Prospective Study of Social and Other Risk Factors for Incidence of Type 2 Diabetes in the Whitehall II Study

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Background: Social inequalities in the incidence of type 2 diabetes and the relation of health behaviors and psychosocial factors to the incidence of type 2 diabetes are not well established.


Results: Participants working in the lower employment grades had a higher incidence of diabetes than those in higher employment grades (men: odds ratio [OR], 2.9; 95% confidence interval [CI], 1.9-4.4; women: OR, 1.7 [95% CI, 0.8-3.7]). Body mass index and other risk factors considered traditional for type 2 diabetes were found to be so in this cohort. In men, of the psychosocial risk factors examined, only effort-reward imbalance was related to incidence of diabetes (OR, 1.7 [95% CI, 1.0-2.8]). The General Health Questionnaire depression subscale was related to incidence of diabetes and impaired glucose tolerance (OR, 1.25 [95% CI, 1.0-1.6]). These associations remained after adjustment for other confounding factors. In men only, social difference in incidence of diabetes was reduced but still significant after adjustment for conventional risk factors.

Conclusions: An inverse relationship exists between social position and incidence of diabetes that is partly explained by health behaviors and other risk factors. Effort-reward imbalance, which is reportedly associated with coronary heart disease, is also associated with type 2 diabetes.

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CARDIOVASCULAR DISEASE IS related to social position and psychosocial factors. Although type 2 diabetes and coronary heart disease (CHD) share a number of common etiologic factors, few studies have investigated the relation of incidence of diabetes to social position or psychosocial factors. Recent studies have reported an increase in prevalence of type 2 diabetes in deprived areas and described a significant inverse relationship between impaired glucose tolerance and grade of employment in the civil service. American adults with type 2 diabetes have less education and lower income compared with those who do not have the disease.

The worldwide prevalence of type 2 diabetes mellitus is very high and increasing. Diabetes is associated with a high risk for microvascular and macrovascular complications and premature death. For prevention purposes, the identification of risk factors for development of diabetes is of great interest. Family history, ethnicity, increased body mass index (BMI) (calculated as weight in kilograms divided by the square of height in meters), and physical inactivity are established risk factors for both type 2 diabetes and CHD. However, the relationship of diabetes with smoking appears unclear. The role that these risk factors play in mediating social inequalities in type 2 diabetes is unclear.

Psychosocial factors such as low job control, low social support, depression, and effort-reward imbalance are now established as risk factors for CHD. However, the association with the onset of type 2 diabetes is not well described. Air traffic controllers with a high-demand job have been reported to have a high prevalence of diabetes and job strain and low social support at work, factors that have been reported to be associated with increased levels of glycosylated hemoglobin among nondiabetic populations. Excessive overtime, suggesting overcommitment to work, has been reported to be...
associated with increased incidence of type 2 diabetes in Japanese men independent of other risk factors.28

The Whitehall II Study was established to examine the causes of the social gradient in mortality and morbidity and therefore enables examination of the relationship between social position and incidence of type 2 diabetes. At baseline, we have data on health behavior and other risk factors for type 2 diabetes, including a number of additional psychosocial risk factors for CHD. This study has the advantage that incidence of new diabetes is established using glucose tolerance tests in addition to clinically diagnosed diabetes. In the present study, we examined the relationship between social position and incidence of type 2 diabetes and whether psychosocial risk factors for CHD are associated with incident type 2 diabetes. In addition, we examined how much these factors contribute to the social gradient in type 2 diabetes.

METHODS

STUDY POPULATION

The recruitment phase (phase 1; 1985-1988) of the Whitehall II Study included 20 London-based civil service departments. The response rate was 73%, but detailed investigation in 1 department showed that 4% of those present on the list of employees had moved before our study, and so the true response rate is likely to have been higher. Follow-up screening examinations occurred in phases 3 (1991-1993) and 5 (1997-1999), and questionnaires were mailed to participants in phases 2 (1989) and 4 (1995). The participation rates at phases 3 and 5 were 83% and 76%, respectively. Demographic and psychosocial characteristics and health and risk factor status of the 10,308 participants at baseline have been described previously.2

MARKERS OF SOCIAL POSITION

The civil service identifies 12 nonindustrial grades on the basis of salary. There was a steep increment in salaries from an annual salary in 1987 ranging from £3061 to £5841 in the clerical and office support grades to £18020 to £62100 in unified grades 1 through 6. Participants reported their civil service grade title, which was assigned to one of these grades. For this report, employment grade is classified into the following 3 categories: administrative (the top 7 unified grades), executive (including senior executive officers, higher executive officers, executive officers, and other professional and technical staff receiving similar salaries), and clerical (including clerical and office support grades). Other indicators of social position were car ownership and housing tenure. Housing tenure was determined by answers to the question “Is the accommodation in which you live owned or rented?” Response categories included “own outright or have mortgage,” “rent from local authority,” “rent privately unfurnished,” and “rent privately furnished.” Material problems were assessed by 4 questions on financial, housing, and neighborhood difficulties.20

CORONARY RISK FACTORS

Family history of diabetes mellitus was assessed at baseline using the questions “Has either of your parents suffered from diabetes?” and “Do any of your siblings suffer from diabetes?” The percentage of participants with a family history of diabetes was 11%. Ethnic group was defined by observer (at phase 1) and self-report (at phase 5 follow-up). At phase 1 screening, a study team member classified all participants as white European, South Asian, Afro-Caribbean, Chinese, other, or uncertain. At phase 5, 7204 participants self-assigned their ethnicity, on the basis of 9 categories used in the English 1991 census, as black African, black Caribbean, black other, Indian, Pakistani, Bangladeshi, Chinese, white, and other. The 2 definitions of ethnic group showed excellent agreement, with a κ of 0.85 (93% confidence interval [CI], 0.83-0.87). In this report, self-reported ethnicity is used where available and observer-assigned ethnicity otherwise. There were 9162 white, 560 South Asian, and 368 Afro-Caribbean participants; 98 of other ethnicity; and 120 with missing data on ethnic group.

Data on cigarette smoking and physical activity were obtained by means of questionnaire at phase 1. Smoking behavior was grouped as never smokers, ex-smokers, and current smokers. Alcohol consumption in the previous week was grouped into 5 categories based on sensible drinking recommendations. The following 3 categories of physical activity were created: vigorous (subjects who reported ≥1.5 h/wk of vigorous activity), moderate (subjects who reported ≥1.5 h/wk of moderate activity but <1.5 h/wk of vigorous activity), and none/mild (subjects who reported <1.5 h/wk of vigorous or moderate activity). A healthy diet indicator (scored 0-3) was constructed on the basis of questions about type of bread and milk used and frequency of consuming fruit and vegetables. A score of 3 indicated the healthiest diet consisting of wholemeal, granary, or wheat-mead bread; skim or semiskim milk; and at least daily consumption of fresh fruits or vegetables. In this report, scores of 0 or 1 on the healthy diet indicator were classified as a poor diet and scores of 2 or 3 were classified as a good diet. Height and weight were recorded, and BMI was calculated. Body mass index was subdivided into underweight (<20), normal weight (20.0-24.9), overweight (25.0-29.9), and obese (≥30). Diastolic and systolic blood pressure were obtained and hypertension defined as diastolic blood pressure greater than or equal to 95 mm Hg, systolic blood pressure greater than or equal to 160 mm Hg, or use of drugs to lower blood pressure.

PSYCHOSOCIAL WORK CHARACTERISTICS

Effort-reward imbalance conceptualizes psychosocial stress at work in terms of an imbalance between efforts and rewards as developed by Siegrist.30 High efforts spent and low rewards received are hypothesized to result in emotional distress and adverse health effects. In a previous Whitehall II Study analysis, an indicator of effort-reward imbalance was constructed that had the following 3 categories: neither high effort nor low reward (category 1), either high effort or low reward (category 2), and both high effort and low reward (category 3). High efforts were defined as competitiveness and work-related overcommitment or hostility. Low rewards were defined as poor promotion prospects or a blocked career. Questions to measure dimensions of the job-strain model based on the Karasek and Theorell Job Content Instrument were included at phase 1.19,31 These include decision latitude and job demands with an additional dimension of social support. Fifteen items dealt with decision authority and skill discretion, and these were combined into an index of decision latitude.17,32 Social support at work, measured by 6 items, is made up of the following 3 types: support from colleagues, support from supervisors, and consistency of information from supervisors. The job-strain scales were divided into tertiles.

SOCIAL SUPPORTS AND NETWORKS

Three types of social support (confiding/emotional, practical, and negative aspects of close relationships) were measured from questions about support received from the person nominated as closest on the Close Persons Questionnaire.33 Social net-
works were measured using questions derived by Berkman and Syme. The network measures were summarized on a scale measuring the network beyond the household, which includes frequency of contact and number of contacts with friends and relatives and participation in social groups.

**PSYCHIATRIC MORBIDITY**

Minor psychiatric disorder, mainly anxiety and depression, was defined as a score of 5 or more on the 30-item General Health Questionnaire. Factor analysis of the General Health Questionnaire allowed identification of a depression subscale with scores divided into ranges of 0 to 3 and 4 or greater.

**LIFE EVENTS**

Life events in the past 12 months were based on questions about serious personal illness, death of a close relative or friend, illness of a close relative or friend, major financial difficulty, divorce, separation or break of a personal intimate relationship, other marital or family problem, and experience of a mugging, robbery, accident, or similar event. The number of these events were grouped as 0, 1, and 2 or more.

**DIABETES**

Diagnosis of type 2 diabetes mellitus was made according to the World Health Organization definition. The occurrence of type 2 diabetes during the follow-up was assessed on the basis of self-reported diabetes at phases 2, 3, 4, and 5. Participants were asked “Do you suffer from diabetes?” at phases 1, 2, and 3, and “Has a diabetes during the follow-up was assessed on the basis of self-reports.”

**STATISTICAL ANALYSIS**

Logistic regression was used to examine the association of risk factors with incidence of diabetes. Results are expressed as odds ratios (ORs) together with their 95% CIs. Incident cases of diabetes could be identified at phase 3 or phase 5, so an adjustment for length of follow-up was included in all analyses. All analyses were performed separately for men and women and adjusted for age using 5-year bands.

We first ran analyses examining the association between psychosocial risk factors and incidence of diabetes with adjustment for age, length of follow-up, employment grade, and ethnic group. Then we ran models with additional adjustments for other potential confounding factors, including family history of diabetes, BMI, height, systolic blood pressure, presence of electrocardiographic abnormalities, exercise, smoking, and life events. These analyses included participants with complete data on all these variables.

**RESULTS**

After an average of 10.5 years of follow-up, 4% of participants (242 men and 119 women) were classified as incident cases of diabetes by phase 5. The rate of new diabetes was 3.8 per 1000 person-years in men and 4.3 per 1000 person-years in women.

**Table 1** shows that there was an increased incidence of type 2 diabetes in male and female participants working in lower employment grades and with increasing material problems. Although there was a tendency for increased incidence of diabetes in male participants living in council-rented accommodations, no relationship was apparent for women. In men with no access to a car, there was an increased incidence of diabetes, but again this association was not apparent for women.

**Table 2** shows the relationship between conventional risk factors and incidence of diabetes after adjustment for age, length of follow-up, employment grade, and ethnic group and after additional adjustment for the other conventional risk factors. As anticipated, there was a relationship between parental history of diabetes and incidence of new diabetes. This association was robust to adjustment for other confounders including BMI, systolic blood pressure, exercise, and smoking in men. There was also an association with diabetes in siblings. This association was somewhat reduced after adjustment for other baseline risk factors. Ethnicity was associated with incidence of diabetes with increased incidence in South Asian and Afro-Caribbean men. After adjustment for additional risk factors, South Asian and Afro-Caribbean men had a greater than 2-fold increase in incidence of diabetes compared with Europeans. Although not always reaching statistical significance, the pattern of results was similar in women to that described in men.

### Table 1. Age-Adjusted Odds Incidence of Type 2 Diabetes Mellitus by Measures of Social Position*

<table>
<thead>
<tr>
<th>Measure (No. of Men/Women)</th>
<th>Men, % (95% CI)</th>
<th>Women, % (95% CI)</th>
</tr>
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<tbody>
<tr>
<td><strong>Civil service employment grade</strong> (5950/2534)</td>
<td></td>
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<tr>
<td>Administrative 3 1.00 2 1.00</td>
<td></td>
<td></td>
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<tr>
<td>Executive 4 1.53 (1.1-2.1) 4 1.38 (0.6-3.0)</td>
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<tr>
<td>Clerical 9 2.93 (1.9-4.4) 7 1.72 (0.8-3.7)</td>
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<tr>
<td><strong>Housing tenure</strong> (5913/2647)</td>
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<tr>
<td>Owner occupied 4 1.00</td>
<td>4 1.00</td>
<td></td>
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<tr>
<td>Council rented 7 1.58 (0.9-2.9) 4 0.71 (0.4-1.3)</td>
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<tr>
<td>Private rented 4 0.79 (0.3-2.2) 3 0.45 (0.1-1.4)</td>
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<tr>
<td>Other 5 1.21 (0.5-2.8) 4 1.00 (0.2-4.2)</td>
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<tr>
<td><strong>Car ownership</strong> (5936/2663)</td>
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<tr>
<td>Yes 4 1.00 5 1.00</td>
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<tr>
<td>No 6 1.63 (1.2-2.3) 4 0.82 (0.5-1.3)</td>
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<tr>
<td><strong>Material problems</strong> (5700/2534)</td>
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<td></td>
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<tr>
<td>Low 4 1.00</td>
<td>3 1.00</td>
<td></td>
</tr>
<tr>
<td>Medium 4 1.14 (0.8-1.6) 6 1.77 (1.1-2.8)</td>
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<tr>
<td>High 5 1.39 (1.0-1.9) 5 1.56 (1.0-2.5)</td>
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</tbody>
</table>

Abbreviations: CI, confidence interval; OR, odds ratio.

*Based on the World Health Organization definition of a 2-hour glucose tolerance test finding of at least 200 mg/dL (≥11.1 mmol/L) or, if the 2-hour postload value was missing, a fasting glucose level of ≥126 mg/dL (≥7.0 mmol/L). Measurements were obtained during a mean of 10.5 years of follow-up.

†Adjusted for age and length of follow-up.
Overweight (BMI, 25.0-29.9) and obese men and women (BMI, >30) were at increased risk of diabetes, with ORs of 5.34 and 4.03, respectively, compared with participants in the normal BMI range during phase 1. There was an association between continuous BMI score and incidence of diabetes. Hypertension was also associated with increased risk for diabetes in men and women. These effects remained after adjustment for the other risk factors. Height was also associated with incidence of diabetes independent of the other risk factors in men. Thus, increased height was associated with decreased incidence of diabetes independent of employment grade, ethnicity, family history of diabetes, BMI, systolic blood pressure, exercise, and smoking. Similar trends were apparent in women but did not reach significance.

Lifestyle factors were associated with the incidence of diabetes in the expected direction. Vigorous exercise was associated with reduced risk of diabetes compared with no exercise in men. This association remained after adjustment for additional risk factors. Smoking was not associated with the incidence of diabetes in men. Data in women were similar to those in men but did not reach statistical significance. Poor diet had a trend toward increased incidence of diabetes in men (OR, 1.33 [95% CI, 0.9-1.8]; n=4363) and women (OR, 1.12 [95% CI, 0.7-1.8]; n=1873). Alcohol consumption was not related to incidence of diabetes in men or women (results not shown).

The relationships between work and nonwork psychosocial factors and incidence of type 2 diabetes are shown in Table 3. Effort-reward imbalance was associated with incidence of type 2 diabetes independent of the established risk factors in men (OR, 1.71 [95% CI, 1.0-2.8]) but not in women. However, the interaction between sex and effort-reward imbalance was not significant in the model adjusted for age, follow-up, and ethnicity (P=.16 for interaction term) or in the model adjusted for additional variables (P=.20 for interaction term). The work characteristics decision latitude, job demands, and social supports were not related to incidence of diabetes in men or women (results not shown).
idence of diabetes in men or women. Additional psychosocial risk factors for CHD were also not related to incidence of diabetes. Thus, the depression subscale of the General Health Questionnaire was not associated with incidence of diabetes in men or women. However, when those with new incidence of impaired glucose tolerance were included in the analyses, a relationship was apparent with the depression subscale in men (OR, 1.25 [95% CI, 1.0-1.6]). This relationship was still apparent after adjustment by the additional risk factors examined (OR, 1.27 [95% CI, 1.0-1.6]). The number of life events showed a tendency for increased incidence of diabetes in men (OR, 1.20 [95% CI, 0.9-1.7]) and women (OR, 1.27 [95% CI, 0.8-2.1]). In women this trend appeared to be nonlinear. Marital status and types of social support received outside work (ie, emotional/confiding, practical and negative aspects of close relationships) were not related to incidence of diabetes (results not shown).

Examination of whether the association between employment grade and incidence of diabetes could be explained by any of the risk factors is shown in Table 4. The trend for increased diabetes in male participants working in the lower employment grades remained significant after adjustment for ethnicity, family history of diabetes, height, systolic blood pressure, BMI, physical activity, and smoking (OR, 1.65 [95% CI, 1.0-2.6]). Further adjustment for effort-reward imbalance reduced the OR to 1.52 (95% CI, 0.9-2.4). This, however, did not hold true for women, for whom any trend that was apparent before adjustment for these factors disappeared (OR, 1.01; 95% CI, 0.4-2.3). Additional adjustments for work psychosocial factors did not alter the ORs for employment grade in men or women.

**COMMENT**

We have demonstrated that there is a social gradient in incidence of type 2 diabetes in middle-aged men and women in white-collar occupations. In addition, we show that effort-reward imbalance is associated with incidence of type 2 diabetes in men only. Factors considered conventional risk factors for diabetes were shown to be so in this cohort. The association between effort-reward imbalance and incidence of type 2 diabetes was independent of these risk factors. The relationship between social position, measured by employment grade in the civil service, was also not fully explained by these risk factors in men, with the OR for clerical vs top administrative grades reduced from 3.0 before adjustment to 1.6 after adjustment.

To our knowledge, there are no previous reports of incidence of type 2 diabetes and social position.
evidence has been reported of prevalence of diabetes and measures of social position with increased type 2 diabetes in deprived areas, although this is not always the case. We found that material problems are related to the incidence of diabetes in men and women. We also found increased prevalence of diabetes, glucose intolerance, and metabolic syndrome in participants who work in lower employment grades in the British civil service, and education was inversely related to risk for metabolic syndrome in women. Conventional risk factors for CHD explained the relationship between social position and incidence of type 2 diabetes in women. In men, the relationship remained significant after adjustment for these and additional factors, including the appropriate psychological risk factors. The sex differences observed may be due to smaller numbers of women included in our study.

Our data accord with those of other studies in that family history, ethnicity, increased BMI, physical inactivity, BMI, and hypertension were all predictive of incidence of diabetes, whereas smoking was not. Vigorous physical activity was protective of diabetes, in agreement with findings from intervention studies that seek to reduce weight and increase physical activity. Thus, all the factors that we would expect to be predictors of diabetes are in this cohort, suggesting that the findings are concordant with those of other studies and can be generalized.

We observed a relationship with height for men and women that was independent of other risk factors, which may suggest that early-life environment effects are important in determining onset of diabetes. Previously, leg length has been demonstrated to be associated with type 2 diabetes, suggesting a causal role for infant nutrition. However, the father’s social class was not related to incidence of diabetes. The relationship between prevalence of diabetes and height has been described in men and women, and a recent prospective study described a relationship between smaller height and incidence of type 2 diabetes in women but, unlike our findings, not in men. The explanation for this relationship seems unclear. It has been suggested that the effect may be mediated by underlying insulin resistance, which could be a consequence of a poor intrauterine environment that in turn is predictive of type 2 diabetes. Insulin is anabolic and as such, insulin resistance may prevent the attainment of height potential. A report has suggested a genetic link between height and type 2 diabetes; however, this is controversial.

Effort-reward imbalance was related to incidence of diabetes, but the other psychosocial risk factors for CHD we examined did not suggest that overall incidence of diabetes was weakly related to the psychosocial factors examined. These data accord with previous reports that low control in the workplace is not related to diabetes prevalence or incidence. The relationship between the progression of diabetes and psychosocial risk factors for CHD is not examined herein.

The only psychosocial risk factor for CHD to show a relationship with incidence of diabetes is effort-reward imbalance. In addition, General Health Questionnaire–defined depression was related to the incidence of impaired glucose tolerance and diabetes. The effort-reward imbalance scale used contains a number of constructs, including hostility and overcommitment to work, and has previously been related to poor physical and psychological functioning. Although the relationship between effort-reward imbalance and diabetes has not been examined previously, a relationship between overtime and incidence of diabetes has been described in Japanese men, in whom overtime is a public health concern because it is thought to be a cause of stress-related cardiovascular episodes. Separate analyses of the relationship between incidence of diabetes and efforts and rewards did not result in a stronger relationship than for effort-reward imbalance. Hostility was also not related to incidence of diabetes.

The relationship with effort-reward imbalance was robust to adjustment for the additional cardiovascular risk factors we examined, which makes it unlikely that it is mediated through changes in behaviors such as diet or physical activity. It is possible that effort-reward imbalance is related to aspects of food intake and physical activity not captured in this study. For example, it might
be envisaged that work overcommitment predisposes individuals to unusual eating patterns that cannot be examined in this study. Effort-reward imbalance is associated with a number of cardiovascular disease risk factors, including hypertension and ratio of cholesterol level to high-density lipoprotein cholesterol level. However, adjustment for blood pressure failed to markedly alter the association between effort-reward imbalance and diabetes, suggesting that additional mechanisms are in play. The relationship between the depression subscale and impaired glucose tolerance might suggest a direct stress mechanism that requires further investigation.

Limitations of this study need to be considered. Confounding by loss to follow-up (when participants withdrew from the study or could not be located) would result in underestimation of the effect with social position and psychosocial factors, as there has been greater loss to follow-up in participants from the lower employment grades. These participants are more likely to have greater effort-reward imbalance and greater rates of diabetes. However, effort-reward imbalance at baseline was not associated with subsequent loss to follow-up. The incidence of diabetes in this population was 2.4 per 1000 person-years, which is high compared with studies that report clinically diagnosed diabetes but is comparable to reported incidence when measured by a glucose tolerance test, and may reflect undiagnosed diabetes. Although we did not ask our participants to discriminate between types 1 and 2 diabetes, we are unlikely to have many misclassified cases of diabetes, because incidence of type 1 diabetes mellitus tends to be in those younger than 35 years. Participants reporting diabetes at phase 1 (aged 35-55 years) were removed from the analyses. However, incidence of diabetes needs to be interpreted with caution, because a glucose tolerance test was not administered at baseline, potentially leading to the inclusion of undetected prevalent diabetes in the incident cases. It is unlikely that this inclusion would be biased, as diabetes at early stages is asymptomatic and participants would be unaware of the disease.

One limitation of our study is that our baseline measure of effort-reward imbalance did not include the complete set of questions suggested in the original formulation of this model. However, core notions of the model are reflected in our measure. Thus, it may be reasonable to assume that our restricted measure may underestimate an association of effort-reward imbalance with incident diabetes.

CONCLUSIONS

Our data indicate that a social gradient exists in incident diabetes in a relatively healthy working population. In this middle-aged cohort of men and women in whom conventional risk factors for diabetes were confirmed, effort-reward imbalance was associated with incidence of type 2 diabetes. The employment grade gradient apparent for incidence of diabetes was fully explained by conventional risk factors in women but not in men. These findings indicate that additional factors may be involved in mediating the relation of type 2 diabetes mellitus and social position.