

## **Hyperglycemia, type 2 diabetes, and depressive symptoms: the British Whitehall II study.**

Mika Kivimaki, Adam Tabak, G David Batty, Archana Singh-Manoux, Markus Jokela, Tasnime Akbaraly, Daniel Witte, Eric Brunner, Michael Marmot, Debbie Lawlor

► **To cite this version:**

Mika Kivimaki, Adam Tabak, G David Batty, Archana Singh-Manoux, Markus Jokela, et al.. Hyperglycemia, type 2 diabetes, and depressive symptoms: the British Whitehall II study.. Diabetes Care, American Diabetes Association, 2009, 32 (10), pp.1867-9. 10.2337/dc09-0716 . inserm-00426437

**HAL Id: inserm-00426437**

**<https://www.hal.inserm.fr/inserm-00426437>**

Submitted on 26 Oct 2009

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

**Hyperglycaemia, Type 2 Diabetes and Depressive Symptoms: The British Whitehall II****Study**

Running title: Glycaemia, Diabetes and Depressive Symptoms

Mika Kivimaki, PhD,<sup>a,b</sup> Adam G. Tabak, MD, PhD,<sup>a,c</sup> G. David Batty, PhD,<sup>d,e,f</sup> Archana Singh-Manoux, PhD,<sup>a,g</sup> Markus Jokela, PhD,<sup>a</sup> Tasnime N. Akbaraly, PhD,<sup>a,h</sup> Daniel R. Witte, MD, PhD<sup>i</sup> Eric J. Brunner, PhD,<sup>a</sup> Michael G. Marmot, PhD,<sup>a</sup> Debbie A. Lawlor, MD, PhD<sup>j</sup>

<sup>(a)</sup> Department of Epidemiology and Public Health, University College London, UK

<sup>(b)</sup> Finnish Institute of Occupational Health, Helsinki, Finland

<sup>(c)</sup> Semmelweis University Faculty of Medicine, 1st Department of Medicine, Hungary

<sup>(d)</sup> MRC Social & Public Health Sciences Unit, University of Glasgow, Glasgow, UK

<sup>(e)</sup> Centre for Cognitive Ageing and Cognitive Epidemiology, Department of Psychology, University of Edinburgh, Edinburgh, UK

<sup>(f)</sup> Renal and Metabolic Division, The George Institute for International Health, Sydney, Australia

<sup>(g)</sup> INSERM U687-IFR69, AP-HP, Paris, France

<sup>(h)</sup> INSERM U 888, Montpellier F-34093, France

<sup>(i)</sup> Steno Diabetes Center, Gentofte, Denmark

<sup>(j)</sup> MRC Centre for Causal Analyses in Translational Epidemiology, University of Bristol, UK

Address correspondence and reprint requests to:

Prof. Mika Kivimaki, Department of Epidemiology and Public Health, 1-19 Torrington Place, University College London, London WC1E 6BT, UK

Email : [m.kivimaki@ucl.ac.uk](mailto:m.kivimaki@ucl.ac.uk)

Tel:+44(0)20 7679 8260, Fax: +44(0)20 74196732

MANUSCRIPT STATISTICS: 979 words in text; 136 in abstract; 4 references; 1 figure, 1 Annex.

**ABSTRACT**

**OBJECTIVE**—The recent suggestion that impaired fasting glucose may protect against depression, whereas a diagnosis of diabetes might then result in depression, warrants further examination.

**RESEARCH DESIGN AND METHODS**—Cross-sectional analysis of 4228 adults (mean age 60.7 years, 73.0% male) who underwent oral glucose tolerance testing and completed the Center for Epidemiologic Studies Depression (CES-D) scale.

**RESULTS**—After adjustment for demographic factors, health behaviours and clinical measurements (BMI, waist circumference, lipid profile and blood pressure), there was a 'U'-shaped association between fasting glucose and depression ( $P_{\text{curve}}=0.001$ ), with elevated CES-D at low and very high glucose levels. This finding was replicable with 2-hour postload glucose ( $p=0.11$ ) and HbA1c ( $p=0.007$ ).

**CONCLUSION**—The 'U'-shaped association between blood glucose and CES-D, with the lowest depression risk seen amongst those in the normoglycaemic range of HbA1c did not support the hypothesized protective effect of hyperglycaemia.

The association between type 2 diabetes and depression, both major public health challenges, remains unclear (1-8). In a recent U. S. report, people with type 2 diabetes had an increased risk of depressive symptoms, whereas, conversely, in non-diabetic individuals higher impaired fasting glucose (IFG) appeared to confer protection against depression (7). While an increased prevalence of depression in people receiving a diagnosis of a pernicious chronic disease such as type 2 diabetes is perhaps unsurprising, the apparent counter-intuitive protective effect of IFG warrants further scrutiny. In the Whitehall II study we were able to explore the relationship between depression and a greater range of glycaemia measures [fasting and postload glucose, glycated haemoglobin 1c (HbA1c)] than has previously been possible.

**RESEARCH DESIGN AND METHODS**—In 2003/04 data collection phase of the Whitehall II study (described in detail elsewhere)(9), 4228 men and women aged 50 to 74 years completed a depression questionnaire and, if without known diabetes, underwent an oral glucose tolerance test (OGTT). Venous blood samples were taken after at least 8 hours of fasting, before OGTT, and at 2-hour post administration of a 75g glucose solution. Blood glucose was measured using the glucose oxidase method (10) on a YSI MODEL 2300 STAT PLUS Analyzer (YSI Corporation, Yellow Springs, OH, USA) (mean coefficient of variation (CV): 1.4%-3.1%)(11). Diabetes was defined by a fasting glucose  $\geq 7.0$  mmol/L or a 2-hour postload glucose  $\geq 11.1$  mmol/L or reported doctor diagnosed diabetes or use of diabetes medication (12). In non-diabetic participants, we classified moderate hyperglycaemia as IFG (fasting glucose between 5.6 to 6.9 mmol/L) and Impaired Glucose Tolerance (IGT, 2-hour

postload glucose between 7.8 and 11.0 mmol/L)(12). HbA1c was measured on whole blood with a calibrated HPLC system (CV: 0.8%).

Depressive symptoms were assessed with the Center for Epidemiologic Studies Depression scale (CES-D) summary score (13), a measure that has been validated among diabetic patients (14). Ethnicity (white or non-white), body mass index [weight (kg) per height squared ( $m^2$ )], waist circumference (cm), systolic and diastolic blood pressure (mm Hg), HDL- and LDL-cholesterol (mmol/L), triglycerides (mmol/L), current smoking (yes/no), alcohol consumption (none, 1 to 3 units per day, >3 units per day) and physical inactivity (<2.5 hrs moderate and <1 hr vigorous exercise per week) were measured according to standardised protocols.

### **Statistical methods**

All 4228 participants had adequate data on CES-D and diabetes status, but there were some missing data for some of the different glucose parameters. Thus, our different analyses are based on between 3945 (93.3% of the 4228) and 4228 (100%) of the eligible participants. Values for triglycerides were log-transformed prior to analyses due to skewed distribution. We used linear regression analysis to model the associations of IFG and IGT with the CES-D score. The shape of the associations between fasting glucose, postload glucose, HbA1c and CES-D were studied by treating all these measures as continuous variables. To test for curvilinear trends a squared term of the glycaemic measures was added to an equation containing the linear term. The models were adjusted for age, sex, ethnicity and clinical characteristics (BMI, waist, systolic and diastolic blood pressure, HDL- and LDL-cholesterol,

triglycerides, smoking, alcohol consumption, and physical activity). The statistical tests were performed with Stata version 10.1.

**RESULTS**—Of the 4228 participants, 2038 (73.0%) were men and 3895 (92.1%) Caucasian. Mean±SD age was 60.7±6.0 years and the levels of clinical characteristics were 128±17/74±10 mm Hg for systolic/diastolic blood pressure, 1.6±0.4 mmol/L for HDL-cholesterol, 3.58±1.9 mmol/L for LDL-cholesterol, 26.7±4.4 kg/m<sup>2</sup> for BMI, and 94.2±10.7 (men) and 84.3±13.0 cm (women) for waist circumference. For triglycerides, median±IQR was 1.2±0.9 mmol/L. Of the participants, 7.9% were current smokers, 16.0% were physically inactive, 17.8% consumed more than 3 units alcohol per day and 16.2% did not consume alcohol regularly. Overall CESD-mean score was 9.9±6.6.

**Fasting glucose**—Mean±SD was 5.55±1.51 mmol/L. Compared to participants with normal fasting glucose [n=3038, mean±SD CES-D=9.9±6.7], those with IFG (n=735) showed a marginally reduced CES-D score [Mean±SD=9.0±6.1, P=0.05], while those with diabetes (n=455) showed an elevated CES-D score [Mean±SD=11.2±7.0, P=0.002] after taking into account age, sex and ethnicity. As shown in Figure 1-Panel A, there was a U-shaped association between fasting glucose and CES-D (P<sub>curve</sub>=0.001 after adjustment for age, sex and ethnicity, n=3986), with elevated CES-D values at glucose levels <4.5 mmol/L and >9.0 mmol/L. The curvilinear trend was robust to additional adjustment for clinical characteristics (P=0.001).

**Postload glucose**—Mean±SD was 6.38±2.09 mmol/L. IGT [n=423, CES-D mean±SD=9.49±6.58] and isolated IGT (n=284) were not associated with CES-D (P>=0.53). However, there was a U-shaped association between postload glucose and CES-D (Figure 1-

Panel B,  $n=3455$ ,  $P_{\text{curve}}=0.05$  after adjustment for age, sex and ethnicity;  $P_{\text{curve}}=0.11$  after additional adjustment for clinical characteristics).

**HbA1c**—Mean $\pm$ SD was  $5.36\pm 0.73\%$ . Again, a curvilinear association with CES-D was evident ( $p=0.04$ ,  $n=4160$ ), Figure 1-Panel C. The lowest CES-D scores were between HbA1c levels 4.0% to 5.5% (nadir 4.4% in age, sex and ethnicity adjusted model) and this was also seen in raw data (Appendix). The curvilinear trend remained after additional adjustment for all clinical characteristics ( $P=0.007$ ).

**CONCLUSIONS**—We examined the associations of various glycaemic measures, including fasting and postload glucose and HbA1c with symptoms of depression. Our results show slightly lower levels of depressive symptoms among non-diabetic individuals with IFG (7). However, this finding was generated by a ‘U’-shaped association between fasting glucose and CES-D with elevated depression scores seen at both ends of the glucose distribution, a finding which was replicated for 2-hour postload glucose and HbA1c. While low depression scores were observed both at normal and prediabetic ranges of fasting and postload glucose, findings from long-term glucose levels (HbA1c) clearly demonstrated that normoglycaemic individuals had the lowest depression risk.

In summary, our results do not support the protective effect of long-term hyperglycaemia but they are in agreement with the recommendation that clinicians consider screening for depression among patients with diabetes. Future research should determine explanatory mechanisms for increased depressive symptoms among non-diabetic individuals with low glucose levels.

**Acknowledgements:** The Whitehall II study has been supported by grants from the Medical Research Council; British Heart Foundation; Health and Safety Executive; Department of Health; National Heart Lung and Blood Institute (HL36310), US, NIH: National Institute on Aging (AG13196), US, NIH; Agency for Health Care Policy Research (HS06516); and the John D and Catherine T MacArthur Foundation Research Networks on Successful Midlife Development and Socio-economic Status and Health. MK is supported by the Academy of Finland; GDB is a Wellcome Trust Research Fellow; AS-M is supported by a ‘EURYI’ award from the European Science Foundation; JEF is supported by the UK Medical Research Council; MGM is supported by a MRC Research Professorship; DAL works in a centre that receives some core funding from the UK Medical Research Council. The funding bodies have not influenced the conduct of this study or any of its conclusions. The views expressed here are those of authors and not necessarily any funding body.

**Disclosure:** No conflict of interest to disclose.



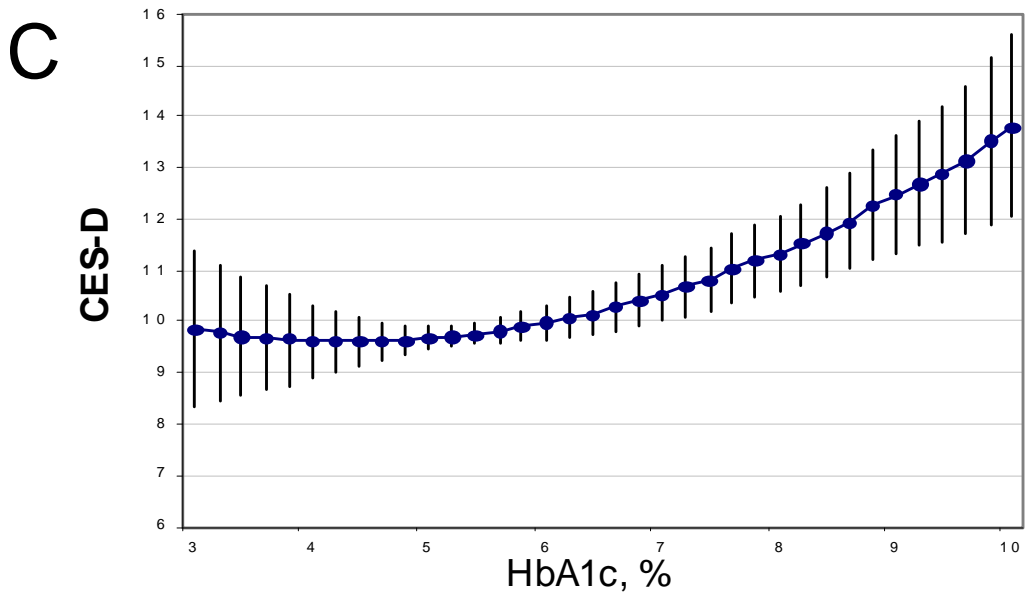
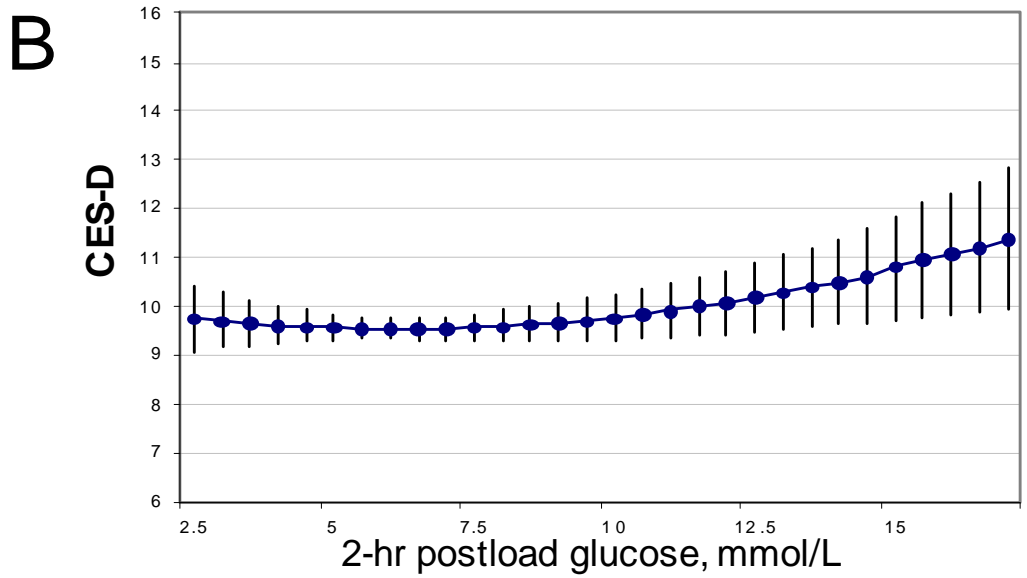
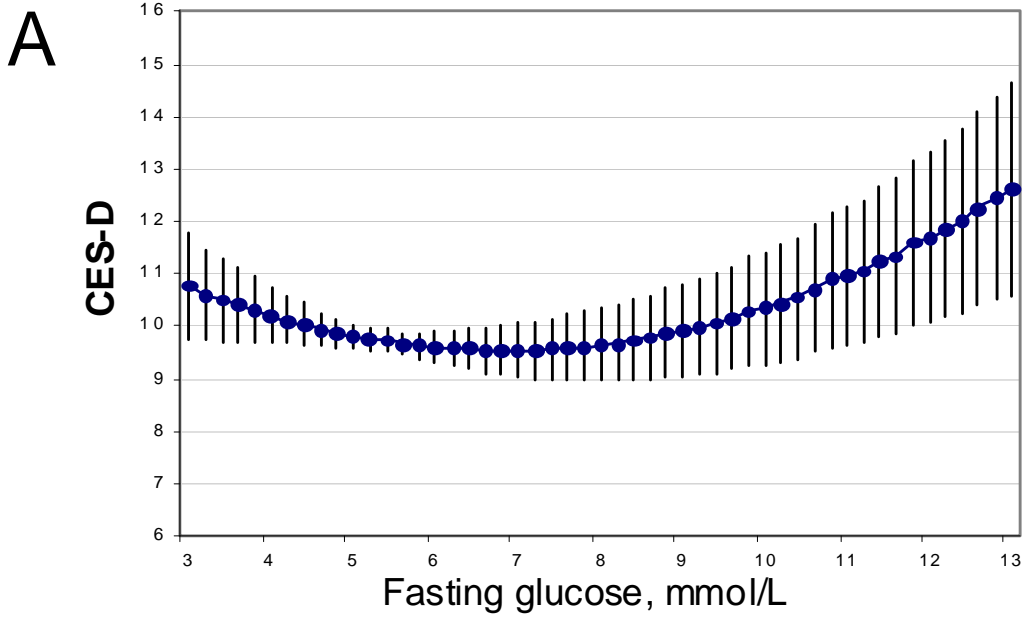
**References**

1. Palinkas LA, Lee PP, Barrett-Connor E. A prospective study of Type 2 diabetes and depressive symptoms in the elderly: the Rancho Bernardo Study. *Diabet Med* 2004;21:1185-91.
2. de Jonge P, Roy JF, Saz P, Marcos G, Lobo A. Prevalent and incident depression in community-dwelling elderly persons with diabetes mellitus: results from the ZARADEMP project. *Diabetologia* 2006;49:2627-33.
3. Maraldi C, Volpato S, Penninx BW, et al. Diabetes mellitus, glycemic control, and incident depressive symptoms among 70- to 79-year-old persons: the health, aging, and body composition study. *Arch Intern Med* 2007;167:1137-44.
4. Polsky D, Doshi JA, Marcus S, et al. Long-term risk for depressive symptoms after a medical diagnosis. *Arch Intern Med* 2005;165:1260-6.
5. Brown LC, Majumdar SR, Newman SC, Johnson JA. Type 2 diabetes does not increase risk of depression. *CMAJ* 2006;175:42-6.
6. Kim JM, Stewart R, Kim SW, Yang SJ, Shin IS, Yoon JS. Vascular risk factors and incident late-life depression in a Korean population. *Br J Psychiatry* 2006;189:26-30.
7. Golden SH, Lazo M, Carnethon M, et al. Examining a bidirectional association between depressive symptoms and diabetes. *JAMA* 2008;299:2751-9.
8. Boyle SH, Surwit RS, Georgiades A, et al. Depressive symptoms, race, and glucose concentrations: the role of cortisol as mediator. *Diabetes Care* 2007;30:2484-8.
9. Marmot M, Brunner E. Cohort Profile: the Whitehall II study. *Int J Epidemiol* 2005;34:251-6.

10. Cooper GR. Methods for determining the amount of glucose in blood. *CRC Crit Rev Clin Lab Sci* 1973;4:101-45.
11. Astles JR, Sedor FA, Toffaletti JG. Evaluation of the YSI 2300 glucose analyzer: algorithm-corrected results are accurate and specific. *Clin Biochem* 1996;29:27-31.
12. Report of the expert committee on the diagnosis and classification of diabetes mellitus. *Diabetes Care* 2003;26 Suppl 1:S5-20.
13. Radloff LS, Locke BZ. Center for Epidemiologic Studies Depression Scale (CES-D). In: Rush AJ, ed. *Handbook of Psychiatric Measures*. Washington, DC: American Psychiatric Association, 2000:523-526.
14. Fisher L, Chesla CA, Mullan JT, Skaff MM, Kanter RA. Contributors to depression in Latino and European-American patients with type 2 diabetes. *Diabetes Care* 2001;24:1751-7.

## FIGURE LEGENDS

**Figure 1.** Age, Sex and Ethnicity/Race Adjusted Associations of Fasting Glucose (A), 2-hour Postload Glucose (B) and Glycated Hemoglobin (C) with Depression Assessed by the Center for Epidemiologic Studies Depression scale (CES-D).



**Appendix:** Lowess Smoother Curve Based on Raw Data on HbA1c and CES-D