Personality and HbA1c: Findings from six samples

Yannick Stephan, Angelina R. Sutin, Martina Luchetti, Brice Canada, Antonio Terracciano

RUNNING HEAD: Personality and HbA1c

Personality and HbA1c: Findings from Six Samples

Yannick Stephan[1*], Angelina R. Sutin[2], Martina Luchetti[2], Brice Canada[3] & Antonio Terracciano[2]

[1] Euromov, University of Montpellier, France

[2]Florida State University College of Medicine, USA

[3]University of Lyon 1, France

Word count: 3256 words

Correspondence concerning this article should be addressed to Yannick Stephan, Euromov, University of Montpellier, UFRSTAPS, 700, Avenue du Pic St Loup, 34090 Montpellier, France. E-mail: yannick.stephan@umontpellier.fr

Abstract

Personality traits are associated with risk of diabetes, but most research to date has relied on participants reported diagnosis rather than objective markers of glycaemia. The present study examined the association between the five major domains of personality (neuroticism, extraversion, openness, agreeableness and conscientiousness) and haemoglobin A1c (HbA1c). Participants (N> 26,000) were individuals aged from 16 to 104 years from six large community samples from the US, Europe, and Japan who had data on personality, demographic factors, body mass index (BMI), physical activity, and HbA1c. Of the five factors, only higher conscientiousness was related consistently to lower HbA1c level across most samples and in the meta-analysis. Conscientiousness was also related to lower risk of HbA1c ≥6.5% (OR = .85, 95%CI = 0.80-0.90). BMI and physical activity partially mediated the link between conscientiousness and HbA1c. There were not consistent associations for the other four traits across the six samples and no consistent associations between personality and likelihood of undiagnosed diabetes. The present study found replicable associations between conscientiousness and HbA1c in adulthood. Assessment of conscientiousness may improve the identification of individuals at risk of diabetes and guide personalized interventions for regulation of HbA1c level.

Keywords: Personality, diabetes, HbA1c

1. Introduction

Type 2 diabetes is one of the leading causes of disability and mortality worldwide (James et al., 2018). The prevalence rate is estimated to range between 8 to 10% (NCD Risk Factor Collaboration, 2016; Menke et al., 2015), with higher prevalence among older adults (Menke et al., 2015). Lifestyle factors, such as physical inactivity and body mass index, play a crucial role in the incidence of Type 2 diabetes (Abdullah et al., 2010; Joseph et al., 2016). In addition, personality traits, commonly defined as enduring patterns of thoughts, feelings, and behaviors, have been found to predict the risk of diabetes (Cukic et al., 2016; Cukic & Weiss, 2014; Jokela et al., 2014; Weston, Hill & Jackson, 2015). Among the Five Factor Model of personality (McCrae & John, 1992), conscientiousness (the propensity to be self-disciplined and thoughtful) is associated consistently with a lower risk of diabetes (Jokela et al., 2014; Weston et al., 2015). This association is explained in part by the lower obesity risk and more frequent physical activity of conscientious individuals (Jokela et al., 2014; Sutin et al., 2016; Sutin & Terracciano, 2016). The evidence for neuroticism (the tendency to experience distress and negative emotions) is more mixed: some studies found that higher neuroticism is predictive of lower risk of diabetes (Cukic & Weiss, 2014) whereas others reported that higher neuroticism is a risk factor (Cukic et al., 2016) or not associated (Jokela et al., 2014). Openness (the tendency to be creative and curious) has been related to a lower likelihood of diabetes in one study (Cukic et al., 2016) but not in others (Jokela et al., 2014; Weston et al., 2015). Extraversion (the propensity to be sociable and active) and agreeableness (the propensity to be altruistic and trusting) are generally not associated with diabetes (Cukic et al., 2016; Cukic & Weiss, 2014; Jokela et al., 2014; Weston et al., 2015).

This research has mostly examined the association between personality traits and self-reported diabetes, using questions on whether a medical doctor ever told the participant that they have diabetes or whether they have been treated for diabetes. Less is known about the

link between personality traits and objective markers of glycaemia, specifically haemoglobin A1c (HbA1c). HbA1c is an indicator of individuals' glycemic status over the past two to three months and is used for the diagnosis of type 2 diabetes (clinical threshold of HbA1c ≥ 6.5%, American Diabetes Association, 2010). HbA1c can be used to identify individuals with undiagnosed diabetes (i.e., individuals with HbA1c levels past the clinical threshold but have not yet been diagnosed by a medical doctor). The few published studies on the association between personality and HbA1c are relatively inconsistent. Sutin and colleagues (2018), for example, found that lower conscientiousness was associated with higher HbA1c in the Health and Retirement Study (HRS), and Waller and colleagues (2013) found that lower conscientiousness and lower agreeableness were associated with higher HbA1c in a sample of young patients with type 1 diabetes. In contrast, Cukic and colleagues (2015) found that lower openness was associated with higher HbA1c in the Lothian Birth Cohort 1936 but that the other four traits were unrelated to it. Other studies have found no association between personality and HbA1c among individuals with diabetes (Phillips & Guarnaccia, 2016; Skinner et al., 2014). The current literature thus provides an unclear picture of the association between personality and HbA1c. To our knowledge, no large scale, analysis of multiple samples has been conducted to test for replicable associations between personality traits and HbA1c. Furthermore, no research has yet tested whether personality traits may be related to the HbA1c-threshold for diabetes-diagnosis and whether personality traits predicts undiagnosed diabetes.

Based upon six large samples of adults, the present study examined the association between personality and HbA1c in adulthood. Consistent with past research on self-reported diabetes (Jokela et al., 2014), it was hypothesized that conscientiousness would be related to lower HbA1c. In addition, given the importance of BMI and physical activity to HbA1c and their association with personality, BMI and physical activity were tested as mediators. Finally,

we also tested whether personality predicts undiagnosed diabetes and whether the association between personality and HbA1c varies depending upon self-reported diabetes.

2. Method

2.1. Participants

Participants were drawn from six samples of adults: The Midlife in the United States Survey (MIDUS), the Midlife in Japan survey (MIDJA), the Health and Retirement Study (HRS), the English Longitudinal Study of Ageing (ELSA), the National Social Life, Health, and Aging Project (NSHAP) and the United Kingdom Household Longitudinal Study (UKHLS). Descriptive statistics for the six samples are presented in Table 1.

The MIDUS is a longitudinal study of non-institutionalized, English-speaking US adults. The second wave (2004-2006, MIDUS II) was used in the present study because it included an assessment of HbA1c. A total of 988 participants (55% female; Mean age: 55.34 years, SD: 11.77) provided complete data on personality, HbA1c and demographic information.

The MIDJA is a parallel survey of the MIDUS conducted on randomly selected adults from the Tokyo metropolitan area. Personality and demographic data were obtained from the first wave in 2008, and HbA1c data were obtained in 2009-2010. The current analysis included a total of 377 individuals (56% female; Mean age: 54.08 years, SD: 14.06) with complete data.

The HRS is a national longitudinal study of Americans older than 50 years and their spouses. Personality, demographic, and HbA1c data were obtained from half of the sample in 2012 and in 2014 from the other half of the sample. These two waves were chosen because the HbA1c data were not examined in past research. Both waves were combined, resulting in a total of 9745 participants (59% female; Mean age: 67.88; SD: 10.23).

ELSA is a representative cohort of men and women living in England aged 50 years and older. Personality traits and demographic factors were assessed at Wave 5 (2010) and HbA1c was available in Wave 6 (2012). A total of 4,656 individuals (55%, Mean age: 65.76, SD: 8.02) provided complete data.

The NSHAP is a longitudinal, population-based study of health and social factors, among older community-dwelling Americans. Personality traits, demographic factors and HbA1c were obtained from Wave 2 (2010-2011), because it was the first wave that included HbA1c. Complete data were obtained from 1888 participants (53% female, Mean age: 72.47, SD: 7.08)

The UKHLS is a large, nationally representative panel study of UK households. Personality traits and demographic factors were obtained from the third wave (2011-2013). HbA1c was available for some participants on Wave 2 (2010-2012) and for other participants on Wave 3. The analysis was conducted among a total of 8,417 individuals with complete data (56% women, Mean age: 51.34, SD: 16.54).

2.2. Measures

2.2.1. Personality.

Participants completed the Midlife Development Inventory (MIDI; Zimprich et al., 2012) in the MIDUS, MIDJA, HRS, ELSA and NSHAP. They were asked to indicate on a scale ranging from 1 (*not at all*) to 4 (*a lot*) how well adjectives assessing the five traits described themselves such as moody (e.g. neuroticism), outgoing (e.g. extraversion), curious (e.g. openness), warm (e.g. agreeableness), and organized (e.g. conscientiousness). A 26 version of the MIDI was used in the MIDUS, MIDJA, HRS, and ELSA, whereas a 21-item version was used in the NSHAP. A 15-item version of the Big Five Inventory (Soto & John, 2017) was used in the UKHLS. Following the sentence “I see myself as someone who…”, Participants were asked to rate items assessing neuroticism (e.g., nervous), extraversion (e.g.,

is talkative), openness (e.g., has an active imagination), agreeableness (e.g., is kind), and conscientiousness (e.g., is efficient) using a scale from 1 (*does not apply to me at all*) to 7 (*applies to me perfectly*).

2.2.2. HbA1c.

Blood samples were collected in the six samples. In the MIDUS, the HbA1c assay was performed using a Cobas Integra Systems instrument (Roche Diagnostics). In the MIDJA, HbA1c assay was performed at the Showa Lab in Tokyo, Japan using a latex agglutination assay (Showa Medical Service Co. LTD). In the HRS and NSHAP, HbA1c uses an automated ion-exchange high-performance liquid chromatography (IE-HPLC) system. In UKHLS, HbA1c is measured from whole blood using HPLC cation exchange on a Tosoh G8 analyser. In ELSA, HbA1c was measured using a Tosoh G7 analyser (Tosoh, Tokyo, Japan). HbA1C was expressed into percentage of the total hemoglobin in the MIDUS, MIDJA, HRS, and NSHAP whereas it was expressed into mmol/mol in ELSA and the UKHLS. These values were converted into % using the following formula: (Value in mmol/mol/10,929)+2.15.

2.2.3. Self-reported diabetes.

In each sample, participants were asked to indicate whether they ever had been diagnosed with diabetes by a doctor or a health professional or whether they have been treated for diabetes. Individuals were categorized into either self-reported diabetes (either reported diagnosis and/or treatment for diabetes) or no self-reported diabetes. Of note, no distinction was made between type I and II diabetes.

2.2.4. Mediators.

Mediation analysis was conducted to examine whether the association between personality and HbA1c was mediated by BMI or physical activity. In the six samples, objective measurement of weight and height were used to compute BMI as kg/m^2. Physical activity measures were available in five out of six samples (physical activity was not available

at wave 3 in the UKHLS). In the MIDUS participants were asked to indicate the frequency of their vigorous and moderate leisure physical activity during both the summer months and the winter months on a scale from 1 (never) to 6 (several times a week or more). Items were averaged. In the HRS and ELSA, the mean of two items asking how often individuals participated in vigorous and moderate physical activity on a scale from 1 (hardly ever or never) to 4 (more than once a week) was computed. In the MIDJA, participants reported how frequently they followed exercise therapies such as yoga or thaï chi in the past 12 months on a scale from 1 (*never*) to 5 (*a lot*). In the NSHAP, participants were asked to report their frequency of vigorous physical activity on a scale ranging from 0 (never) to 5 (five or more times a week).

2.2.5. Covariates.

In each sample, age, gender (coded as 1 for male and 0 for female), and education were controlled for. Race was also controlled for in the HRS, MIDUS, NSHAP, ELSA, and UKHKS and was coded as 0 for white and 1 for other.

2.3. Data Analysis

In each sample, regression analysis was used to predict HbA1c from personality, controlling for the covariates. Each personality trait was analyzed separately. The PROCESS macro (Hayes, 2013), using 5,000 bootstrapped samples and 95% bias-corrected confidence intervals, was used to test whether BMI and physical activity mediated these associations, controlling for the covariates. Supplementary regression analyses were conducted to test the association between personality and HbA1c separately among individuals with and without self-reported diabetes.

Logistic regression was used to examine whether personality traits were associated with the likelihood of exceeding the clinical threshold indicative of diabetes (HbA1C $\geq$ 6.5%), controlling for demographic factors. Furthermore, the same analysis was conducted to test for

the association between personality and undiagnosed diabetes, that is HbA1c ≥ 6.5% among individuals without a diagnosis of diabetes. This analysis controlled for the same covariates and excluded individuals with self-reported diabetes. To facilitate interpretation of the logistic regression analysis, each trait was standardized as z-scores (M = 0 and SD = 1). A random effects meta-analysis was conducted that combined the results from linear and logistic regressions with Comprehensive Meta-Analysis software. A meta-analysis of indirect and direct effects in the mediation analysis was also conducted.

3. Results

Supporting our main hypothesis, higher conscientiousness was related to lower HbA1c, controlling for demographic factors (see Table 2). This association was observed in every sample except for MIDUS. Higher extraversion was related to lower HbA1c in HRS, ELSA, and NSHAP and higher HbA1c in MIDUS. Agreeableness was associated with lower HbA1c in ELSA and higher HbA1c in MIDUS. Higher openness was related to lower HbA1c in MIDJA and NSHAP. No association was found between neuroticism and HbA1c across the six samples. The meta-analysis supported the association between conscientiousness and lower HbA1c and suggested a marginally significant relationship with openness (p=.045). No other associations were found (see Table 2).

The mediational analysis suggested that the association between conscientiousness and HbA1c was mediated by both BMI and physical activity in the HRS, NSHAP, ELSA and by BMI in the UKHLS (Table 3). The meta-analysis confirmed this pattern of mediation (see Table 3). The proportion of mediated effect by BMI and physical activity was, respectively, 18% and 21% in the HRS, 16% and 29% in the NSHAP, 19% and 17% in ELSA, and was 32% for BMI in the UKHLS. The association between extraversion and HbA1c was mediated by both BMI and physical activity in the HRS (proportion mediated: 27% and 39%, respectively) and ELSA (proportion mediated: 10% and 19%, respectively), and by physical

activity in the NSHAP (proportion mediated: 20%). Physical activity mediated the association between openness and HbA1c in the NSHAP (proportion mediated: 30%) (Table 3). The meta-analysis supported the mediating role of physical activity in the relationship between both extraversion and openness and HbA1c. The pattern of associations was less consistent when examining individuals with and without self-reported diabetes separately (see supplementary analysis).

Analyses were conducted to examine whether personality traits were related to the clinical threshold in the total sample. The results revealed that higher conscientiousness was related to lower risk of exceeding the diabetes-diagnosis threshold (see Table 4). There was also a weak effect for agreeableness associated with a lower likelihood of exceeding the clinical cutoff. Finally, there was little evidence that personality was associated with undiagnosed diabetes. Conscientiousness was associated with a reduced risk of undiagnosed diabetes in the ELSA, and extraversion and agreeableness were related to higher risk of undiagnosed diabetes in the UKHLS and the NSHAP, respectively (Table 5). No associations were found in the MIDUS and the HRS. These analyses were not conducted in the MIDJA because of the small number of participants both without self-reported diabetes and clinical level of HbA1c (N= 6).

4. Discussion

Based upon six large samples of adults, the present study suggests that conscientiousness is related to HbA1c. That is, as expected, higher conscientiousness was related consistently to lower HbA1c, and this association was mediated partly by BMI and physical activity. Although less consistent, extraversion, openness and agreeableness were associated with lower HbA1C level in some samples. Personality traits were mostly unrelated to likelihood of undiagnosed diabetes. The present study provides robust evidence for the relation between conscientiousness and HbA1c.

Among the five traits, conscientiousness was the most consistent personality correlate of HbA1c. This result supports past findings on the association between conscientiousness and lower likelihood of incident self-reported diabetes (Jokela et al., 2014). While such comparisons should be done cautiously, it is of note that in the previous study conscientiousness predicted incident self-report diagnosis of diabetes with a meta-analytic OR = 0.87 (95%CI = 0.82-0.91) (Jokela et al., 2014), which is very similar to the meta-analytic OR = .85 (95%CI = 0.80-0.90) we found for the cross-sectional association of conscientiousness with HbA1c ≥ 6.5% (Table 4). These findings suggest that the self-report work is unlikely to overestimate the associations between personality and risk of diabetes. However, we found little evidence of an association between personality and undiagnosed diabetes, that is a higher diagnostic level of HbA1c among individuals without a diagnosis of diabetes. Overall, the relationship between personality and objective measure of diabetes provides a relatively similar conclusion to the research based on self-reported measures. This study also supports the role of conscientiousness in more positive health outcomes (Strickhouser et al., 2017). Several pathways may explain this association. As indicated by the mediation analysis, self-disciplined, organized and thoughtful individuals have lower level of HbA1c in part because they have lower adiposity and are more physically active. There are likely to be other pathways that also contribute to this association. For example, higher conscientiousness is related to higher adherence to doctors' orders and medication (Hill & Roberts, 2011) that may reduce the likelihood of elevated HbA1c (Skinner et al 2014; Wheeler et al 2012). Individuals higher in conscientiousness tend to consume less alcohol (Hakulinen et al., 2015; Luchetti et al., 2018) and have better sleep quality (Stephan et al., 2018), which are both associated with lower HbA1c and protect against diabetes (Baliunas et al., 2009; Knutson et al., 2006). Furthermore, conscientiousness is related to a healthy diet (Mottus et al., 2013; Weston et al., 2020) and better fitness (Terracciano et al., 2013) that may

contribute to lower HbA1c. At the biological level, conscientiousness is associated with lower systemic inflammation (Luchetti et al., 2014) that may also be implicated in the development of diabetes (Wang et al., 2013).

In contrast to conscientiousness, the associations with extraversion, openness and agreeableness were much less consistent. In addition, neuroticism was unrelated to HbA1c across the six samples and in the meta-analysis. This finding suggests that the propensity to experience distress and negative emotions is not implicated in individuals' glycemic status. Perhaps the detrimental effects of negative emotions are canceled out by better glycemic control driven by health-related worries.

The present study adds to existing knowledge by providing the most comprehensive evidence to date of the association between personality traits and HbA1c across adulthood. That is, replicable associations were found across samples with participants who ranged in age from 16 to 104. It also adds to existing models on personality and health. HbA1c could be a biological pathway that contributes to the association between personality and a range of health-related outcomes. Specifically, conscientiousness is related consistently to lower risk of dementia (Terracciano et al., 2017) and mortality (Graham et al., 2017). Elevated HbA1c is a risk factor for dementia (Ramirez et al., 2015) and mortality (Forbes et al., 2018). Therefore, conscientiousness may be related to lower dementia and higher longevity in part through its association with lower levels of HbA1c. From a practical perspective, assessment of conscientiousness may improve the identification of individuals at risk of diabetes. Furthermore, such assessment may guide personalized interventions directed toward the regulation of HbA1c level and ultimately the promotion of health among individuals low in conscientiousness.

The present study has several strengths, particularly the inclusion of six large samples of adults from different cultures, the use of validated measures of all five major dimensions of

personality, and the focus on HbA1c, an objectively assessed and clinically relevant outcome. There are also several limitations to consider. The observational design of the present study does not allow to establish causality. Reciprocal associations may exist, such that HbA1c may also be predictive of personality level and change. Longitudinal research designs are needed to test for these reciprocal associations. Moreover, further research using a facet-level measures of personality may provide a more detailed understanding of the personality-HbA1c association. Although the inclusion of an Asian sample increases the generalizability of our findings, future work should examine the conscientiousness-HbA1c association in other international samples, to test, for example, if this association replicates in countries with lower gross domestic product. Furthermore, the present study focused on a limited set of mediating variables. Future research may include additional potential mediators such as depressive symptoms and cognitive decline. Finally, the present study missed information about the extent to which participants had type 1 or type 2 diabetes.

In sum, the present study found replicable associations between personality and HbA1c in adulthood. In particular, higher conscientiousness was consistently related to lower level of HbA1c and reduced probability of diabetes diagnosis.

Declaration of Interest:
None

Ethical Approval:
The six samples received approval from their respective Institutional Review Board. All participants in each sample provided informed consent. This study was based on publicly available de-identified datasets, and therefore was exempt from Institutional Review Board review.

Data Availability:
MIDUS data are publically available at http://midus.wisc.edu/index.php. MIDJA data are publically available at http://midus.wisc.edu/index.php. HRS data are publically available at http://hrsonline.isr.umich.edu/. ELSA data are available from the UK Data Service (UKDS, https://www.ukdataservice.ac.uk/). Information on how to access the NSHAP data can be found at: http://www.norc.org/Research/Projects/Pages/national-social-life-health-and-aging-project.aspx. Data of UKHLS are available at : https://www.understandingsociety.ac.uk/.

Acknowledgment
The Midlife in the United States (MIDUS) is sponsored by the MacArthur Foundation Research Network on Successful Midlife Development, the National Institute on Aging (P01-AG020166 ; U19-AG051426), and grants from the General Clinical Research Centers Program (M01-RR023942, M01-RR00865) and the National Center for Advancing Translational Sciences (UL1TR000427). The Midlife in Japan study (MIDJA) was supported by a grant from the National Institute on Aging (5R37AG027343). The Health and Retirement Study (HRS) is sponsored by the National Institute on Aging (NIA-U01AG009740) and conducted by the University of Michigan. Funding for the English Longitudinal Study of Ageing is provided by the National Institute of Aging [grants 2RO1AG7644-01A1 and 2RO1AG017644] and a consortium of UK government departments coordinated by the Office for National Statistics. The National Health, Social Life and Aging Project (NSHAP) is supported by the National Institutes of Health, including the National Institute on Aging, the Office of Women's Health Research, the Office of AIDS Research, and the Office of Behavioral and Social Sciences Research (grants R01 AG021487, R37 AG030481, R01 AG033903, R01 AG043538, and R01 AG048511). UKHLS is primarily funded by the Economic and Social Research Council (ESRC).

References

Abdullah, A., Peeters, A., de Courten, M., Stoelwinder, J. 2010. The magnitude of association between overweight and obesity and the risk of diabetes: a meta-analysis of prospective cohort studies. Diabetes Res Clin Pract 89(3), 309-319. doi: 10.1016/j.diabres.2010.04.012.

American Diabetes Association 2010. Standards of medical care in diabetes--2010. Diabetes Care 33 Suppl 1(Suppl 1), S11–S61. doi:10.2337/dc10-S011

Baliunas, D. O., Taylor, B. J., Irving, H., Roerecke, M., Patra, J., Mohapatra, S., Rehm, J. 2009. Alcohol as a risk factor for type 2 diabetes: A systematic review and meta-analysis. Diabetes Care 32(11), 2123–2132. doi:10.2337/dc09-0227

Barnes, D. E., Yaffe, K. 2011. The projected effect of risk factor reduction on Alzheimer's disease prevalence. The Lancet Neurology 10(9), 819-828. doi: 10.1016/S1474-4422(11)70072-2.

Biessels, G. J., Despa, F. 2018. Cognitive decline and dementia in diabetes mellitus: mechanisms and clinical implications. Nat Rev Endocrinol. 14, 591–604. doi: 10.1038/s41574-018-0048-7.

Čukić, I., Mõttus, R., Luciano, M., Starr, J. M., Weiss, A., Deary, I. J. 2015. Do personality traits moderate the manifestation of type 2 diabetes genetic risk?. J Psychosom Res. 79(4), 303-308. doi: 10.1016/j.jpsychores.2015.07.003.

Čukić, I., Mõttus, R., Realo, A., Allik, J. 2016. Elucidating the links between personality traits and diabetes mellitus: Examining the role of facets, assessment methods, and selected mediators. Pers Individ Dif. 94, 377-382. doi: 10.1016/j.paid.2016.01.052

Čukić, I., Weiss, A. 2014. Personality and diabetes mellitus incidence in a national sample. J Psychosom Res. 77(3), 163-168. doi: 10.1016/j.jpsychores.2014.07.004.

Hakulinen, C., Elovainio, M., Batty, G. D., Virtanen, M., Kivimäki, M., Jokela, M. 2015. Personality and alcohol consumption: Pooled analysis of 72,949 adults from eight cohort studies. Drug Alcohol Depend. 151, 110-114. doi: 10.1016/j.drugalcdep.2015.03.008.

Forbes, A., Murrells, T., Mulnier, H., Sinclair, A. J. 2018. Mean HbA1c, HbA1c variability, and mortality in people with diabetes aged 70 years and older: a retrospective cohort study. Lancet Diabetes Endocrinol. 6(6), 476-486. doi: 10.1016/S2213-8587(18)30048-2.

Graham, E. K., Rutsohn, J. P., Turiano, N. A., Bendayan, R., Batterham, P. J., Gerstorf, D., et al. 2017. Personality predicts mortality risk: An integrative data analysis of 15 international longitudinal studies. J Res Pers. 70, 174-186. doi: 10.1016/j.jrp.2017.07.005

Hayes, A. F. 2013. An introduction to mediation, moderation, and conditional process analysis: A regression-based approach. New York, NY: Guilford Press.

Hill, P. L., Roberts, B. W. 2011. The role of adherence in the relationship between conscientiousness and perceived health. Health Psychol. 30(6), 797–804. doi:10.1037/a0023860

James, S. L., Abate, D., Abate, K. H., Abay, S. M., Abbafati, C., Abbasi, N., et al. 2018. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet 392, 1789-1858. doi: 10.1016/S0140-6736(18)32279-7.

Jokela, M., Elovainio, M., Nyberg, S. T., Tabák, A. G., Hintsa, T., Batty, G. D., Kivimäki, M. 2014. Personality and risk of diabetes in adults: Pooled analysis of 5 cohort studies. Health Psychol. 33(12), 1618-1621.doi: 10.1037/hea0000003

Jansen, H., Stolk, R. P., Nolte, I. M., Kema, I. P., Wolffenbuttel, B. H. R., Snieder, H. 2013. Determinants of HbA1c in nondiabetic Dutch adults: genetic loci and clinical and lifestyle

parameters, and their interactions in the Lifelines Cohort Study. J Intern Med. 273(3), 283-293. doi: 10.1111/joim.12010.

Joseph, J. J., Echouffo-Tcheugui, J. B., Golden, S. H., Chen, H., Jenny, N. S., Carnethon, M. R., et al. 2016. Physical activity, sedentary behaviors and the incidence of type 2 diabetes mellitus: the Multi-Ethnic Study of Atherosclerosis (MESA). BMJ Open Diabetes Res Care. 4(1), e000185. doi: 10.1136/bmjdrc-2015-000185.

Knutson, K. L., Ryden, A. M., Mander, B. A., Van Cauter, E. 2006. Role of sleep duration and quality in the risk and severity of type 2 diabetes mellitus. Arch Intern Med. 166(16), 1768-1774. doi:10.1001/archinte.166.16.1768

Luchetti, M., Barkley, J. M., Stephan, Y., Terracciano, A., Sutin, A. R. 2014. Five-Factor Model personality traits and inflammatory markers: New data and a meta-analysis. Psychoneuroendocrinology 50, 181-193. doi: 10.1016/j.psyneuen.2014.08.014.

Luchetti, M., Sutin, A. R., Delitala, A., Stephan, Y., Fiorillo, E., Marongiu, M., et al. 2018. Personality traits and facets linked with self-reported alcohol consumption and biomarkers of liver health. Addict Behav. 82, 135-141. doi: 10.1016/j.addbeh.2018.02.034.

McCrae, R. R., John, O. P. 1992. An introduction to the five-factor model and its applications. J Pers. 60(2), 175-215. doi: 10.1111/j.1467-6494.1992.tb00970.x

Menke, A., Casagrande, S., Geiss, L., Cowie, C. C. 2015. Prevalence of and trends in diabetes among adults in the United States, 1988-2012. JAMA 314(10), 1021-1029. doi: 10.1001/jama.2015.10029.

Mõttus, R., McNeill, G., Jia, X., Craig, L. C. A., Starr, J. M., Deary, I. J. 2013. The associations between personality, diet and body mass index in older people. Health Psychol. 32(4), 353-360. doi : 10.1037/a0025537

NCD Risk Factor Collaboration. 2016. Worldwide trends in diabetes since 1980: a pooled analysis of 751 population-based studies with 4· 4 million participants. The Lancet 387(10027), 1513-1530. doi: 10.1016/S0140-6736(16)00618-8.

Sutin, A. R., Stephan, Y., Terracciano, A. 2018. Facets of conscientiousness and objective markers of health status. Psychol Health. 33, 1100-1115. doi: 10.1080/08870446.2018.1464165

Phillips, A. S., Guarnaccia, C. A. 2016. The five-factor model of personality and self-reported versus biomarker diabetic control. J Health Psychol. 21(10), 2328-2338. doi: 10.1177/1359105315576349.

Skinner, T. C., Bruce, D. G., Davis, T. M. E., Davis, W. A. 2014. Personality traits, self-care behaviours and glycaemic control in Type 2 diabetes: The Fremantle Diabetes Study Phase II. Diabet Med. 31(4), 487-492.

Soto, C. J., John, O. P. 2017. Short and extra-short forms of the Big Five Inventory–2: The BFI-2-S and BFI-2-XS. J Res Pers. 68, 69-81. doi: 10.1016/j.jrp.2017.02.004

Ramirez, A., Wolfsgruber, S., Lange, C., Kaduszkiewicz, H., Weyerer, S., Werle, J., et al. 2015. Elevated HbA1c is associated with increased risk of incident dementia in primary care patients. J Alzheimers Dis. 44(4), 1203-1212. doi: 10.3233/JAD-141521.

Spears, S. K., Montgomery-Downs, H. E., Steinman, S. A., Duggan, K. A., Turiano, N. A. 2019. Sleep: A pathway linking personality to mortality risk. J Res Pers. 81, 11-24.

Stephan, Y., Sutin, A. R., Bayard, S., Križan, Z., Terracciano, A. 2018. Personality and sleep quality: Evidence from four prospective studies. Health Psychol. 37(3), 271-281. doi: 10.1037/hea0000577

Strickhouser, J. E., Zell, E., & Krizan, Z. (2017). Does personality predict health and well-being? A metasynthesis. Health Psychol. 36(8), 797-810 doi : 10.1037/hea0000475

Sutin, A. R., Stephan, Y., Luchetti, M., Artese, A., Oshio, A., Terracciano, A. 2016. The five-factor model of personality and physical inactivity: A meta-analysis of 16 samples. J Res Pers. 63, 22-28. doi: 10.1016/j.jrp.2016.05.001

Sutin, A. R., Stephan, Y., Terracciano, A. 2018. Facets of conscientiousness and objective markers of health status. Psychol Health. 33(9), 1100-1115. doi: 10.1080/08870446.2018.1464165.

Sutin, A. R., Terracciano, A. 2016. Five-factor model personality traits and the objective and subjective experience of body weight. J. Pers. 84(1), 102-112.

Terracciano, A., Schrack, J. A., Sutin, A. R., Chan, W., Simonsick, E. M., Ferrucci, L. 2013. Personality, metabolic rate and aerobic capacity. *PloS One 8*(1), e54746. doi : 10.1371/journal.pone.0054746

Terracciano, A., Stephan, Y., Luchetti, M., Albanese, E., Sutin, A. R. 2017. Personality traits and risk of cognitive impairment and dementia. J Psychiatr Res. 89, 22–27. doi:10.1016/j.jpsychires.2017.01.011

Waller, D., Johnston, C., Molyneaux, L., Brown-Singh, L., Hatherly, K., Smith, L., Overland, J. 2013. Glycemic control and blood glucose monitoring over time in a sample of young Australians with type 1 diabetes: the role of personality. Diabetes Care 36(10), 2968–2973. doi:10.2337/dc12-1743

Wang, X., Bao, W., Liu, J., Ouyang, Y. Y., Wang, D., Rong, S., et al. 2013. Inflammatory markers and risk of type 2 diabetes: a systematic review and meta-analysis. Diabetes Care 36(1), 166–175. doi:10.2337/dc12-0702

Weston, S. J., Hill, P. L., Jackson, J. J. 2015. Personality traits predict the onset of disease. Soc Psychol Personal Sci. 6(3), 309-317. doi: 10.1177/1948550614553248

Weston, S. J., Edmonds, G. W., Hill, P. L. 2020. Personality traits predict dietary habits in middle-to-older adults. Psychol Health Med. 25(3), 379-387. doi : 10.1080/13548506.2019.1687918.

Wheeler, K., Wagaman, A., McCord, D. 2012. Personality traits as predictors of adherence in adolescents with type I diabetes. J Child Adolesc Psychiatr Nurs. 25(2), 66-74. doi : 10.1111/j.1744-6171.2012.00329.x

Zimprich, D., Allemand, M., Lachman, M. E. 2012. Factorial structure and age-related psychometrics of the MIDUS personality adjective items across the lifespan. Psychol Assess. 24, 173–186. doi : 10.1037/a0025265

Table 1. *Characteristics of the Samples*

	MIDUS		MIDJA		HRS		ELSA		NSHAP		UKHLS	
Variables	*M/%*	*SD*	*M/%*	*SD*	*M/%*	*SD*	*M/%*	*SD*	*M/%*	*SD*	*M/%*	*SD*
Age (Years)	55.34	11.77	54.08	14.06	67.88	10.23	65.76	8.02	72.47	7.08	51.34	16.54
Sex (% women)	55%	-	56%	-	59%	-	55%	-	53%	-	56%	-
Race (% Non White)	5%	-	100%	-	21%	-	2%	-	15%	-	4%	-
Education[a]	7.76	2.46	13.78	2.54	13.12	2.87	4.31	2.19	2.79	1.00	7.66	6.51
Self-reported diabetes (%)	8%	-	5%	-	25%	-	8%	-	23%	-	6%	-
Body Mass Index[a]	29.11	5.87	22.58	2.94	29.80	6.16	28.02	4.98	29.36	6.18	27.90	5.38
Physical Activity[a]	3.87	1.63	2.18	1.53	2.45	1.09	2.69	0.93	2.71	1.85	-	-
Neuroticism[a]	2.01	0.62	2.13	0.58	2.00	0.62	2.09	0.59	2.40	0.59	3.49	1.44
Extraversion[a]	3.13	0.57	2.45	0.66	3.17	0.57	3.18	0.55	3.20	0.56	4.64	1.31
Openness[a]	2.96	0.52	2.22	0.58	2.91	0.57	2.90	0.53	2.92	0.65	4.58	1.29
Agreeableness[a]	3.43	0.51	2.68	0.63	3.50	0.50	3.52	0.47	3.47	0.51	5.67	1.00
Conscientiousness[a]	3.40	0.45	2.65	0.55	3.37	0.48	3.32	0.48	3.36	0.55	5.54	1.08
HbA1c	5.98	0.88	5.12	0.61	5.91	0.99	5.91	0.74	5.88	0.75	5.53	0.72
HbA1c (% equal or above 6.5%)	12.35		3.98		17.17		10.29		12.39		5.08	
Undiagnosed diabetes	6.63		1.67		5.18		4.31		2.56		1.45	

Note. MIDUS:

N= 988; MIDJA: N= 377; HRS: N= 9745; ELSA: N= 4656; NSHAP: N= 1888; UKHLS: N= 8417. Ns were lower for BMI and physical activity, due to missing data.

[a] See method section for differences in measures used in each sample

Table 2.
Summary of Regression Analysis Predicting HbA1C from Personality Traits in the Six Samples

	Neuroticism β	Extraversion β	Openness β	Agreeableness β	Conscientiousness β
MIDUS[a]	-0.02(-0.09;0.04)	0.10**(0.04;0.16)	0.05(-0.01;0.11)	0.07*(0.01;0.14)	-0.01(-0.07;0.05)
MIDJA[b]	-0.01(-0.11;0.09)	-0.05(-0.15;0.04)	-0.10*(-0.20;-0.004)	-0.06(-0.15;0.04)	-0.10*(-0.20;-0.008)
HRS [a]	0.01(-0.005; 0.03)	-0.04***(-0.06; -0.02)	-0.02(-0.04;0.003)	-0.02*(-0.04;-0.0008)	-0.06***(-0.08;-0.04)
ELSA [a]	0.02(-0.004;0.05)	-0.09***(-0.12;-0.06)	-0.03(-0.06;0.003)	-0.03*(-0.06;-0.005)	-0.09***(-0.12;-0.06)
NSHAP[a]	-0.01(-0.06;0.03)	-0.08***(-0.12;-0.03)	-0.05*(-0.10;-0.006)	-0.03(-0.08;0.02)	-0.05*(-0.10;-0.007)
UKHLS[a]	-0.01(-0.03;0.01)	0.01(-0.01;0.03)	-0.01(-0.03;0.01)	-0.01(-0.03;0.007)	-0.04***(-0.06;-0.02)
Random Effect	0.002	-0.027	-0.021*	-0.015	-0.06***
	(-0.010;0.015)	(-0.072;0.018)	(-0.041;0.000)	(-0.035;0.005)	(-0.078;-0.037)
Heterogeneity Tau	0.000	0.051	0.017	0.016	0.017

Note. MIDUS: N= 988; MIDJA: N= 377; HRS: N= 9745; ELSA: N= 4656; NSHAP: N= 1888; UKHLS: N= 8417; β = Standardized regression coefficient

[a] Adjusted for age, sex, education, and race

[b] Adjusted for age, sex, education

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 3. *Summary of Bootstrap Analysis*

Variables	Bootstrap Analysis[b]				
	Neuroticism	Extraversion	Openness	Agreeableness	Conscientiousness
MIDUS[a]					
BMI	-.003(-.018; .011)	-.017(-.036;-.002)	-.011(-.029;.006)	-.014(-.003;.034)	-.015(-.037;.005)
Physical activity	.002 (-.003;.008)	-.013(-.027; -.002)	-.007(-.018;.005)	-.000(-.007;.007)	-.004(-.013;.023)
Direct effect[c]	-.02	.12***	.06	.07*	.00
MIDJA[a]					
BMI	-.017(-.042;.004)	.022(.003;.047)	.003(-.019;.025)	.013(-.005;.035)	-.005(-.030;.016)
Physical activity	-.0001(-.008;.006)	-.002(-.016;.010)	-.002(-.012;.007)	-.002(-.014;.008)	-.003(-.019;.013)
Direct effect[c]	-.04	-.07	-.10*	-.06	-.06
HRS[a]					
BMI	-.008(-.014;-.001)	-.018(-.025;-.010)	-.006(-.013;.001)	.003(-.005; .010)	-.025(-.035;-.017)
Physical activity	.012(.008; .016)	-.026(-.034;-.018)	-.019(-.026;-.013)	-.009(-.014;-.006)	-.022(-.029;-.015)
Direct effect[c]	.01	-.01	-.00	-.01	-.03***
ELSA[a]					
BMI	-.004(-.012;.005)	-.011(-.021;-.002)	.004(-.005;.013)	.010(-.0008;.020)	-.025(-.037;-.014)
Physical activity	.008(.003;.013)	-.021(-.030;-.013)	-.014(-.021;-.008)	-.001(-.006;.003)	-.017(-.026;-.010)
Direct effect[c]	.02	-.06***	-.01	-.04*	-.06***
NSHAP[a]					

BMI	-.002(-.007;.004)	-.003(-.009;.002)	-.002(-.007;.004)	-.001(-.007;.004)	-.007(-.014;-.001)
Physical activity	.004(-.000;.008)	-.013(-.022;-.005)	-.012(-.019;-.005)	-.005(-.010;-.001)	-.013(-.021;-.006)
Direct effect[c]	-.02	-.06**	-.04	-.03	-.03
UKHLS[a]					
BMI	-.001(-.003;.0008)	.004(.002;.007)	-.003(-.006;-.001)	-.0008(-.004;.002)	-.008(-.011;-.005)
Physical activity	-	-	-	-	-
Direct effect[c]	-.01	.01	-.01	-.01	-.03*
Meta-Analysis					
BMI					
Random Effect	-0.004(-0.017;0.008)	-0.008(-0.020;0.005)	-0.001(-0.013;0.011)	0.002(-0.010;0.015)	-0.017(-0.030;-0.005)
Heterogeneity Tau	0.00	0.00	0.00	0.00	0.00
Physical Activity					
Random Effect	0.009(-0.006;0.024)	-0.022(-0.037;-0.007)	-0.016(-0.030;-0.0007)	-0.006(-0.021;0.009)	-0.018(-0.033;-0.003)
Heterogeneity Tau	0.00	0.00	0.00	0.00	0.00
Direct Effect					
Random Effect	0.000(-0.012;0.014)	-0.011(-0.050;0.028)	-0.009(-0.029;0.012)	-0.014(-0.036;0.008)	-0.035(-0.047;-0.022)
Heterogeneity Tau	0.003	0.042	0.017	0.019	0.00

Note. * p<.05, ** p<.01,*** p< .001

MIDUS: N= 986; MIDJA: N=372; HRS: N= 9075; ELSA: N= 4525; NSHAP: N= 1822; UKHLS: N= 8223

[b] Bootstrap estimates and 95% bias-corrected confidence interval for indirect effects of personality traits on HbA1c through BMI and physical activity, controlling for age, sex, education, and race (except for the MIDJA).

[c] Direct effect of personality traits on HbA1C adjusted for mediators, age, sex, education, and race (except for the MIDJA); Coefficients are standardized regression coefficient

Table 4.

Summary of Logistic Regression Analysis Predicting Clinical Threshold of HbA1c from Personality Traits in the Six Samples

	Neuroticism	Extraversion	Openness	Agreeableness	Conscientiousness
MIDUS[a]	1.03 (0.84-1.27)	1.14 (0.93-1.40)	1.01 (0.82-1.23)	1.18 (0.95-1.47)	0.90 (0.74-1.10)
MIDJA[b]	1.00 (0.61-1.64)	0.63 (0.34-1.14)	0.52* (0.28-0.97)	0.78 (0.44-1.37)	0.49* (0.26-0.91)
HRS[a]	1.07* (1.01-1.13)	0.89*** (0.85-0.94)	0.95 (0.90-1.01)	0.95* (0.90-1.00)	0.88*** (0.83-0.92)
ELSA[a]	1.04 (0.95-1.15)	0.80*** (0.73-0.88)	0.98 (0.89-1.07)	0.94 (0.85-1.03)	0.78*** (0.71-0.85)
NSHAP[a]	1.00 (0.94-1.06)	0.78*** (0.68-0.90)	0.81** (0.71-0.94)	0.90 (0.78-1.03)	0.88 (0.77-1.01)
UKHLS[a]	1.00 (0.89-1.11)	1.06 (0.96-1.17)	1.03 (0.93-1.14)	0.97 (0.88-1.07)	0.86** (0.79-0.95)
Random Effect	1.03 (1.00-1.07)	0.90 (0.81-1.01)	0.95 (0.88-1.02)	0.95* (0.92-0.99)	0.85 (0.80-0.90)***
Heterogeneity Tau	0.00	0.114	0.07	0.004	0.045

Note.
MIDUS: N= 988; MIDJA: N= 377;
HRS: N= 9745; ELSA: N= 4656;
NSHAP: N= 1888;
UKHLS: N= 8417;
[a] Adjusted for age, sex, education, and race [b] Adjusted for age, sex, education

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 5.
Summary of Logistic Regression Analysis Predicting Undiagnosed Diabetes from Personality Traits

	Neuroticism	Extraversion	Openness	Agreeableness	Conscientiousness
MIDUS	1.25 (0.94-1.66)	1.01 (0.76-1.34)	0.85 (0.65-1.13)	0.99 (0.74-1.32)	0.88 (0.67-1.15)
HRS	0.94 (0.84-1.05)	1.01 (0.90-1.12)	1.04 (0.93-1.16)	0.98 (0.88-1.08)	0.94 (0.84-1.04)
ELSA	0.95 (0.81-1.11)	0.91 (0.78-1.05)	1.08 (0.93-1.26)	0.93 (0.81-1.08)	0.80** (0.70-0.92)
NSHAP	0.96 (0.69-1.34)	1.35 (0.94-1.94)	1.27 (0.90-1.81)	1.60* (1.05-2.42)	1.35 (0.94-1.95)
UKHLS	0.98 (0.81-1.19)	1.22* (1.01-1.47)	1.14 (0.94-1.37)	1.16 (0.96-1.41)	1.13 (0.94-1.37)
Random Effect	0.97 (0.90-1.05)	1.05 (0.93-1.19)	1.06 (0.98-1.15)	1.04 (0.92-1.17)	0.97 (0.83-1.12)
Heterogeneity Tau	0.00	0.095	0.022	0.096	0.136

Note. MIDUS: N= 905; HRS: N= 7339; ELSA: N= 4272; NSHAP: N= 1445; UKHLS: N= 7923;
Adjusted for age, sex, education, and race

* $p < .05$, ** $p < .01$, *** $p < .001$