnaires returned, a short questionnaire containing questions about country of birth, diabetes diagnosis, and family history was sent to all women living within the five municipalities in the appropriate age-groups (35–56 years).
naires, 16,481 (85%) completed questionnaires were returned after two reminders were sent by mail. At this stage, 8,178 (49%) were excluded due to insufficient knowledge of FHD and incomplete responses \( (n = 6,330) \) or as a result of already-known diabetes, foreign origin, unclear FHD, mental retardation, death, or the person moving out of the municipality \( (n = 1,848) \).

In the second step, the remaining 8,303 women were divided into three groups, consisting of 3,583 women with FHD, 4,296 without FHD, and 424 with gestational diabetes. All women with FHD were asked to participate in a physical health examination, along with 3,497 randomly selected women without FHD but who were matched to the first group according to age and municipality. All women with gestational diabetes were also invited.

From a total of 7,504 women, 4,946 (66%) completed the health examination. Women at this stage were excluded because they had no wish to participate, because they were not available, or due to death \( (n = 2,092) \). The study size was also limited due to financial reasons by excluding one-third of all women born between 1952 and 1961 from the 23rd to the 31st in every month, i.e., 466 women. At the primary health care center examination, an oral glucose tolerance test (OGTT) was administered and weight, height, waist and hip circumferences, and blood pressure were measured. In addition, the women responded to a detailed questionnaire with \( >120 \) questions about lifestyle factors that could be of importance for the risk of type 2 diabetes and impaired glucose tolerance (IGT). After the examination, 129 (2%) were excluded due to breast-feeding, pregnancy, certain medication, uncertain heredity, or foreign origin. Four women had mistakenly been reported as excluded at some time point; therefore, the study population consisted of 4,821 women.

**Design**

This case-control study derives from a cross-sectional study design. Women with normal glucose tolerance were used as the control group. Women with IGT were excluded for further analysis. When adjusting for confounders, risk factors such as FHD, waist-to-hip ratio (WHR), BMI, smoking habits, and physical inactivity were analyzed.
and a 2-h value of 7.8–mulas were slightly modi-
ing insulin sensitivity) was calculated as fast-
model assessment (HOMA) (13). HOMA
culated according to the homeostasis
women with type 2 diabetes. This was cal-
cose intolerance, insulin resistance and
ples were treated equally.
study period. By doing so, all blood sam-
these were changed (11,12) during the
for plasma glucose, due to the fact that
was based on
Evaluation of self-reported work stress
Psychosocial stress factors

Table 1—RRs and 95% CIs for demands, decision latitude, and job strain (high demands in combination with low decision latitude) in association with type 2 diabetes

<table>
<thead>
<tr>
<th>Demands</th>
<th>Control Subjects (n)</th>
<th>Diabetic Subjects (n)</th>
<th>Demands and decision latitude in separate analysis [RR (95% CI)]</th>
<th>Demands and decision latitude mutually adjusted [RR (95% CI)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>1,155</td>
<td>14</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Middle</td>
<td>1,748</td>
<td>14</td>
<td>0.7 (0.3–1.4)</td>
<td>0.7 (0.3–1.5)</td>
</tr>
<tr>
<td>High</td>
<td>1,396</td>
<td>16</td>
<td>1.0 (0.5–2.0)</td>
<td>1.1 (0.5–2.2)</td>
</tr>
<tr>
<td>Decision latitude</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>1,376</td>
<td>9</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Middle</td>
<td>1,463</td>
<td>23</td>
<td>1.6 (0.7–3.7)</td>
<td>1.6 (0.7–3.7)</td>
</tr>
<tr>
<td>Low</td>
<td>1,462</td>
<td>12</td>
<td>2.1 (1.0–4.7)</td>
<td>2.2 (1.0–4.8)</td>
</tr>
<tr>
<td>Job strain</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High demands/low decision latitude</td>
<td>377</td>
<td>7</td>
<td>2.1 (0.8–5.2)*</td>
<td>2.1 (0.8–5.2)*</td>
</tr>
</tbody>
</table>

All analysis are controlled for age (35–40, 41–46, 47–51, and 52–56 years). *Adjusted for physical inactivity (high/low).

Classification of type 2 diabetes and IGT
The 75-g OGTT was performed according to the World Health Organization criteria (10). Diabetes was classified when fasting plasma glucose was ≥7.8 mmol/l and/or a 2-h value ≥11.1 mmol/l and IGT when fasting plasma glucose was <7.8 mmol/l and a 2-h value of 7.8–11.0 mmol/l. We chose to use the old classifications established by the World Health Organization for plasma glucose, due to the fact that these were changed (11,12) during the study period. By doing so, all blood samples were treated equally.

For a more detailed analysis of glucose intolerance, insulin resistance and β-cell function were analyzed among women with type 2 diabetes. This was calculated according to the homeostasis model assessment (HOMA) (13). HOMA (insulin sensitivity) was calculated as fasting insulin × fasting glucose and HOMA (β-cell function) as fasting insulin/ (fasting glucose − 3.5). The original formulas were slightly modified by removal of constants 20 (β-cell function) and 22.5 (insulin resistance), as previously suggested (14). HOMA (insulin resistance) was defined from values in the highest tertile (≥59.41) and HOMA (β-cell function) from values in the lowest tertile (≤7.58).

Psychosocial stress factors
Evaluation of self-reported work stress was based on five questions on work demands and five questions on decision latitude. These questions were obtained from the well-established Swedish version of the Karasek & Theorell demand-decisions latitude questionnaire (4,6). 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?”, but had a similar question: “Do you have the freedom to decide what 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, and job strain is the combination of high demands and low decision latitude (7).

Separate analyses were performed for demands and decision latitude. An index on each 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 scores among all respondents, cutoff groups were created from the upper, median, and lower quartiles. The upper quartile was defined as high demands or high decision latitude, the lower quartile as low demands or low decision latitude, and those in between the upper and lower quartile as middle demands or middle decision latitude.

For job strain, the quartile with high demands and the quartile with low decision latitude were combined and regarded as exposed to job strain. Those with low and middle demands and high and middle decision latitude were combined and regarded as unexposed.

Self-reported SOC was based on three questions on sense of comprehensibility, meaningfulness, and manageability. The original measurement tool is a 29-item questionnaire based on the three dimensions of comprehensibility, meaningfulness, and manageability (8). It was not possible, however, in our study to use the original tool due to an already overextensive questionnaire. Instead, we used a simplified way of measuring SOC that has been previously recommended (15) and is suggested to capture the essence of the three dimensions of SOC.

For the purpose of analysis, an index was created from the three questions. The responding alternative “yes usually” scored 3 points, “yes sometimes” scored 2 points, and “no” scored 1 point. The question on comprehensibility was also scored in the reverse order.

The index of summed scores among all respondents was then divided into four groups with regard to the percentage distribution. Those with scores of 9 points (18.9% of all women) were defined as having a high SOC, whereas those with scores ≤6 points were defined as having a low SOC (20.76% of all women).

To obtain the combination between SOC and demands or decision latitude, the three cutoff groups from demands and latitude decision latitude, respectively, were analyzed in combination with the four cutoff groups from SOC. The combination was calculated as in the demand-decision latitude model, meaning that the quartile with high demands or low decision latitude and low
Work stress and type 2 diabetes

Table 2—RRs and 95% CIs for SOC in association with type 2 diabetes

<table>
<thead>
<tr>
<th>SOC</th>
<th>Control Subjects (n)</th>
<th>Diabetic Subjects (n)</th>
<th>SOC risk for type 2 diabetes [RR (95% CI)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>870</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Upper middle</td>
<td>1,386</td>
<td>15</td>
<td>2.4 (0.8–7.4)</td>
</tr>
<tr>
<td>Lower middle</td>
<td>1,403</td>
<td>18</td>
<td>3.0 (1.0–9.0)</td>
</tr>
<tr>
<td>Low</td>
<td>938</td>
<td>15</td>
<td>3.7 (1.2–11.2)</td>
</tr>
</tbody>
</table>

All analysis are controlled for age (35–40, 41–46, 47–51, and 52–56 years).

SOC were regarded as exposed and the rest as unexposed.

Potential confounders
BMI (kg/m²) was divided into four groups (≥24.9, 25.0–27.9, 28.0–29.9, and ≥30), and WHR was defined as high (≥0.8) or low (<0.8). Physical activity was analyzed based on the question regarding how physically active the person had been during the previous year. There were four responding alternatives, including low exercise activity, moderate exercise, moderate regular exercise, and regular exercise and training. In the analysis, low and moderate exercise were combined and regarded as low physical activity. Smoking habits were categorized as smokers or nonsmokers (nonsmokers included previous smokers). FHD was defined as having at least one first-degree relative (mother, father, sister, or brother) or two second-degree relatives (grandparents, uncles, or aunts) with type 2 diabetes and was categorized as positive or negative.

Statistical analysis
Odds ratios with 95% CIs were estimated in a logistic regression model with dummy variables and interpreted as relative risks (RRs). The potential confounders we checked for in the analysis were FHD, BMI, WHR, smoking, and physical inactivity. The effect of each variable was studied in relation to the outcome of stress variables and disease. A variable was considered as a confounder if the RR in the exposure of interest changed the crude measure in some important way (over ±15%). The variable was used in the final analysis only if the change of the RR in the exposure of interest remained (over ±15%) after adjusting for age. The analyses were computed with the SAS Statistical Program version 8.2 (16).

RESULTS — The OGTT identified 52 women with unknown type 2 diabetes in the analysis of demands, decision latitude, and job strain, eight patients with type 2 diabetes were excluded because of missing information.

High demands at work did not have any influence in the mutually adjusted regression analysis on the RR of type 2 diabetes (1.1 [CI 0.5–2.1]). On the other hand, low decision latitude at work was associated with type 2 diabetes with a RR of 2.2 (1.0–4.8). A combined exposure to high demands and low decision latitude (job strain) had a RR of 2.1 (0.8–5.2), virtually the same as for low decision latitude alone (Table 1).

Women with low SOC were nearly four times as likely (RR 3.7 [CI 1.2–11.2]) to have type 2 diabetes. The results also show an increasing risk with worse SOC (Table 2). When combining SOC with demands, no associations were found (figures not shown). We then looked at different combinations of SOC and decision latitude. The impact of high SOC on low decision latitude resulted in the disappearance of type 2 diabetes risk (RR 1.2 [0.6–2.6]). Similarly, the impact of high decision latitude on low SOC eliminated the risk of type 2 diabetes (RR 0.8 [0.2–2.6]). However, the combination of low SOC and low decision latitude was associated with type 2 diabetes (RR 2.6 [1.2–5.7]) (Table 3).

HOMA analysis was used to assess β-cell function and insulin sensitivity (Table 4). In the diabetic patients, the RR of low decision latitude to be associated with low β-cell function (lowest third) was 2.3 (CI 0.8–6.5) and with insulin resistance (highest third) was 2.0 (0.9–4.7). Low SOC in association with low β-cell function had a RR of 1.5 (0.4–5.1), while the association with insulin resistance had a RR of 4.2 (CI 1.2–15.0). Also, in women with decreasing SOC, there was a tendency for an increased risk of insulin resistance (Table 4).

CONCLUSIONS — This study demonstrates that self-reported low decision latitude at work and low SOC were associated with type 2 diabetes. The demand–decision latitude theory is aiming toward long-term environmental constraints (7), and a person’s SOC develops over time (8). Exposure to long-term stress affects the entire neuroendocrine system, activating the HPA axis and/or the central sympathetic nervous system (17). Increased cortisol levels following activation of the HPA axis could play a role in the development of decreased glucose tolerance. Thus, cortisol has been shown to induce insulin resistance by increasing hepatic glucose production, suppressing glucose usage, and inhibiting insulin secretion (3,18,19). The RR related to low decision latitude and low SOC were preserved even after controlling for other risk factors such as FHD, BMI, WHR, smoking, and physical inactivity. Therefore, it is plausible that effects of low decision latitude and low SOC directly affect glucose tolerance and contribute to the onset of type 2 diabetes. According to the HOMA analysis, an association was dem-

Table 3—RRs and 95% CIs for SOC in combination with decision latitude in association with type 2 diabetes

<table>
<thead>
<tr>
<th>SOC</th>
<th>Decision latitude</th>
<th>Control Subjects (n)</th>
<th>Diabetic Subjects (n)</th>
<th>Combination of SOC and decision latitude [RR (95% CI)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>High</td>
<td>2,389</td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
<td>448</td>
<td>3</td>
<td>0.8 (0.2–2.6)</td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
<td>1,061</td>
<td>11</td>
<td>1.2 (0.6–2.5)</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>401</td>
<td>9</td>
<td>2.6 (1.2–5.7)</td>
</tr>
</tbody>
</table>

All analysis are controlled for age (35–40, 41–46, 47–51, and 52–56 years).
shown between low SOC and insulin resistance, suggesting a more important role of the liver and extrahepatic tissues relative to β-cell function in the development of glucose intolerance.

The impact of demands on the risk of type 2 diabetes was negligible, and low decision latitude and job strain showed an almost similar association with type 2 diabetes. This implies that the effects of job strain could solely be explained by low decision latitude. Similarly, recent publications on cardiovascular disease among men underscore the importance of low decision latitude on the risk for heart disease, while associations with high demands are less consistent (20–24).

Among women, similar trends are found to those in men (20,23,25,26), although fewer studies have been published investigating these associations.

SOC has often been related with the ability to cope with stressful life events, such as severe disease (27,28). In our study, the concept was analyzed as a basic coping resource (8) of handling with stressors without knowledge of a disease. A low SOC, interpreted as a low ability to cope with stressors, was associated with type 2 diabetes. It could be suggested that people with low SOC are more likely to have unhealthy lifestyle patterns, which lead to disease. Thus, as mentioned previously, the associations were not explained by confounding factors and there is, according to Antonovsky (8), a direct relationship between low SOC and physiological consequences affecting health. Our simplified way of measuring SOC by three questions instead of the 29-item questionnaire could put the use of the theory in question. On the other hand, this modified way has been used (29) and tested previously, showing a satisfactory reliability and also discussed to be valid in relation to the original theory (15).

A previous study has concluded that job strain effects should include an interaction with SOC (30). In our analysis of decision latitude and SOC, women were at risk for type 2 diabetes only if they were exposed to both low decision latitude and low SOC. Interestingly, there was no risk for type 2 diabetes if the SOC was high, even if the decision latitude was low. From these observations, it may be concluded that those with low decision latitude are buffered by a high SOC. On the other hand, women with low SOC did not have any risk for type 2 diabetes if the decision latitude was high. Our interpretation of these findings is that high decision latitude could protect against low SOC, while high SOC could protect against low decision latitude. Moreover, if both are present, there could be a joint effect.

There are some methodological issues that may influence our results. First, the women filled in questionnaires about their former lifestyles, which could imply recall bias. However, all women answered the questions without knowing about their blood glucose status. Since both case and control subjects filled in the questionnaire under equal circumstances, possible misclassification should not overestimate the RR. Second, it may be questioned whether diabetes caused the stress. However, women with already known diabetes were excluded from the study and a reversed causation is unlikely, since the women were unaware of their diabetes when answering the questions. In addition, it was apparent from the questionnaire that women with unknown diabetes did not complain more than women without diabetes on having symptoms of illness, such as fatigue (data not shown). Another issue is the possible bias due to the fact that we could only use 10 of the 11 items from the original demand–decision latitude questionnaire. The effect could be random misclassification of exposure to low decision latitude. If anything, this would lead to a slight underestimation of the true association between low decision latitude and type 2 diabetes.

Before this study, there was little epidemiological evidence that environmental stress could contribute to the onset of type 2 diabetes. However, a recent cross-sectional study in the Netherlands has shown that stressful life events, e.g., death of a partner and moving from a house, are associated with the risk of type 2 diabetes (31). Our results provide new evidence that low decision latitude at work and low SOC are associated with type 2 diabetes in middle-aged Swedish women. Whether these associations are similar in men remains an open question and requires further investigation.

**Table 4—RRs and 95% CIs for SOC and decision latitude in association with HOMA (low β-cell function and insulin resistance) in type 2 diabetes**

<table>
<thead>
<tr>
<th>Decision latitude</th>
<th>Normal glucose tolerance (n)</th>
<th>HOMA (β-cell function), lowest third [RR (95% CI)]</th>
<th>HOMA (insulin resistance), highest third [RR (95% CI)]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(n)</td>
<td>(n)</td>
</tr>
<tr>
<td>High</td>
<td>1,376</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Middle</td>
<td>1,463</td>
<td>8</td>
<td>1.5 (0.5–4.5)*</td>
</tr>
<tr>
<td>Low</td>
<td>1,462</td>
<td>13</td>
<td>2.3 (0.8–6.5)*</td>
</tr>
<tr>
<td>SOC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>870</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Upper middle</td>
<td>1,386</td>
<td>7</td>
<td>1.1 (0.3–3.7)</td>
</tr>
<tr>
<td>Lower middle</td>
<td>1,403</td>
<td>10</td>
<td>1.5 (0.5–4.8)†</td>
</tr>
<tr>
<td>Low</td>
<td>9.38</td>
<td>8</td>
<td>1.5 (0.4–5.1)†</td>
</tr>
</tbody>
</table>

All analyses are controlled for age (35–40, 41–46, 47–51, and 52–56 years). *Adjusted for physical inactivity (high/low); †adjusted for smoking and WHR.
References


