

Personality and metabolic syndrome

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Received: 11 February 2010 / Accepted: 11 May 2010 / Published online: 22 June 2010
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Abstract The prevalence of metabolic syndrome has paralleled the sharp increase in obesity. Given its tremendous physical, emotional, and financial burden, it is of critical importance to identify who is most at risk and the potential points of intervention. Psychological traits, in addition to physiological and social risk factors, may contribute to metabolic syndrome. The objective of the present research is to test whether personality traits are associated with metabolic syndrome in a large community sample. Participants ($N=5,662$) from Sardinia, Italy, completed a comprehensive personality questionnaire, the NEO-PI-R, and were assessed on all components of metabolic syndrome (waist circumference, triglycerides, high-

density lipoprotein cholesterol, blood pressure, and fasting glucose). Logistic regressions were used to predict metabolic syndrome from personality traits, controlling for age, sex, education, and current smoking status. Among adults over age 45 ($n=2,419$), Neuroticism and low Agreeableness were associated with metabolic syndrome, whereas high Conscientiousness was protective. Individuals who scored in the top 10% on Conscientiousness were approximately 40% less likely to have metabolic syndrome (OR=0.61, 95% CI=0.41–0.92), whereas those who scored in the lowest 10% on Agreeableness were 50% more likely to have it (OR=1.53, 95% CI=1.09–2.16). At the facet level, traits related to impulsivity and hostility were the most strongly associated with metabolic syndrome. The present research indicates that those with fewer psychological resources are more vulnerable to metabolic syndrome and suggests a psychological component to other established risk factors.

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Keywords Metabolic syndrome · Physical health ·
Personality · Impulsivity · Hostility

Introduction

Metabolic syndrome is a constellation of interrelated anthropometric, metabolic, and hemodynamic risk factors that significantly increases the likelihood of type II diabetes and cardiovascular morbidity and mortality (Grundey et al. 2005). Metabolic syndrome is diagnosed when an individual has three or more risk factors, including elevated waist circumference, tri-

glycerides, blood pressure, fasting glucose, and reduced high-density lipoprotein (HDL) cholesterol. The prevalence of metabolic syndrome has paralleled the sharp increase in obesity (Grundy 2008), sparking fears over an epidemic rise in diabetes, cardiovascular disease, and mortality (Ford et al. 2008; Scuteri et al. 2009). Given the tremendous physical, emotional, and financial burden of metabolic syndrome for the individual and the health-care costs for society, it has become of critical importance to identify who is at risk and what are the potential points of intervention.

One area of increasing interest in the etiology of metabolic syndrome is the role of personality traits, which are enduring characteristics often referred to as temperament in infancy. Personality traits have previously been associated with a number of the components of metabolic syndrome, but there has yet to be a comprehensive study of the associations between personality and the syndrome as a whole. For example, impulsive individuals tend to have larger waistlines (Sullivan et al. 2007; Terracciano et al. 2009), higher levels of triglycerides (Sutin et al. 2010b), and are more likely to have hypertension (Goodwin et al. 2006). In contrast, conscientious individuals tend to be leaner (Chapman et al. 2009; Roehling et al. 2008; Terracciano et al. 2009), have lower triglycerides and higher HDL cholesterol (Sutin et al. 2010b), and are less likely to have hypertension (Goodwin and Friedman 2006). Previous research has linked psychological factors to the development and progression of metabolic syndrome (see Goldbacher and Matthews 2007 for a review). This research, however, has focused primarily on the psychological characteristics previously identified as risk factors for heart disease and diabetes, such as depression and hostility, rather than examining the full spectrum of personality traits.

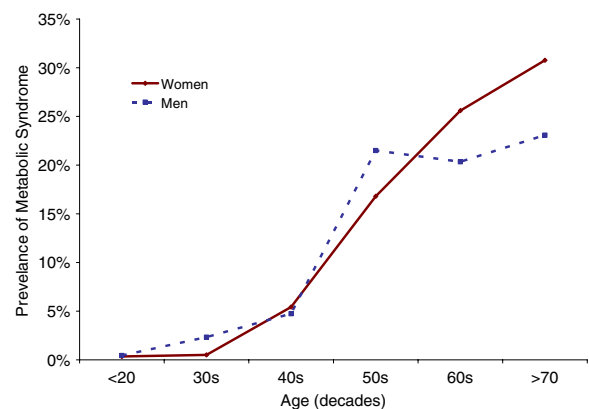
The present research uses a large, population-based sample to examine whether personality is associated with metabolic syndrome. We focus on middle-age and older adults because the prevalence of metabolic syndrome increases sharply in middle age, and age becomes a significant risk factor for many of the components starting in midlife (National Cholesterol Education Program Expert Panel 2002). With the five-factor model (FFM) as our guiding framework, we test whether the five major domains of personality, Neuroticism, Extraversion, Openness to experience, Agreeableness, and Conscientiousness, and their more

circumscribed facets, are associated with metabolic syndrome.

Subjects and methods

Participants Participants were drawn from the SardiNIA project, a large multidisciplinary study of the genetic and environmental basis of complex traits and age-related processes (Costa et al. 2007; Pilia et al. 2006). Approximately 62% of the population ($N=6,148$ individuals; 57% female), aged 14 to 102 years, from a cluster of four towns in the Ogliastra province enrolled in the study. Valid personality and metabolic data were obtained from 5,662 participants (58% female). Age ranged from 14 to 94 ($M=42.65$; $SD=16.93$). The project was approved by institutional review boards in Italy and the USA, and procedures were in accordance with the Helsinki Declaration.

We focus primarily on a subset of participants who are at or over the age of 45, both because the prevalence of metabolic syndrome increased substantially at this age (see Fig. 1 for trends in the current sample) and because this is the age at which age becomes a risk factor for many of the components of metabolic syndrome (National Cholesterol Education Program Expert Panel 2002; see Fig. 1). This subsample included 2,419 participants (57% female) with an age range from 45 to 94 ($M=59.11$; $SD=9.72$). Sample characteristics are given in Table 1.



Percentage of participants with metabolic syndrome by age.

Fig. 1 Percentage of participants with metabolic syndrome by age

Table 1 Sample characteristics by age group

Variable	Sample characteristics		
	<45	≥45	Total
Age	30.36 (0.75)	59.11 (9.72)	42.65 (16.93)
Gender (female)	58%	57%	58%
Current smoking status	27%	12%	21%
Metabolic syndrome	3%	19%	10%
Neuroticism	5.55 (0.95)	5.50 (0.84)	5.53 (0.90)
Extraversion	5.09 (0.90)	4.62 (0.78)	4.89 (0.88)
Openness	4.94 (0.99)	4.24 (0.88)	4.64 (1.01)
Agreeableness	4.44 (0.95)	4.95 (0.90)	4.65 (0.96)
Conscientiousness	4.79 (1.02)	5.05 (0.83)	4.90 (0.95)

Means (standard deviations) and percentages. Total $N=5,662$, $n=3,214$ for <45 and $n=2,419$ for ≥45

Metabolic syndrome Standard enzymatic methods were used on fasting lipid measurements to determine serum HDL cholesterol and triglycerides. Blood pressure was measured three times after a 5-min resting period; we used the average of the second and third measurements. Waist circumference was measured by a trained staff clinician. Following the updated guidelines from the US National Cholesterol Education Program Adult Treatment Panel III (Grundy et al. 2005), metabolic syndrome was defined as the presence of three or more of the following risk factors: (1) abdominal obesity: waist circumference ≥ 102 cm in men and ≥ 88 cm in women, (2) elevated triglycerides: ≥ 150 mg/dL, (3) reduced HDL cholesterol: < 40 mg/dL in men and < 50 mg/dL in women, (4) elevated blood pressure: ≥ 130 mmHg systolic blood pressure, ≥ 85 mmHg diastolic blood pressure, or on antihypertensive drug treatment, and (5) elevated glucose: ≥ 100 mg/dL or on glucose-lowering drug treatment.

Personality assessment Personality traits were assessed using the Italian version of the Revised NEO Personality Inventory (NEO-PI-R; Terracciano 2003), which measures 30 facets, six for each of the five major dimensions of personality (Costa and McCrae 1992). The 240 items are answered on a five-point Likert scale, from strongly disagree to strongly agree. Participants filled out the self-report questionnaire (89%) or chose to have the questionnaire read by a trained Sardinian psychologist (11%). A variable (test administration) that indicated this difference in the administration of the NEO-PI-R was used as a covariate in the analyses. The NEO-

PI-R was scored based on established procedures given in the Manual (Costa & McCrae, 1992); in this sample, the measure showed good psychometric properties: internal consistency reliabilities for the five factors ranged from 0.80 to 0.87. Targeted factor analysis indicated that the factor structure replicated the American normative structure at both the phenotypic and genetic level. Raw scores were converted to T-scores ($M=5$, $SD=1$) using American combined-sex norms (Costa and McCrae 1992).

Analytic strategy To determine which personality traits were associated with metabolic syndrome, we ran a separate logistic regression analysis for each trait. In addition to test administration, we controlled for both demographic and other variables known to be associated with the components of metabolic syndrome (Park et al. 2003). Specifically, we controlled for sex, age, age squared, self-reported level of education, and self-reported current smoking status (“Do you smoke now?” 12% current vs. 88% former/never). When there was an effect of personality on metabolic syndrome, we performed supplemental analyses that compared the top and bottom 10% of the distribution of the trait to the remaining 90%. To test whether the findings could be completely accounted for by the weight component of metabolic syndrome, additional analyses also controlled for body mass index (BMI). Finally, we tested whether age or sex moderated the associations between personality and metabolic syndrome. Unless otherwise specified, all reported associations are on continuous measures of personality, scaled in one standard deviation increments.

Results

Of the 2,419 participants at or over the age of 45, a total of 464 (19%) met the criteria for metabolic syndrome. Among these participants, age in years (OR=1.04, 95% CI=1.02–1.06, $p<.01$), age squared (OR=0.998, 95% CI=0.997–0.999, $p<.01$), and education (OR=0.86, 95% CI=0.77–0.96, $p<.01$) were associated with metabolic syndrome; sex (OR=1.13, 95% CI=0.91–1.40, ns), smoking (OR=0.86, 95% CI=0.59–1.23, ns), and test administration (OR=0.85, 95% CI=0.64–1.12, ns) were not.

Consistent with the literature linking Neuroticism and Conscientiousness to health outcomes (Goodwin and Friedman 2006; Terracciano et al. 2008), Neuroticism was associated with metabolic syndrome, whereas Conscientiousness was protective (see Table 2). That is, every one standard deviation increase in Neuroticism was associated with an approximately 15% greater chance of having metabolic syndrome, and every one standard deviation increase in Conscientiousness was associated with a nearly 25% reduction in the likelihood of having it. Supplemental analyses indicated that participants who scored in the top 10% of the distribution of Conscientiousness were almost 40% less likely to have metabolic syndrome (OR=0.61, 95% CI=0.41–0.92, $p<.05$), whereas those in the lowest 10% of Conscientiousness were approximately 40% more likely to have it (OR=1.40, 95% CI=1.01–1.94, $p<.05$). In addition to Neuroticism and Conscientiousness, antagonistic participants were also more likely to have metabolic syndrome (see Table 1). One standard deviation increase in Agreeableness was associated with an almost 20% reduction in metabolic syndrome, and supplemental analyses indicated that participants who scored in the bottom 10% on Agreeableness were approximately 50% more likely to have it (OR=1.53, 95% CI=1.09–2.16, $p<.05$).

Turning to the specific facets of personality, the traits associated with metabolic syndrome clustered around two broad themes: impulsivity and hostility. Participants who scored high in either N5: Impulsivity or E5: Excitement-seeking were more likely to have metabolic syndrome, whereas those who scored high in C5: Self-discipline or C6: Deliberation were less likely to have it. Two other facets of Conscientiousness, C2: Order and C3: Dutifulness, were also protective. Finally, facets of Neuroticism and Agree-

Table 2 Odds ratios (95% CI) from logistic regressions predicting metabolic syndrome from continuous personality traits scaled in 1 standard deviation increments

Personality	Metabolic syndrome
Domains	
Neuroticism	1.15 (1.01–1.31)*
Extraversion	1.07 (0.93–1.23)
Openness	1.03 (0.90–1.17)
Agreeableness	0.83 (0.73–0.94)**, ^a
Conscientiousness	0.77 (0.67–0.87)**, ^a
Facets	
N1: Anxiety	1.08 (0.95–1.22)
N2: Angry hostility	1.18 (1.06–1.32)**
N3: Depression	1.04 (0.93–1.17)
N4: Self-consciousness	0.96 (0.86–1.08)
N5: Impulsiveness	1.33 (1.18–1.51)**, ^a
N6: Vulnerability	1.04 (0.94–1.15)
E1: Warmth	0.95 (0.85–1.07)
E2: Gregariousness	0.98 (0.87–1.10)
E3: Assertiveness	1.07 (0.93–1.22)
E4: Activity	0.94 (0.82–1.07)
E5: Excitement-seeking	1.17 (1.03–1.34)*
E6: Positive emotions	1.12 (1.00–1.25)*, ^a
O1: Fantasy	1.02 (0.90–1.15)
O2: Aesthetics	1.04 (0.91–1.18)
O3: Feelings	1.06 (0.94–1.19)
O4: Actions	1.01 (0.90–1.13)
O5: Ideas	1.02 (0.91–1.15)
O6: Values	0.94 (0.82–1.06)
A1: Trust	0.95 (0.85–1.06)
A2: Straightforwardness	0.83 (0.74–0.93)**, ^a
A3: Altruism	0.88 (0.79–0.99)*
A4: Compliance	0.88 (0.80–0.98)*
A5: Modesty	0.90 (0.80–1.02) ^a
A6: Tender-mindedness	1.01 (0.91–1.12)
C1: Competence	0.92 (0.82–1.04)
C2: Order	0.84 (0.74–0.94)**, ^a
C3: Dutifulness	0.82 (0.73–0.93)**, ^a
C4: Achievement striving	0.95 (0.84–1.07)
C5: Self-discipline	0.75 (0.67–0.85)**, ^a
C6: Deliberation	0.83 (0.74–0.93)**, ^a

Odds ratio (95% confidence interval) per 1 SD increase in personality, controlling for age, age squared, sex, education, smoking, and test administration. $N=2,419$ ($n=464$ metabolic syndrome/1,955 no metabolic syndrome)

* $p<.05$

** $p<.01$

^aSignificant on the entire sample ($N=5,662$)

ableness related to hostility were also associated with metabolic syndrome, specifically high N2: Angry hostility, Low A2: Straightforwardness, Low A3: Altruism, and Low A4: Compliance. It is of note that most findings remained significant after controlling for the effect of obesity. Although the p values for Neuroticism, E5: Excitement-seeking, E6: Positive emotions, A3: Altruism, and C2: Order Were Reduced To A Trend ($P < .10$) after controlling for BMI, the magnitude of the odds ratios were essentially the same after including BMI in the model; all other findings remained significant. Most findings held when we reran the analyses on the entire sample (see Table 2).

Finally, sex and age moderated very few of the personality-metabolic syndrome associations. Although N5: Impulsiveness was associated with metabolic syndrome for both men and women, sex interacted with this trait such that the association was stronger among men ($OR_{N5: Impulsiveness \times sex} = 1.38$, 95% CI=1.08–1.76, $p < .05$). In addition, there was an interaction between sex and Openness, such that this trait was associated with metabolic syndrome among men but not women ($OR_{Openness \times sex} = 1.37$, 95% CI=1.08–1.75, $p < .05$); the same pattern was found for O1: Fantasy ($OR_{O1: Fantasy \times sex} = 1.33$, 95% CI=1.05–1.68, $p < .05$) and O5: Ideas ($OR_{O5: Ideas \times sex} = 1.36$, 95% CI=1.10–1.68, $p < .01$). Finally, there was an age \times O4: Actions interaction ($OR_{O4: Actions \times age} = 1.01$, 95% CI=1.00–1.02, $p < .05$), which indicated that this trait was more strongly associated with metabolic syndrome at older ages. The dearth of interactions with these two demographic factors indicates that the relations between personality and metabolic syndrome were consistent across both sexes and across middle and older age.

Discussion

The present study used a comprehensive measure of FFM personality traits to examine whether stable individual differences in personality were associated with metabolic syndrome, a constellation of physiological risk factors that greatly increases risk of type II diabetes and cardiovascular morbidity and mortality. Three of the five broad domains, as well as many of the more circumscribed facets, of the FFM were significantly associated with metabolic syndrome.

Metabolic syndrome is a complex phenotype and, as such, many factors contribute to its development and course. Personality is one such factor with effect sizes roughly similar to that of other major risk factors, including physical inactivity (OR=1.40) and (low) SES (ORs range from 1.20 to 1.50; Park et al. 2003).

The personality traits related to impulsivity and hostility were the most strongly associated with metabolic syndrome. Impulsivity reflects the inability to delay, inhibit, or control behavior. Under this broad definition, Whiteside and Lynam (2001) identified four distinct facets: (1) the tendency to give in to impulses (N5: Impulsivity), (2) the desire to engage in risky or dangerous activities for fun (E5: Excitement-seeking), (3) the inability to stay committed to a task or lifestyle amid distractions or difficulties (C5: Self-discipline), and (4) the inability to foresee the consequences of a behavior (C6: Deliberation). It is of note that in the current study, all four of these components were associated with metabolic syndrome. In fact, two of these components, N5: Impulsiveness and C5: Self-discipline, shared the strongest associations with metabolic syndrome, with a one standard deviation difference corresponding to an approximately 30% higher and 25% lower likelihood of having it, respectively.

Difficulty controlling one's behavior appears early in life (Kochanska et al. 2000) and manifests itself in various ways across the lifespan. In the health domain, impulsive individuals tend to engage in the behaviors that increase the chances of developing metabolic syndrome. For example, they tend to weigh more (Terracciano et al. 2009), smoke (Terracciano and Costa 2004), exercise less (Courneya and Hellsten 1998), and engage in binge eating or drinking (Benjamin and Wulfert 2005). These behaviors, in turn, may partially mediate the association between impulsivity and poor health (Sutin et al. 2010a). In contrast to impulsive individuals, those who are more conscientious may have the self-discipline to resist life's temptations and order their lives to include time for exercise and healthy eating. The reward for such discipline may be fewer health problems as they age.

Consistent with previous reports that those higher in trait anger are more susceptible to developing metabolic syndrome (Räikkönen et al. 2004), in the present study, those who are quick to experience anger (N2: Angry hostility) and/or those who are quick

to express anger ((low) A4: Compliance) were more likely to also have metabolic syndrome. Goldbacher and Matthews (2007) argued that the path from psychological characteristics, such as anger and hostility, to the metabolic syndrome may be mediated by both behavioral factors, such as diet and smoking, and by biological factors, such as dysregulation of the sympathetic-adrenal-medullary and hypothalamic-pituitary-adrenal axes. Indeed, during daily activities, angry and hostile individuals have heightened cardiovascular and neuroendocrine reactivity, such as increased blood pressure (Polk et al. 2002) and cortisol excretion (Pope and Smith 1991), and, once stressed, they are not easily soothed by close others (Lepore 1995). Even as early as adolescence, trait anger and hostility are associated with greater central adiposity and arterial stiffness (Midei and Matthews 2009). Over time, these physiological factors are likely compounded, ultimately leading to greater metabolic risk by middle age.

Metabolic syndrome takes a toll not just on physical health but also on mental health and limits the individual's physical activities and productivity (Ford and Li 2008). Experts tend to agree that prevention and intervention strategies must include significant lifestyle changes, such as increased physical activity and a better diet (Grundy et al. 2004). Knowledge of the individual's full personality profile may help tailor effective interventions to the individual. For example, those who are at risk for metabolic syndrome because of their low Conscientiousness may respond differently to exercise interventions based on their level of Extraversion. Individuals high in Extraversion may be more likely to commit to a group exercise program, whereas those low on Extraversion may benefit more from solitary exercise routines. As such, knowing an individual's level of Extraversion may inform intervention strategies for those who are also low on Conscientiousness. Further, text messaging has been found to be an effective intervention for increasing adherence to medication regimes (Strandbygaard et al. 2010); similar interventions may be useful for individuals who have difficulty with self-regulation. For example, highly impulsive individuals may benefit from reminders to regulate their behavior. Personality traits are likely to be good predictors of who will benefit from particular interventions (e.g., text messaging, cash incentives, and exercise

setting), but there is a need for translational research to test the potential of personality traits in tailoring interventions and increase success rates.

While personalized interventions may be effective for some individuals, others, despite their best intentions, may have more difficulty with adherence. Given that low Conscientiousness and high impulsivity likely contribute to the etiology of metabolic syndrome, relying on individuals' own resources to regulate their behavior may only be one component of prevention. As with other public health concerns, societal-level interventions may be more cost-effective than person-specific ones in reducing the prevalence of metabolic syndrome. For example, the public health campaign to reduce cigarette smoking, including taxation and tobacco-control efforts, has been remarkably effective in reducing both the number of smokers and cardiovascular mortalities (Polednak 2009). Similar campaigns that tax sugared beverages stand to have a comparable effect on the rates of obesity (Brownell and Frieden 2009), which is perhaps the strongest contributor to metabolic syndrome (Scuteri et al. 2009).

It is estimated that approximately one quarter of the adult population in the USA and Europe meets the criteria for metabolic syndrome (Grundy 2008). With an aging population, the prevalence is likely to increase worldwide, and those with fewer economic and psychological resources are the most vulnerable. The present research identifies the personality traits that are associated with metabolic syndrome and suggests a psychological component to the established physiological and social risk factors. Such knowledge will help tailor effective intervention strategies aimed at individuals and inform public policy for prevention and treatment approaches.

Acknowledgements This research was supported entirely by the Intramural Research Program of the National Institutes of Health, National Institute on Aging. Paul Costa receives royalties from the Revised NEO Personality Inventory.

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