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# Personality and type 2 diabetes risk: a systematic review

**Liliana Leticia Juárez Medina** — Doctoral student, Universidad Autónoma de Nuevo León, Facultad de Enfermería - Corresponding Author

**Alexandra A. García** — Associate Professor, The University of Texas at Austin School of Nursing

**Esther C. Gallegos Cabriales** — Associate Professor, Universidad Autónoma de Nuevo León, Facultad de Enfermería.

**ABSTRACT** The aim was to examine studies that report relationships between types of personality and type 2 Diabetes Mellitus risk (T2DMR). We searched the following databases: Academic Search Complete, CINAHL, MEDLINE, PsycINFO, and PubMed. Sixteen full text articles were identified as eligible after review. Studies were grouped by the Big Five personality traits (neuroticism, extraversion, openness, agreeableness, conscientiousness); Cloninger model of temperament (novelty seeking, harm avoidance, reward dependence, and persistence); hostility, Type D personality and anger; also by design (cross-sectional or longitudinal). Neuroticism was the trait most associated with T2DMR and conscientiousness was related to health promoting behaviors. The personality types of the Cloninger Model of Temperament were not clearly associated with T2DMR. Knowledge of the association between personality and the T2DMR can be used in the context of preventive measures to identify and treat persons at risk.

**KEYWORDS** :type 2 diabetes risk, metabolic risk, personality traits, temperament.

## INTRODUCTION:

The worldwide incidence of type 2 diabetes mellitus (T2DM) has increased rapidly and there are now more than 415 million people with diabetes in the world (International Diabetes Federation, [IDF], 2015). T2DM is an epidemic resulting from obesity, physical inactivity, and unhealthy lifestyles. Risk factors for developing T2DM include advancing age, Hispanic ethnicity, family history, obesity, hypertension, high levels of cholesterol, lack of exercise, impaired glucose tolerance (IGT), impaired fasting glucose (IFG) and high levels of glycated hemoglobin (HbA1c) (American Diabetes Association [ADA], 2016). Heredity alone contributes approximately 40% of the risk for people with a first-degree relative who has T2DM (Lyssenko & Laakso, 2013). However, environmental and behavioral factors influence whether the genes associated with T2DM are activated.

Metabolic syndrome and cardiometabolic disease, as well as their individual components, are also risk factors for developing T2DM. Metabolic syndrome, which arises from insulin resistance accompanying abnormal adipose deposition and function, is diagnosed when a patient has at least three of the following related conditions: hypertension, hyperglycemia, hypertriglyceridemia, reduced high-density lipoprotein cholesterol (HDL-C) and abdominal obesity (ADA, 2016). Cardiometabolic risk refers to a similar group of risk factors that together and individually increase the likelihood of experiencing vascular disease or developing diabetes, that include age, sex, family history, hypertension, dysglycemia, dyslipidemia, smoking, abdominal obesity (measured by waist circumference), insulin resistance, inflammation as measured by high-sensitivity C-reactive protein (hsCRP) levels, lack of consumption of fruits and vegetables, sedentary lifestyle, and psychosocial stress (Chatterjee *et al*., 2012).

Besides the physiologic and behavioral risks, the risk of developing chronic diseases is also linked to various psychological factors, among them, individual personality types. Personality is the integration of all the psychological features and characteristics of the individual that determine his or her way of behaving. An individual's personality develops from the environmental, biological, and social characteristics that explain, modulate, and maintain behaviors (Montaño, Palacios & Gantiva, 2009). A personality trait is stable through time and in various circumstances, which allows predictions about behaviors.

The Five Factor Model (FFM) described by Costa and McCrae (Costa & McCrae, 1999), recognizes five personality traits: neuroticism, extraversion, openness, agreeableness, and conscientiousness as the primary drivers of behavior. The Neuroticism, Extraversion, Openness Personality Inventory Revised (NEO PI – R) scale is used to measure levels of the traits that make up the FFM (Costa & McCrae, 1999). Empirical literature has shown the usefulness of the FFM in predicting positive and negative life outcomes, including many different mental and physical disorders (Lahey, 2009). Cloninger's Psychobiological Model (Cloninger, Svrakic & Przybeck, 1991) suggests that a different set of four personality traits: novelty seeking, harm avoidance, reward dependence, and persistence are relevant drivers of behaviors. The Tridimensional Personality Questionnaire (TPQ) and the Temperament and Character Inventory (TCI) measure traits in Cloninger's model (Cloninger *et al*., 1991). The FFM and the Cloninger Psychobiological Model are similar in that both models attempt to describe differences among individual personalities and the relationships among the personality traits. Each of the Cloninger model traits is related to at least one of the traits in the FFM. For example neuroticism scores are strongly correlated with harm avoidance scores, whereas extraversion scores are negatively related to harm avoidance scores and positively related to novelty-seeking and reward dependence scores (Stallings *et al*., 1996).

Type D (Distressed) personality has been associated with an increased risk of adverse cardiac events in patients with a cardiovascular condition (Denollet, Pedersen, Vrints & Conraads, 2006), most likely through the effect of stress and emotions rather than directly on behavior. Denollet refers type D personality as a combination of negative affectivity and social inhibition (Denollet, 2005); although some theorists argue that type D personality is merely another measure of neuroticism (Lesperance & Frasure, 1996). Type D personalities are thought to experience negative emotions and inhibit the expression of these emotions in social interactions, suggesting that negative affectivity as well as how an individual copes with his or her negative emotions should be considered as risk factors for physical and mental illnesses. The scale DS14 is used to assess type D personality (Denollet, 2005).

Some studies report an association between negative emotional states, such as anger and hostility with unhealthy lifestyles that increases the risk of coronary heart diseases, diabetes, bulimic behaviors and road accidents (Staicu & Cuţov, 2010). The Cook-Medley Hostility Scale (CMHOST) is a measure of hostility (Barefoot *et al*., 1989). Trait anger is another relatively stable and enduring personality emotional state that consists of feelings that vary in intensity, from mild irritation or annoyance to intense fury and rage. The Spielberger Trait Anger Scale is used to assess trait anger, which is associated with negative health outcomes (Spielberger, Jacobs, Russell & Crane, 1983).

A recent systematic review concluded that the personality traits of neuroticism, impulsivity, and sensitivity to reward appeared to be risk factors for obesity, while responsibility and self-control appeared to protect against weight gain (Gerlach, Herpertz & Loeber, 2015). Futhermore, Mommersteeg and Pouwer systematic review (2012) concluded that a negative or hostile personality may be associated with an increased prevalence of metabolic syndrome, although there was not a clear association between personality and development of metabolic syndrome. Neither review looked at personality traits as risk factors for development of T2DM. Thus, the objective of the present systematic review was to examine studies that measured personality traits associated with T2DM and its risk factors of metabolic syndrome risk, cardiometabolic risk and their components. In this context, the research question was: What traits or personality types are related to the risk of T2DM?

## METHODS:

The search for literature was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Liberati *et al*., 2009). The following databases were searched: Academic Search Complete, Cumulative Index for Nursing and Allied Health (CINAHL), MEDLINE, PsycINFO and PubMed. Search terms were combined according to standard Medical Subject Headings (MeSH). The terms used to search PubMed were: ((Diabetes risk OR diabetes type 2 risk OR diabetes type II risk OR nondiabetic OR development diabetes OR metabolic risk OR prediabetes OR cardio metabolic risk)) AND (Personality type [Title] OR personality traits [Title] OR big five [Title] OR neuroticism [Title] OR temperament [Title]). For the other four databases the terms were: ((Diabetes risk OR diabetes type 2 risk OR diabetes type II risk OR nondiabetic OR development diabetes OR metabolic risk OR prediabetes OR cardio metabolic risk) AND (Personality OR personality traits OR big five OR neuroticism OR temperament)). We included in the search the cardiometabolic risk and metabolic risk terms because they are precursors to T2DM. The limiters used in all database searches were: journal articles published since January 1992 (coinciding with the publication of the FFM and Cloninger's Psychobiological Model); in English or Spanish that included analyses of correlation or association. Articles were excluded if they addressed type 1 diabetes or participants were children.

The search of the databases produced 145 articles from which 34 duplicates were removed. The titles and abstracts of the remaining 111 were screened and 84 more studies were removed because they did not meet the eligibility criteria. Twenty-seven full-text articles were identified as eligible. In case of uncertainty as to whether an article met the exclusion or inclusion criteria, the three authors conferred until consensus was met. In the last phase the entire articles were reviewed, leaving a total of 16 studies that met the inclusion criteria (Figure 1).

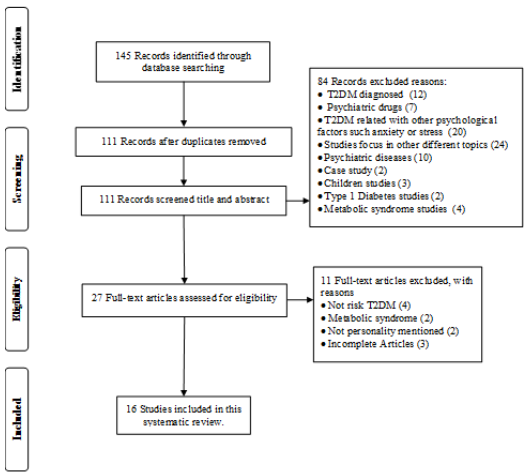


**Figure 1**. Flow chart for study selection.

We created two tables for data extraction based on the Cochrane Consumers and Communication Review Group's data extraction template (Cochrane, 2015); one for the cross-sectional studies and the other for longitudinal designs. The following data were extracted for each article: general information about the article (name of author, date, country), participants (sample, female percent, mean age), diabetes risk factors included in the study, study methods (statistical analysis, personality scale), and results (by personality trait or type).

## RESULTS:

Sixteen articles were selected for the systematic review. Studies were grouped by design, either cross-sectional or longitudinal, and by personality group, as part of the FFM, Cloninger's Psycho behavioral Model, Type D, or anger and hostility. The studies and their findings are described below.

**Association between personality and T2DM risk – cross-sectional studies**

Eight cross-sectional studies examined the link between personality traits and risk factors for T2DM; four from the USA, two from the Netherlands, one from Korea and one from Switzerland. The samples were composed of mostly female participants (61.9%), ranging in age from 20 – 56 years. Sample sizes ranged from 98 – 2,755. The studies explored several risks for T2DM, with BMI the most common along with glucose and insulin levels, HDL-C, blood pressure values, and diagnosis of cardiometabolic risk and metabolic syndrome. The personality traits or types examined were five personality types, hostility, and Type D personality. The results of cross-sectional studies are summarized in Table 1.

***Big five personality types (neuroticism, extraversion, openness, agreeableness, conscientiousness) and T2DM risk.***

Five studies cross-sectional measured the five personality traits in relation to T2DM risk. Neuroticism was significantly associated with T2DM risk in three of them but was not associated with T2DM in the other two. Tsenkova and colleagues (2012) showed a positive association of neuroticism with insulin level (r= .08, p= .01), index of insulin resistance (r= .08, p= .01), and negative association with HbA1c (r= .07, p= .03). In that study neuroticism interacted with BMI to predict insulin ($R^2$= 0.34, β= 0.05, p< .05) and insulin resistance ($R^2$=0.34, β= 0.05, p< .05) in 972 non-diabetic adults (85% White, 57% female). Dermody (*et al*., 2015) showed a positive association of neuroticism with cardiometabolic risk (β= .09; p= .056) in a sample of 856 adults free of cardiovascular disease or diabetes (54% female, 86% White). Hengartner (*et al*., 2016) found an association between neuroticism and total cholesterol (β=0.308, $R^2$=0.095, p< 0.001) and C - reactive protein (β= 0.187, $R^2$= 0.062) in 1125 randomly chosen Swiss residents (54% women).

Extraversion was slightly negatively associated with abnormal glucose regulation (β= -0.16, p= 0.026; OR 0.97, 95 % CI 0.95–0.99, p= 0.011) in Shim (*et al*., 2014) study of 1617 female Koreans not previously diagnosed with diabetes, however other personality traits were not associated with glucose regulation. In two of the five studies in which it was measured, openness was associated with T2DM risk. Dermody (*et al*., 2015) found a small and negative relationship between openness and cardiometabolic risk (β= −0.13, p= .004, $R^2$= .02), but Van Reedt Dortland (*et al*., 2011) found a negative association of openness with triglycerides (TG, β= −.090, p= <.001) and systolic blood pressure (SBP, β= −.042, p= .01) in a sample of 2755 patients with anxiety or depression (66% female) in the Netherlands. Agreeableness had a small negative association with cardiometabolic risk (β= −0.11, p= .02, $R^2$= .01); (Dermody *et al*., 2015) and overall metabolic risk, WC, and TG (β= −.050; p= .002) (Van Reedt Dortland *et al.*, 2011). Conscientiousness was negatively associated with cardiometabolic risk (β= −0.15, p= .001, $R^2$= .02); (Dermody *et al*., 2015) and C-reactive protein (β= 0.195); (Hengartner *et al*., 2016). Combined with neuroticism, conscientiousness was significantly related to C-reactive protein ($R^2$ = 0.062), (Hengartner *et al*., 2016).

***Hostility, Type D personality and T2DM risk***

Hostility was correlated with insulin sensitivity (r= 0.24; p ≤ 0.05) and fasting glucose in African-Americans (r= 0.41; p ≤ 0.01), and fasting glucose levels (r= 0.29, p ≤ 0.05) and insulin sensitivity (r= 0.50; p ≤ 0.01) in women (both African American and White) in USA in Surwit (*et al*., 2002) study of 98 healthy participants (64% African American, 57% female). Hostility was correlated with glucose effectiveness (β= −0.39, p= .04) in African American women in another Surwit (*et al*., 2009) study of 115 participants (50.4% African American, 49.6% white). Mommersteeg (*et al*., 2010) found that type D personality was related to a two-fold increase in risk of metabolic syndrome (OR= 2.2,

95% CI= 1.2-4.0, p= .011) and that persons with Type D personality adhered less to physical activity (OR= 1.5, 95%CI= 1.1-2.0, p= .02), had a less varied diet (OR= 0.50, 95% CI= 0.40-0.70, p< .0005), and were less likely to restrict their fat intake (OR= 0.70, 95%CI = 0.50-0.90, p= .01). In addition Type D personality was positively associated with abnormal lipid levels (p=0.007) and high blood pressure (p=.040) in a Dutch sample (N=1592, 50% female); (Mommersteeg *et al*., 2010).

In summary, the cross sectional studies showed that neuroticism was positively associated with the T2DM risk factors insulin resistance and cardiometabolic risk in three studies. Extraversion was negatively associated with abnormal glucose regulation just in one study. Openness and agreeableness were negative associated with T2DM risk cardiometabolic risk and metabolic syndrome risk in two studies. Conscientiousness was positive associated with cardiometabolic risk. Hostility was correlated with insulin resistance in African American women and Type D personality showed the strongest association with a twofold increased risk of metabolic syndrome.

Table 1. Cross-sectional studies on personality and type 2 diabetes risk

| Author (Date) Country | N Fem% Mean age | Diabetes risk factors | Stat analysis | Scale | Results | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Neuroticisı | Extrave sion | Openness | Agreeable ness | Conscienti ousness | Hostility | Type D |
| Dermody *et al*., (2015) USA | 856 54% 44.3 | 1 – 6 | SEM | NEO PI-R | (+) CMR | NR | (-) CMR | (-) CMR | (-) CMR | NM | NM |
| Hengartner *et al*., (201 Switzerland | 1,155 54.4% 29.6 | 2, 4,6,7,8 | MRM | NEO PI-R Germa adaptation | (+) HDL-C, LDL-C (+)CRP | NR | NR | NR | (+) CRP | NM | NM |
| Mommersteeg *et al*., (2010) Netherland | 1,592 50.4% 46.9 | 2,3,4,5,6 ,9,10,11 | MLR | DS14 | NM | NM | NM | NM | NM | NM | (+) MSR (-)PA (-)HD (+)HDLC (+) HBP |
| Shim *et al*., (2013) Korea | 1,617 100% 25±4 | 2,4,6, 12,13 | MRM | NEO PI- R Korean version | NR | (-) AGR | NR | NR | NR | NM | NM |
| Surwit *et al*., (2002) USA | 98 57% 33.2 | 2,14,16 | MRM | CM HOST | NM | NM | NM | NM | NM | (+) 16 women (+) 16 African(-) American | NM |
| Surwit *et al*., (2009) USA | 115 56% 34.7±5.2 | 2,9,16 | MRM | CM HOST | NM | NM | NM | NM | NM | (-) 17 African American women | NM |
| Tsenkova *et al*., (2012) USA | 952 57% 56.6 | 2,14,15 | MRM | NEO PI- R | (+)insulin (+)16 (-)HbA1c | NM | NM | NM | NM | NM | NM |
| Van Reedt Dortland *et al*., (2011)Netherlands | 2,755 66.4% 41.9 | 1,3,4,5,6 | MRM | NEO PI-R | NR | NR | (-)MSR (+)HDLC (-)TG(- )WC | (-)MSR (-)TG (-)WC | NM | NM | NM |

1.High glucose, 2.BMI body mass index, 3.WC waist circumference, 4.HDL- C, high density lipoprotein cholesterol, 5.TG triglycerides, 6.HBP high blood pressure, 7. LDL- C low density lipoprotein cholesterol, 8.CRP (C- reactive protein), 9.PA physical activity, 10. HD healthy diet; 11.cardiac disease, 12.family history, 13.AGR Abnormal glucose regulation, 14.HOMA, homeostatic model assessment, 15.HbA1c, glycated haemoglobin, 16.Fasting glucose and insulin sensitivity. 17.Glucose effectiveness. CMHOST, Cook-Medley hostility scale; CMR, cardiometabolic risk; DS14, Type D Scale 14-item; MSR, metabolic syndrome risk; NEOPI-R, Neuroticism, Extraversion, Openness Personality Inventory Revised; SEM, Structural equation modeling; MRM, Multiple regression model; MLR, Multiple logistic regression. NR, Not related; NM, Not measure; (+), positive association; (-), negative association.

**Association between personality and T2DM risk – longitudinal studies:**

Eight longitudinal studies, four from USA, three from Finland and one from Scotland, were reviewed. The samples were mostly female (55.2.8%) and only one study's sample was entirely male. The ages ranged from 29 – 69 years. The follow-up period ranged from 3 – 31 years. Factors evaluated as risks for T2DM were BMI, the most commonly measured; glucose, HDL-C, insulin levels; blood pressure, insulin resistance, and cardiometabolic risk. The personality traits measured were the FFM types (neuroticism, extraversion, openness, agreeableness, conscientiousness), the Cloninger Model of types (novelty seeking, harm avoidance, reward dependence, and persistence), and anger. The longitudinal studies are summarized in Table 2. ***Big five personality types (neuroticism, extraversion, openness, agreeableness, conscientiousness) and T2DM risk.***

Čukić & Weiss (2014) found that lower neuroticism was associated with decreased risk for T2DM (26% per standard deviation) even after controlling for ethnicity and age in a ten year follow-up period in a USA nationwide probability sample of 6798 mostly White (89.3%) and female (67.3%) participants. Wickrama (*et al*., 2015) and Jokela (*et al*., 2013) found no significant association between neuroticism and T2DM risk. Higher extraversion was significantly associated with decreased T2DM risk associated with age and being black (17% per standard deviation); (Čukić & Weiss, 2014). However, the studies of Čukić (*et al*., 2015) conducted in Scotland with 837 participants (51% female) over 3-years and Wickrama (*et al*., 2015) with 12,424 young adults (53% female and 61%) followed for 13 years did not find a significant association between extroversion and T2DM risk. Lower levels of openness were related to increased levels of HbA1c (β= −0.014, p= .032); (Čukić *et al*., 2015) but were not significantly correlated in the other studies (Čukić & Weiss, 2014; Wickrama *et al*., 2015). Lower level of agreeableness predicted T2DM genetic risk score and HbA1c (β= −0.08, p= .021); (Čukić *et al*., 2015) but was not significantly correlated in Wickrama study (*et al*., 2015). Finally, lower levels of conscientiousness were associated with a stronger association between T2DM genetic risk score and HbA1c levels (β=0.09, p = .04); (Čukić *et al*., 2015). Wickrama (*et al*., 2015) found that people who

scored higher in conscientious exhibited less cardiometabolic risk (β= -.04, $R^2$= .10). Jokela (*et al*., 2013) found that low conscientiousness was associated with an elevated diabetes risk (OR= 0.87, 95% CI= 0.82– 0.91 per 1 standard deviation increment in conscientiousness).

**Cloninger's Psychobiological Model, anger and diabetes risk:**

Of the two studies that evaluated the traits from Cloninger's Psychobiological Model, Keltikangas-Jarvinen (*et al*., 1999) showed data from 182 Finnish men formed four clusters of temperament types. The level for metabolic risk factors at years 0, 3 and 6 was highest among men belonging to a cluster characterized by high persistence, reward dependence, low harm avoidance, and an average level of novelty seeking. In another Finnish sample (n= 4364, 55% female), Sovio (*et al*., 2007) showed that novelty seeking was positively associated with waist circumference and triglycerides in men and waist circumference in women, positively associated with triglycerides in men, and with smoking in both genders. Harm avoidance was positively associated with high levels of SBP in men and with HDL-C and glucose in women. Persistence was inversely related to SBP in men and in women. Reward dependence showed a significant inverse trend with SBP only in women (Sovio *et al*., 2007). Individuals in the highest tertile of trait anger scores had a 34% increased risk of developing diabetes (RH=1.34; 95% confidence interval: 1.10, 1.62) in a sample of 11,615 non-diabetic adults (66% African American) followed for 6 years (Golden *et al*., 2006). Abraham (*et al*., 2015) showed data from a multi-ethnic study of Atherosclerosis (White, Black, Hispanic and Chinese) in a sample of 5598 followed for 11.4 years and high total trait anger was associated with incident T2DM (HR= 1.50; 95% CI 1.08-2.07) relative to low total trait anger; higher anger reaction was also associated with incident T2DM (HR = 1.07; 95% CI 1.03-1.11).

In summary, in longitudinal studies lower neuroticism was associated with lower risk of T2DM risk in one study. Higher extraversion, openness, and agreeableness were associated with decreased T2DM risk. In two studies conscientiousness was negatively associated with T2DM and cardiometabolic risk. High persistence, high reward dependence, low harm avoidance, and an average level of novelty seeking were also related to a high level of cardiometabolic risk in men but low persistence was related to elevated SBP, WC, fasting glucose, TG levels and low HDL-C in women. Anger temperament was a significant risk factor for T2DM. There was more consistency among the longitudinal studies.

Table 2. Longitudinal studies on personality and type 2 diabetes risk

| Author (Date) Country | N %F age | FU | DM risk factors | Statistical analysis *Scale* | Results | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Neuroticism | Extraversion | Openness | Agreeableness | Conscientious ness | Novelty seeking | Harm avoid | Persistence | Reward Dep | Anger |
| Abraham *et al.,* (2015) USA | 5598 53.2%f 61.6 | 11.4 | 1-5 11-14 | MRM *STAS* | NM | NM | NM | NM | NM | NM | NM | NM | NM | (+) T2DM incidence |
| Čukić *et al*., (2014) USA | 6,798 64.4%f 63.8 | 10 | 5,9 | MLR *NEOPI-R* | (-) T2DMR | (+) T2DM incidence | NR | NM | NM | NM | NM | NM | NM | NM |
| Čukić *et al.,* (2015) Scotland | 837 51%f 69.5 | 3 | 8,16 | MLR *NEOPI-R* | NR | NR | (-) HbA1c | (-) T2DM-PR(-) HbA1c | (-) T2DM-PR(-) HbA1c | NM | NM | NM | NM | NM |
| Golden *et al*., (2005) USA | 11,615 53.8%f 56.6 | 6 | 3,5,6 11-15 17,18 | MRM *STAS* | NM | NM | NM | NM | NM | NM | NM | NM | NM | (+) T2DMR |
| Jokela *et al*., (2013) Finland | 34,913 57%f 53.7 | 5.7 | 2,3,5 | Meta-analysis MRM *NEOPI-R* | NR | NR | NR | NR | (-) T2DMR | NM | NM | NM | NM | NM |
| Keltikan Jarvinen *et al*., (1999) Finland | 190 0%f 29 to 35 | 17 | 3,11, 12,151 9 | SEM MRM *TCI* | NM | NM | NM | NM | NM | (+) CMR | (-) CMR | (+) CMR | (+) CMR | NM |
| Sovion *et al*., (2007) Finland | 4,364 54.5%f 31 | 31 | 5,11, 13,15, 18 | MRM *TCI* | NM | NM | NM | NM | NM | (+) WC (+)TG, men (+) smoking | (+) SPB, men (+) HDLC, women | (-) SPB (-) glucose women (-)TG | (-)SPB women | NM |
| Wickram *et al*., (2015) USA | 12,424 53%f 29.13 | 13 | 3,7,8 11,12, 15,18, 20 | SEM *IPIP-BF* | NR | NR | NR | NR | (-) CMR | NM | NM | NM | NM | NM |

1. Age, 2. BP, Blood pressure, 3.BMI, body mass index, 4.Race, 5.smoking, 6.CI, caloric intake, 7.DBP, diastolic blood pressure, 8. HbA1c, glycated haemoglobin, 9.HBP, high blood pressure, 10. HD, healthy diet, 11.HDL- C, high density lipoprotein cholesterol, 12.TG, triglycerides, 13.WC, waist circumference, 14.PA, physical activity, 15.SBP, systolic blood pressures, 16.T2DM-PR type 2 diabetes mellitus polygenic risk, 17.insulin, 18.glucose, 19. IRS, insulin resistance syndrome, 20. LDL- C, low density lipoprotein cholesterol. CMR, cardiometabolic risk;T2DMR, type 2 diabetes mellitus risk; IPIP-BF, International Personality Item Pool five-factor; NEOPI-R, Neuroticism, Extraversion, Openness Personality Inventory Revised; SEM, structural equation modeling; STAS, Spielberger Trait Anger Scale; TCI, Temperament and Character Inventory. MRM, Multiple regression model; MLR, Multiple logistic regression. NR, Not related; NM, Not measure; (+), positive association; (-), negative association.

## DISCUSSION:

The aim of this systematic review was to examine studies that report relationships between types of personality and type 2 diabetes mellitus, metabolic syndrome, cardiometabolic risk, and their components, and health-related behaviors (diet, physical activity). In the cross sectional studies neuroticism was the most frequently measured and the personality type most often associated with T2DM risk. People with higher neuroticism had highest levels of glucose, insulin and HDL-C. Neuroticism was also related to cardiometabolic risk as measured by levels of insulin, glucose, HDL-C, triglycerides, BMI and blood pressure. These results are consistent with Gerlach (*et al*., 2015) systematic review that showed strong evidence that neuroticism is a risk factor for developing overweight and obesity, particularly in women. Nevertheless the associations were low in the cross sectional studies. Contrary to these studies, Čukić (*et al*., 2014) longitudinal study found that lower neuroticism was related to higher T2DM risk and Tsenkova (*et al*, 2012) found a negative association between neuroticism and HbA1c. Neuroticism could be associated with greater vigilance over one's health and perceived susceptibility to health risks, which may lead individuals to seek health care during pre-diabetes, when the condition can still be reversed.

Shim (*et al*., 2014) cross-sectional study found that extraversion was significantly negatively associated with abnormal glucose regulation but in Čukić (*et al*., 2014) longitudinal study higher extraversion was associated with reduced risk for developing T2DM when age and race/ethnicity were controlled. Individuals with lower extraversion scores also demonstrated fewer positive emotions, and this could be related to a poor attitude about self-care behaviors that put individuals at risk for T2DM. However the association with the extraversion in the studies was weak.

According to the FFM, openness to experience is related to being imaginative, creative, and emotionally sensitive; and agreeableness is related to being modest, altruistic and cooperative (Costa & McCrae, 1992). Openness and agreeableness were significantly inversely related to cardiometabolic risk, especially to dyslipidemia and abdominal obesity (Dermody *et al*., 2015) and in a longitudinal study to higher levels of HbA1c (Čukić *et al*., 2015). Greater openness has been linked to protective and health-promoting dietary habits (Lunn *et al*., 2014), perhaps as a consequence of being interested in trying new things like the adoption of new healthful dietary practices such as increasing vegetable consumption. Agreeableness was associated with healthy outcomes such as lower triglyceride levels, lower waist circumference, and lower metabolic risk (Dermody *et al.*, 2015; Van Reedt *et al*., 2011). On the other hand, lower agreeableness was also associated with health-harming behaviors and overall unhealthy lifestyle factors (Deary *et al*., 2010). Lower agreeableness is linked with lower trust in the healthcare system and poor patient communication, which may lower the chances of symptom detection, which could worsen health outcomes (Deary *et al*., 2010). Openness and agreeableness had a small and negative relationship with T2DM risk.

In the FFM, conscientiousness is related to being organized, following rules, and having ethical principles. This review revealed that conscientiousness had a small inverse relationship with cardiometabolic risk (Dermody *et al*., 2015) and health-harming behaviors in several studies (Bogg & Roberts, 2004). Conscientiousness is positively related to health-promoting behaviors; low conscientiousness predicted diabetes-related mortality (Jokela *et al*., 2013), perhaps because of a lower prevalence of obesity and higher levels of physical activity among those with more conscientiousness. This trait is one of the most important related to T2DM risk association as demonstrated in the longitudinal studies.

Hostility was related to hyperinsulinemia and insulin sensitivity in women and Caucasians and to T2DM risk in African-Americans (Surwit *et al*., 2002, 2009). The health behavior model suggests that hostility is associated with high-risk behaviors that subsequently contribute to onset of T2DM (Smith & Gallo, 2001). It is believed that hostility may increase cardiovascular risk either through risk-related behaviors or neuroendocrine risk factors (Miller *et al*., 1996). Stress moderation models suggest that hostile individuals may be constitutionally more reactive to stress, with their exaggerated stress response leading to an increased risk of disease (Smith & Gallo, 2001). Mommersteeg (et al., 2010) reported a two-fold risk of metabolic syndrome associated with Type D personality, independent of socio-demographic, cardiovascular and lifestyle factors. This association suggests both behavioral and biological vulnerability for development of cardiovascular disorders and diabetes. Health related behavior represents one possible mediator of the relationship between Type-D and poor health (Williams *et al*., 2008). People with Type-D personality may be more likely to engage in maladaptive health behaviors such as smoking, lack of exercise and unhealthy diet (Williams *et al*., 2008).

Temperament is associated with several metabolic syndrome markers and this association is partly mediated by lifestyle factors. Sovio (*et al*., 2007) showed an inverse relationship between persistence and various metabolic syndrome markers especially in women. The authors explained that people with low persistence have a low tolerance for frustration and may react more strongly to stressful situations and expectations from others. The positive relationship between harm avoidance and higher metabolic outcome levels in males may also be partly explained by expectations from society. Men are expected to be tough and strong and those who are not may face extra pressure from peers and authorities (Courtenay, 2000). High levels of reward dependence especially in women appear to have a protective effect against metabolic syndrome; this might be due because women are able to share emotions and problems, having the personality trait of reward dependence may prevent emotions from become a burden causing stress (Sovio *et al*., 2007). Individuals with high reward dependence are described as being sympathetic persons eager to help and please others and highly dependent on emotional support and intimacy with others, even vulnerable because of their openness (Keltikangas-Järvinen *et al*., 1999).

Keltikangas-Järvinen (1999) demonstrated that high levels of persistence and reward dependence and a low level of harm avoidance were related to a high level of CMR factors, including insulin resistance in this study the 100% of sample was male. The authors explained that individuals with high persistence expressed determination despite frustration and fatigue. Low harm avoidance is characterized by a lack of inhibition and appropriate caution, even when the situation requires them.

Anger temperament modestly predicted T2DM (Golden *et al*., 2006) perhaps because chronic, intense, and explosive components of trait anger can lead to poor health behaviors and the activation of the sympathetic nervous system catecholamines, which can lead to decreases in insulin sensitivity (Wiesner *et al*., 2003). In the multi-ethnic study there was an increased risk of diabetes for individuals with high trait anger and anger reaction (Abraham *et al*., 2015).

### *Limitations:*

Findings from this review are limited because despite careful search of available literature, some relevant published articles may have been missed, and missed studies could skew results. The definitions and specification of inclusion and exclusion criteria may result in some bias. Studies selected only in English or Spanish. Studies in this review did not focus on Hispanic or Latin American populations and the findings might not be generalizable beyond the populations of the review.

## CONCLUSION:

We found evidence that some personality traits, particularly neuroticism, are associated with T2DM risk. Therefore, researchers and clinicians should measure personality traits and consider prevention strategies for persons with T2DM risk who have high and low levels of neuroticism, for example individual cognitive-behavior therapy (Lahey, 2009). People with personality traits of hostility, anger, and Type D experience more stress and display heightened neuroendocrine reactivity in response to stress. Persons experiencing stress and negative emotions typically have more adverse behavioral risk profiles and experience difficulty maintaining healthy lifestyles and adhering to treatment recommendations; therefore can increase the risk for the development T2DM (Everson-Rose *et al*., 2014)

One the other hand, conscientiousness trait is protective against T2DM risk; higher conscientiousness was associated with behavior-related factors that are protective of diabetes such as stress reduction and adherence to treatments (Roberts *et al*., 2007). The five personality traits were associated with T2DM risk and related conditions but the Cloninger model traits were not clearly associated with T2DM risk. Knowing the personality of people with T2DM risk can help implement strategies to promote healthy lifestyles.

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