The association between lack of sleep, low vitality and impaired glucose tolerance: a Swedish cross-sectional study

Susanne Andersson, RN, PhD \textsuperscript{1,2}, Inger Ekman, RN, PhD \textsuperscript{1,3}, Febe Friberg, RN, PhD \textsuperscript{1,4}, Erik Bøg-Hansen, MD, PhD \textsuperscript{5} \cdot Ulf Lindblad, MD, PhD \textsuperscript{5}

\textsuperscript{1} Institute of Health and Care Sciences, The Sahlgrenska Academy of the University of Gothenburg, Gothenburg, Sweden

\textsuperscript{2} School of Life Sciences, University of Skövde, Sweden, P.O. Box 408, 54128 Skövde, Sweden

\textsuperscript{3} University of Gothenburg, Centre for Person-Centred Care (GPCC), P.O. Box 457, 405 30 Gothenburg, Sweden

\textsuperscript{4} Faculty of Social Sciences, Department of Health, University of Stavanger, Norway

\textsuperscript{5} Institute of Medicine, Department of Primary Health Care, The Sahlgrenska Academy of the University of Gothenburg, Gothenburg, Sweden

Address for correspondence: ulf.lindblad@allmed.gu.se, The Department of primary health care, University of Gothenburg, Box 154, 405 30 Gothenburg, Sweden Tel: +46 (0)31 786 6831

Word account abstract: 257, main text 2763
ABSTRACT

Background

The increased incidence of impaired glucose tolerance (IGT), are serious public health issues, and several studies link sleeping disorders with increased risk of developing type 2 diabetes, impaired glucose tolerance and insulin resistance (IR). This study explore how self-reported lack of sleep and low vitality, are associated with IGT in a representative Swedish population.

Methods

A cross-sectional survey conducted in two municipalities in South-western Sweden. Participants aged 30-75 were randomly selected from the population in strata by sex and age. Altogether, 2,816 participants were surveyed with a participation rates at 76%. Participants with normal glucose tolerance (n=2,314), and those with IGT (n=213) were retained for analyses. The participants answered a questionnaire before the oral glucose tolerance test (OGTT). Associations for questions concerning sleeping disorders, vitality and IGT were analysed using logistic regression and were expressed as odds ratios (OR) with 95% CI.

Results

In men a statistically significant age-adjusted association was found between self-reported lack of sleep and IGT: OR 2.4 (95% CI: 1.1-5.4). It did not weaken after further adjustment for body mass index (BMI), smoking, education, and leisure time physical activity 2.3 (1.0-5.5, p=0.044). No such associations were found in females. Corresponding age-adjusted associations between low vitality and IGT in both men 2.8 (1.3-5.8), and women 2.0 (1.2-3.4) were successively lost in men with increasing adjustment, but remained in women; 1.8 (1.0-3.2, p=0.048).

Conclusions
Insufficient sleep and low vitality seem independently associated with IGT in men and women, respectively. IGT should be considered in patients presenting these symptoms, and underlying mechanisms further explored.

**Key words**

*Impaired Glucose Tolerance, fatigue, sleeping disorders, health conversation, primary health care*
Background

The increased incidence of impaired glucose metabolism (IGM) [1, 2] and its association with vascular complications [3] are serious public health issues. Usually, type 2 diabetes is preceded by a period of hyperinsulinemia as a consequence of insulin resistance (IR), impaired glucose tolerance (IGT) and/or impaired fasting glucose (IFG) [4]. Individuals with IFG have predominantly an increased hepatic insulin resistance and differ from those with IGT who primarily have insulin resistance in skeletal muscle [5]. Estimates predict that 60% of people who develop diabetes have IGT or IFG about 5 years earlier [6]. Sleeping disorders have adverse consequences on multiple systems [7] and several studies link sleeping disorders with IGM and increased risk of developing type 2 diabetes, IGT and IR [8-10]. The causal effects of sleep disorders and the underlying pathophysiological mechanisms involved have not been fully elucidated [11] and the association between diabetes, obesity and sleep disorders may be described as a vicious circle [12].

However, the question remains if the experience of not getting enough sleep to feel thoroughly rested is causally related to the underlying pathophysiological mechanisms in the development of IGT. The feeling of not being fully rested may also be connected to the feeling of low vitality, and fatigue may be one way to express this [13]. Interestingly, we have previously found that people with IGT similarly describe fatigue as abnormal day time sleepiness that increases the need for rest and a feeling of not being as strong as before [13]. An International Diabetes Federation expert committee also recommends professionals consider that patients with IGM may also suffer from sleeping disorders, low vitality and fatigue, and vice versa [14].

In order to better identify characteristics of people who are susceptible to developing type 2 diabetes, it is important to be aware of symptoms that are associated with IGT. Accordingly,
this study aimed to investigate the association of self-reported lack of sleep and low vitality in relation to IGT in a representative Swedish population.

Methods

Study population

The present study is a cross-sectional survey carried out in 2002-2005 in two municipalities in South-western Sweden. Skaraborg County is located in the southwest of Sweden and in the year 2000 had approximately 270,000 inhabitants. About half the population lives in urban areas and the other half in more rural parts. The vast majority have lived in Sweden for generations and only a few percent are immigrants from countries outside Scandinavia. Within the Skaraborg Project a survey was conducted in 2002-2005 in the municipalities of Vara and Skövde, as previously described in detail (n=2816, with a participation rate of 76%) [15]. The participants aged 30-75 were randomly selected from the population in strata by sex and age. Selected participants were invited by mail to participate in a health survey with two visits. The further selection of the current study population of participants with normal glucose tolerance (NGT) or IGT is shown in Figure 1 (n=2,314, and n=213, respectively).

Study procedures

On the first study visit, specially educated laboratory assistants obtained blood samples in the morning after an overnight fast (10 h). Plasma glucose was analysed at the hospital laboratory at Kärnsjukhuset, Skövde, Sweden. During the OGTT, the participants were asked to answer a questionnaire covering information about medical history, current medications, socio-economic factors, smoking habits, leisure time physical activity (LTPA), self-rated health and sleeping disorders. The question regarding sleeping disorders used for this paper was: Do you think that you get enough sleep to feel thoroughly rested? The participants chose one of three...
alternative answers: 1. Yes, usually. 2. Yes, but not often enough. 3. No, never or almost never. The question regarding symptoms of vitality was: Have you during the last four weeks felt full of vitality? The six reply alternatives were: 1. Yes, all of the time. 2. Yes, most of the time. 3. Yes, a lot of the time. 4. Some of the time. 5. No, almost never. 6. No, not at all. The question was categorized, all/most of the time, a lot of/some of the time and almost never/not at all, in 3 categories. The question regarding LTPA was: How much physical effort do you make in your leisure time? The participants chose one of four alternative answers that were categorised: 1. Reading and sedentary activity. 2. Light ordinary physical activity at least 4 h per week. 3. Moderate physical activity at least 2 h per week. 4. Regular hard training or participation in competitive sports, a couple of times per week. Low physical activity included alternatives 1 and 2, while levels 3-4 were considered physically active.

On the second visit two weeks later, a physical examination was conducted by two specially trained nurses. Supine (5 minute rest), systolic and diastolic (phase V) right brachial arterial pressures were recorded to the nearest 2 mmHg. Body height (to the nearest cm) and body weight (to the nearest 0.1 kg) were also measured, as were the waist and hip circumferences (both to the nearest cm). Body mass index (BMI) was calculated by the formula weight (kg) length^{-2} (m), and waist hip ratio (WHR) by dividing the waist circumference (cm) by the hip circumference (cm).

Current smoking was defined as daily smoking (yes/no). Known diabetes was defined as the participant being sure of the diagnosis of diabetes with a history of regular visits at a diabetes out-patient clinic in primary care or in a hospital. All participants were tested for fasting plasma glucose (FPG), and an OGTT was performed in all patients without a known diagnosis of diabetes. All participants with a screening FPG \( \geq 6.1 \text{ mmol L}^{-1} \) had a second analysis of FPG. In participants with a 2h plasma glucose \( \geq 11.1 \text{ mmol L}^{-1} \) at the OGTT no further analyses were performed. New cases of diabetes were defined as two FPG \( \geq 7.0 \text{ mmol L}^{-1} \) or
one 2h value at OGTT ≥11.1 mmol L⁻¹ according to WHO guidelines [16]. IGT was defined by OGTT as a 2h value at OGTT 7.8-11.0 mmol L⁻¹ and FPG <7.0 mmol L⁻¹ [16]. IFG was accordingly defined as FPG 6.1-6.9 mmol L⁻¹ and a 2h plasma value at OGTT <7.8 1 mmol L⁻¹ [16]. NGT was defined as FPG <6.1 mmol L⁻¹ and a 2h plasma value at OGTT <7.8 mmol L⁻¹ [16]. Two subjects had incomplete OGTT, 19 participants did not answer the question on sleep, and 50 subjects did not respond to the question on vitality. The current study populations thus included 2508 participants (lack of sleep) and 2477 (vitality), respectively (Figure 1).

**Statistical analyses**

Characteristics of participants with IGT were presented using participants with normal glucose metabolism as a reference, using SPSS Base System 19.0 for Windows for data analyses. Continuous variables were presented as age-adjusted means with SD (standard deviation). Differences in means between groups were analysed by GLM (Generalized linear model) and associations between categories were analysed using logistic regression and expressed as odds ratios (OR) with 95% CI. All comparisons between groups were adjusted for differences in age and other covariates were included when indicated. All tests were 2-sided and statistical significance was assumed at p <0.05.

**Ethical approval**

The study was approved by the Regional ethical review board, Gothenburg University, Sweden (2001-10-15, Dnr. Ö 199-01) and written consent was obtained from each participant.

**Results**

IGT was diagnosed in 213 participants: 86 men and 127 women (Figure 1). Table I shows that both men and women with IGT were older than men and women with NGT (Table 1), and
they both also had a more atherogenic risk factor profile than participants with NGT. Low level of physical activity, a low level of education, and a diagnosis of hypertension were also more common in both men and women with IGT.

The associations between self-reported lack of sleep and IGT in men and women are shown in Table 2. The OR for IGT in men with a lack of sleep was 2.3 (1.0-5.5), when adjusted for age and BMI. The further adjustment for smoking, low level of education and low physical activity did not weaken this association. No corresponding association was seen in women.

Table 3 shows significant age-adjusted associations between level of vitality and IGT in both men 2.8 (1.3-5.8), and women 2.0 (1.2-3.4). This association remained in men when further adjusting for BMI, smoking, or level of education but was lost when level of LTPA was entered into the model. In women, the corresponding association remained also when adjusting for level of LTPA when all covariates were entered simultaneously; 1.8 (1.0-3.2, p=0.048).

**Discussion**

We found a significant association between self-reported lack of sleep and IGT in men that remained after adjustment for potential confounders such as obesity and health behaviours. No such association was found in women. Furthermore, a significant association was found between low vitality and IGT in both men and women. While the association was more robust in women, it was lost in men when other patient-related factors were considered. The study also confirmed that both men and women with IGT have a more serious cardiovascular disease risk factor profile than participants with NGT.

In support of our findings, the Quebec Family Study [17] found that both short and long total sleeping time predicted type 2 diabetes / IGT in adult men and women. Clinical effects of
sleep deprivation are associated with common symptoms such as sleepiness, increased fatigue, and low motivation [18], a finding that is in agreement with the results of this study. Furthermore, voluntary sleep reduction is increasingly becoming a way of life – a habit related to the modern 24 hour society [19], and studies show that nearly 30% of the middle-aged population reported sleeping less than 6.5 h per night [20]. As a consequence, reports of day-time sleepiness have become more frequent during recent years [21]. The cause of sleep-loss is multi factorial, although obesity is considered an important risk factor for obstructive sleep apnea (OSA) [22]. Accordingly, in the FIN-D2D survey [23], middle-aged men with sleep-disordered-breathing (SDB) had an increased incidence of type 2 diabetes and abnormal glucose tolerance. However, no corresponding association has been found in women in either the FIN-D2D survey [23] or the study of women in Gothenburg [24].

The significant association found between level of vitality and IGT was robust in women, but was diluted and lost in men when successively accounting for other patient-related factors. As fatigue is one of the more common presenting symptoms of type 2 diabetes, this is interesting. Physical activity came out as an explanatory factor in men, but an interaction should be expected in both genders by virtue of its strong association with insulin resistance and consequently the development of both IGT and type 2 diabetes [25]. Since physical activity is known to improve mood, and a good mood most likely increase the motivation for physical activity it may thus also be associated with the vitality factor [26].

As shown in a prospective study, psychological distress such as fatigue, anxiety and insomnia increases the risk for prediabetes and type 2 diabetes in Swedish middle-aged men [27]. There is a common belief that day-time sleepiness is normal or related to poor life style or laziness, especially if it interferes with daily functions [25]. However, OSA often characterized by daytime sleepiness, and diabetes share common mechanisms including age and obesity, but the direction of causality may go both ways [25]. Consequently, OSA should
also be considered when these symptoms are investigated. The underlying mechanism also involving genetics, for example a mutation in the melatonin receptor 1B, should also be considered [28].

Our study question on sleep function did not account for sleep duration or possible SDB. However, the difference between men and women in the association between lack of sleep and IGT is consistent with the findings in the FIN-D2D study [23], and might thus be explained by the fact that men are more exposed to OSA, or more susceptible to the effects of OSA. Nevertheless, our findings were not diluted when BMI was adjusted for. Unfortunately, we did not measure breathing pattern during sleep directly or by questionnaire. In a previous Swedish study, men were also more susceptible to psychological distress in the association with prediabetes than women [27]. We found no corresponding pattern in the association with low vitality. This may probably be explained by low vitality being derived from other mechanisms than psychological distress.

**Strengths and limitations of the study**

This study is based on a large, random population sample with a high participation rate, making the results generalizable to this and other similar populations. A further strength of this study is the enrolment of both men and women over a wide age-band where strategies of diabetes prevention are important. The prevalence of IGT was also congruent with other studies from Sweden [27].

An OGTT was performed in each participant without a known diagnosis of diabetes. According to recommendations from WHO, an OGTT should be performed to diagnose IGT as it is characterized by postprandial hyperglycemia and separate from IFG that is characterized by fasting hyperglycemia. This procedure to identify IGT is supported by experiences from other population studies [29]. The questionnaires were completed before the information of the results of the OGTT was available, and therefore none of the participants
were aware of their potential diagnosis of IGT when answering the questionnaire. In this study we used self-reported information on physical activity in leisure time, (LTPA). However, this question has shown good validity when recently compared to objectively measured total physical activity during 24 hour [30]. Limitations of the study comes from it cross-sectional design, making it impossible to decide on causality in associations. Information on sleep function and vitality was self-reported and not based on direct measurements; however, these questions have been used and validated in other studies with reliable findings. Finally, the protocol did not comprise any measurements on OSA, and thus this important factor could not be accounted for.

Conclusions

There is a link between self-reported lack of sleep, low vitality and IGT. Short sleep duration is a risk factor for developing type 2 diabetes [31] and voluntary sleep restriction may contribute to the global epidemic burden of type 2 diabetes [10]. More research is needed to determine how quality of sleep and low vitality interact in persons who are susceptible to developing IGT, thus facilitating improved strategies for prevention.

For health professionals, this study emphasizes the importance of paying attention to patients’ symptoms of sleep deficiency and low vitality. Patients with lack of sleep and low vitality should be considered for evaluation of a possible IGT in line with the IDF expert committee [14]. Our findings are in accordance with the current strategy of opportunistic screening. In particular, male patients with insufficient sleep and related symptoms such as low vitality should be tested generously for possible IGM, using OGTT more frequently. Primary care is the legitimate setting for primary prevention of type 2 diabetes. Listening to the patients’
symptoms may be one way of helping to identify persons at risk in order to prevent the
development of type 2 diabetes.

**Additional materials**

**Abbreviations**

CI: Confidence interval, IDF: International Diabetes Federation, IFG: Impaired fasting
glucose, IGT: Impaired glucose tolerance, IGM: Impaired glucose metabolism, IR: Insulin
resistance, LTPA Leisure time physical activity, NGT: Normal glucose tolerance, OGTT:
Oral glucose tolerance test, OSA: Obstructive sleep apnoea, SDB: Sleep disordered breathing.

**Competing interests**

The authors declare that they have no competing interests

**Authors contributions**

All authors conceived of the study, and UL supervised the data collection. SA, EB-H and UL
participated in the data and statistical analysis. SA has collect data, been involved in drafting
the study, interpretation of data and manuscript review. UL has drafted and coordinated the
study design, led the analysis of the cross sectional data and full manuscript development.IE
has been involved in drafting the study, interpretation of data, manuscript review, editing for
intellectual content. FF has been involved in drafting the study interpretation of data,
manuscript review and editing for intellectual content. EB-H has collect data, been involved
in drafting the study and the interpretation of data, manuscript review and editing for
intellectual content.All authors read and approved the final manuscript.

**Acknowledgements**
The study was funded by the National Research Foundation Council (VR), Sweden, The Skaraborg Institute in Skövde, Sweden, Skaraborg Primary Care, Sweden, The Health & Medical Care Committee of the Regional Executive Board of the Region Västra Götaland, Sweden, University of Skövde, Sweden and The Sahlgrenska Academy of Gothenburg University, Sweden. The authors would also like to thank the participants from Vara and Skövde who made this study possible.
References


Figure 1 Flowchart of the Skaraborg Project 2002-2005. The total number of participants 2,816, and the participation rate was 76%. Two participants had incomplete OGTT, and of those with NGT or IGT 19 participants did not answer the question on lack of sleep, and 50 subjects did not respond to the question on vitality. The current study populations thus included 2508 participants (lack of sleep) and 2477 (vitality), respectively.

Table 1 Characteristics of 1,216 men and 1,311 women with normal glucose tolerance (NGT), impaired glucose tolerance (IGT) in the Vara-Skövde cohort 2002-2005

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th></th>
<th></th>
<th>Women</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NGT n=1,130</td>
<td>IGT n=86</td>
<td></td>
<td>NGT n=1,184</td>
<td>IGT n=127</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Age (years)</td>
<td>45.9</td>
<td>10.7</td>
<td>56.0</td>
<td>12.3</td>
<td>46.2</td>
<td>10.9</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>122.0</td>
<td>14.3</td>
<td>133.0</td>
<td>19.4</td>
<td>117.0</td>
<td>16.0</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>71.0</td>
<td>9.7</td>
<td>76.0</td>
<td>11.6</td>
<td>68.0</td>
<td>9.7</td>
</tr>
<tr>
<td>S-Cholesterol (mmol L⁻¹)</td>
<td>5.4</td>
<td>1.0</td>
<td>5.6</td>
<td>1.1</td>
<td>5.1</td>
<td>1.1</td>
</tr>
<tr>
<td>BMI (kg m⁻²)</td>
<td>26.5</td>
<td>3.3</td>
<td>28.3</td>
<td>4.1</td>
<td>26.1</td>
<td>4.8</td>
</tr>
<tr>
<td>WHR (m m⁻¹)</td>
<td>0.93</td>
<td>0.1</td>
<td>0.98</td>
<td>0.1</td>
<td>0.82</td>
<td>0.1</td>
</tr>
<tr>
<td>Waist (cm)</td>
<td>93.5</td>
<td>9.2</td>
<td>99.8</td>
<td>11.1</td>
<td>83.8</td>
<td>12.5</td>
</tr>
<tr>
<td>Daily smoking</td>
<td>168</td>
<td>14.9</td>
<td>11</td>
<td>12.8</td>
<td>246</td>
<td>20.8</td>
</tr>
<tr>
<td>Low physical activity</td>
<td>635</td>
<td>57.9</td>
<td>62</td>
<td>76.5</td>
<td>791</td>
<td>69.0</td>
</tr>
<tr>
<td>Hypertension</td>
<td>111</td>
<td>9.4</td>
<td>29</td>
<td>33.7</td>
<td>111</td>
<td>9.8</td>
</tr>
<tr>
<td>Living alone</td>
<td>222</td>
<td>19.7</td>
<td>30</td>
<td>34.9</td>
<td>225</td>
<td>19.0</td>
</tr>
<tr>
<td>Low level of education</td>
<td>307</td>
<td>27.6</td>
<td>39</td>
<td>48.8</td>
<td>236</td>
<td>20.4</td>
</tr>
</tbody>
</table>


Table 2 Association between lack of sleep and IGT

<table>
<thead>
<tr>
<th></th>
<th>None</th>
<th>Intermediate</th>
<th>Severe</th>
<th>None</th>
<th>Intermediate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR</td>
<td>95% CI</td>
<td>OR</td>
<td>95% CI</td>
<td>OR</td>
<td>95% CI</td>
</tr>
<tr>
<td><strong>Men</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of sleep</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted for age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1.6 (0.9-2.7)</td>
<td>2.4</td>
<td>1.1-5.4</td>
<td>1</td>
<td>1.2 (0.8-1.8)</td>
</tr>
<tr>
<td>Adjusted for age, BMI</td>
<td>1</td>
<td>1.5 (0.9-2.6)</td>
<td>2.3</td>
<td>1.0-5.2</td>
<td>1</td>
<td>1.1 (0.7-1.7)</td>
</tr>
<tr>
<td>Adjusted for age, BMI, smoking</td>
<td>1</td>
<td>1.5 (0.9-2.6)</td>
<td>2.4</td>
<td>1.1-5.3</td>
<td>1</td>
<td>1.1 (0.7-1.6)</td>
</tr>
<tr>
<td>Adjusted for age, BMI, smoking, level of education</td>
<td>1</td>
<td>1.4 (0.8-2.5)</td>
<td>2.6</td>
<td>1.2-5.9</td>
<td>1</td>
<td>1.1 (0.7-1.7)</td>
</tr>
<tr>
<td>Adjusted for age, BMI, smoking, level of education, level of physical activity</td>
<td>1</td>
<td>1.3 (0.7-2.3)</td>
<td>2.3</td>
<td>1.0-5.5*</td>
<td>1</td>
<td>1.1 (0.7-1.7)</td>
</tr>
<tr>
<td><strong>Women</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of sleep</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted for age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1.1 (0.6-1.8)</td>
<td>1.0</td>
<td>0.5-2.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Associations were estimated using logistic regression and were expressed by OR and 95% confidence intervals.

* p=0.044
Table 3 Association between low vitality and IGT

<table>
<thead>
<tr>
<th>Low vitality</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Adjusted for age</td>
<td>OR</td>
<td>OR 95% CI</td>
</tr>
<tr>
<td>Adjusted for age, BMI</td>
<td>1</td>
<td>1.4 (0.8-2.2)</td>
</tr>
<tr>
<td>Adjusted for age, BMI, smoking</td>
<td>1</td>
<td>1.4 (0.8-2.3)</td>
</tr>
<tr>
<td>Adjusted for age, BMI, smoking, level of education</td>
<td>1</td>
<td>1.3 (0.8-2.3)</td>
</tr>
<tr>
<td>Adjusted for age, BMI, smoking, level of physical activity</td>
<td>1</td>
<td>1.1 (0.6-1.9)</td>
</tr>
</tbody>
</table>

Associations were estimated using logistic regression and were expressed by OR and 95% confidence intervals.

* p=0.048
Figure 1 Flowchart of the Skaraborg Project 2002-2005. The total number of participants 2,816, and the participation rate was 76%. Two participants had incomplete OGTT, and of those with NGT or IGT 19 participants did not answer the question on lack of sleep, and 50 subjects did not respond to the question on vitality. The current study populations thus included 2508 participants (lack of sleep) and 2477 (vitality), respectively.