Psychosocial Stress and the Insulin Resistance Syndrome

Katri Räikkönen, Liisa Keltikangas-Järvinen, Herman Adlercreutz, and Aarno Hautanen

We examined the association between psychosocial stress–related variables and insulin resistance syndrome (IRS) risk-factor clustering. In 90 middle-aged male volunteers, psychosocial stress–related variables, defined as feelings of excessive tiredness and as personality and behavioral factors reflecting a stress-inducing life-style (type A behavior, hostility, and anger), were significantly correlated with the hyperinsulinemia, hyperglycemia, dyslipidemia, hypertension, increased abdominal obesity, and increased plasminogen activator inhibitor-1 (PAI-1) antigen comprising the IRS. The correlations remained significant after adjusting for body mass index (BMI), age, educational level, smoking status, alcohol consumption, and physical activity. However, the different stress-related factors reflected different risk-factor clustering profiles. Type A behavior was associated with normotension and a normal metabolic profile (canonical $r = .50$, $\chi^2(36) = 59.1$, $P = .008$). Hostility was related to elevated systolic blood pressure (SBP) and elevated triglycerides (TGs) (canonical $r = .38$, $\chi^2(14) = 23.2$, $P = .052$), whereas feelings of excessive tiredness were related to abdominal obesity, augmented glycemic responses to glucose ingestion, dyslipidemia, and increased PAI-1 antigen (canonical $r = .39$, $\chi^2(24) = 36.8$, $P = .046$). Although hostility and feelings of excessive tiredness have partly overlapping but clearly different clinical and metabolic correlates, their combination represents a full-blown IRS. Thus, even though insulin resistance is presumably to some extent genetically determined, these results suggest that considering psychosocial stress may be beneficial in understanding IRS risk-factor clustering.

THE INSULIN RESISTANCE syndrome (IRS)[1,2] is characterized by a clustering of several risk factors for cardiovascular disorders and non–insulin-dependent diabetes mellitus. Metabolic and clinical findings that comprise the IRS include hyperinsulinemia, glucose intolerance, dyslipidemia, hypertension,[1,2] abdominal obesity,[3,4] and increased thrombogenicity at the level of plasminogen activator inhibitor-1 (PAI-1).[5]

It has been hypothesized that social, behavioral, and biological stimuli perceived as stressful, as well as multiple neuroendocrine and hemodynamic perturbations, may be early pathogenic factors for this syndrome.[3,4,6-8] The role of stress in the chain of events promoting the clustering of risk factors has been demonstrated in experimental animal models. In cynomolgus monkeys, the stress of social subordination has been shown to be associated with increased central fat deposition, which in turn relates to hyperglycemia, dyslipidemia, and hypertension.[9] Moreover, in comparison to controls, Sprague-Dawley rats subjected to chronic uncontrollable stress had larger adipocytes and a tendency for a heavier fat pad, plus an increased lipoprotein lipase activity in the mesenteric depot.[10] Only partial evidence can be found to support the hypothesis in humans. It has been shown that indices of psychosocial stress are associated with accumulation of fat in the abdominal area,[11-13] altered insulin/glucose homeostasis,[14] hyperlipidemia,[15] hypertension,[16] and an increased level of PAI-1.[17] However, individuals under a great deal of stress may not only show a single metabolic aberration, but a full range of metabolic and disease indicators characteristic of this syndrome.

Accordingly, we examined whether psychosocial stress–related variables are related to a clustering of risk factors comprising the IRS in middle-aged men who underwent extensive clinical and biochemical investigation. We defined psychosocial stress–related variables as feelings of excessive tiredness, ie, fatigue, increased irritability, and demoralization, labeled vital exhaustion,[18] which is associated with angina pectoris and with future fatal and nonfatal myocardial infarction,[19,20] and as a variety of personality and behavioral factors reflecting a stress-inducing, coronary-prone life-style,[21] namely type A behavior, anger, and hostility. We took into account body mass index (BMI), age, level of education, and health-related life-style factors possibly confounding the associations.

SUBJECTS AND METHODS

Subjects

We studied 101 middle-aged men who responded to a letter sent to large companies, trade unions, and sporting societies inviting middle-aged men to participate in the study. Potential participants read a lay version of the research plan. The study protocol was approved by the local ethics committee.

Of 101 men, 11 were excluded, one because of suspected and subsequently proven renovascular hypertension, and one because of familial hypercholesterolemia. An additional subject had non–insulin-dependent diabetes, and four suffered from coronary heart disease. Finally, of the remaining 94 subjects, four were excluded because of incomplete psychological data, leaving 69 healthy and 21 borderline hypertensive (140/90 to 160/95 mm Hg) 30- to 55-year-old (mean ± SD, 44.5 ± 5.4) men employed in managerial-level positions. Of the borderline hypertensives, 15 had normal and six decreased glucose tolerance according to the established criteria.[22] The subjects took no medication and had no history or evidence of liver, kidney, gastrointestinal, endocrine, inflammatory, or atherothrombotic disease or acute infections as determined by clinical examination and laboratory analyses.

Procedures

The subjects were evaluated on two consecutive mornings, starting at 7:30 AM after an overnight 12-hour fast, as outpatients at the Helsinki University Central Hospital. Blood sampling for determination of lipid profiles was performed on the first morning, and insulin, C-peptide, glucose, and PAI-1 assays followed by

From the Departments of Psychology and Clinical Chemistry, University of Helsinki, Helsinki, Finland.

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Address reprint requests to Katri Räikkönen, PhD, Department of Psychology, University of Helsinki, PO Box 4, FIN-00014 University of Helsinki, Finland.

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anthropometric and blood pressure measurements on the morning of the second day. With the exception of anthropometric measurements, subjects remained at rest either recumbent or semirecumbent during the assessments. A detailed description of the study protocol appears elsewhere.[23]

Lipids. Triglyceride (TG) levels were measured by the GPO-PAP method (Boehringer, Mannheim, Germany).[23] High-density lipoprotein cholesterol (HDLc) was determined after precipitation of very–low-density lipoproteins and low-density lipoproteins with dextran-sulfate magnesium chloride.[24]

Insulin, C-peptide, and glucose. Serum insulin and C-peptide and blood glucose concentrations were measured during the oral glucose tolerance test (OGTT). An indwelling cannula was inserted into an antecubital vein, and 30 minutes later a standard 75-g load of glucose was given. Blood was sampled in the fasting state ($\geq$12 hours) and at 1 and 2 hours after administration of glucose. Commercial radioimmunoassay (RIA) kits were used for determination of insulin (Pharmacia, Uppsala, Sweden), and C-peptide (Byk-Sangtec Diagnostica, Dietzenbach, Germany). Blood glucose was determined by the glucose oxidase method. Mean values for the duplicate determinations were computed. The within- and between-assay imprecision of the RIA methods was 5.1% and 7.5% for insulin and 4.1% and 9.5% for C-peptide, respectively.

In addition to the fasting values, the C-peptide net response (sum of the C-peptide responses at 1 and 2 hours after glucose ingestion minus the level measured in the fasting state) was used to measure the production of insulin, and the mean values of insulin and glucose (mean of three measured values during the OGTT) were used to measure insulin resistance and the glucose response to OGTT.

PAI-1 antigen. Blood samples for determination of PAI-1 antigen were collected in sodium citrate (0.11 mol/L) at 4°C and centrifuged immediately.[25] Plasma was stored frozen at −70°C until assay. PAI-1 antigen concentrations were determined by enzyme-linked immunosorbent assays (TintElize PAI-1; Biopool, Umeå, Sweden). Before the determination, the samples were rapidly thawed at 37°C.

Blood pressure. Systolic (SBP) and diastolic (DBP) blood pressure were determined by standard sphygmomanometer, with the subjects in the supine position for at least 15 minutes previously. Three readings to the nearest even digit were recorded, with the mean of the second and third readings defined as the blood pressure.

Obesity. Abdominal obesity was defined as a ratio of waist circumference and hip circumference (WHR) measured as the smallest girth between the rib cage and the iliac crest and the largest girth between the waist and thigh. BMI was defined as a ratio of weight in kilograms and height in meters squared. WHR and BMI were determined with the participant in underwear and without shoes.

Lifestyle and socioeconomic factors. Smoking was assessed as current reported smoking status, and alcohol consumption as the amount of beer, wine, and hard liquor consumed separately per week, converted into grams of absolute alcohol. Physical activity was measured on a four-point scale ranging from no regular physical activity to strenuous physical activity. The six-point scale for measuring educational level ranged from primary school to university level. Subjects' responses were confirmed by a personal interview.

Psychosocial stress–related variables. The subjects completed a series of psychological tests in the afternoon following blood sampling that encompassed the Jenkins Activity Survey (JAS), form C,[26] for type A behavior; the MMPI-based cynicism factor,[27] the SCL-90–based paranoid ideation subscale,[28] and the Lazare, Klerman, and Armor Trait Test–based pessimism factor[29] for the cynicism, paranoia, and pessimism components of hostility; the Spielberger Anger Expression Scale for anger-in and anger-out[30]; and form B of the Maastricht Questionnaire for Vital Exhaustion.[18] With the exception of type A behavior, the original scales were reformatted for practical reasons into five-point scales ranging from totally agree to totally disagree for hostility and vital exhaustion, and almost never to almost always for anger.

Statistical Analyses

Associations between the psychosocial factors and IRS risk-factor clustering were determined by canonical correlation analysis.[31,32] Canonical variate scores were computed, as partial correlations were used when adjusting for the effects of BMI, age, educational level, and life-style factors. Variable distributions were tested for normality by Shapiro and Wilk *W* statistics, and logarithmic transformations were conducted to normalize the distributions of TG, HDLc, fasting and mean insulin, fasting and mean glucose, and PAI-1 in these analyses.

Canonical correlation analysis. Canonical correlation analysis examines the relationship between two sets of variables, and it can uncover complex relationships reflecting the structure between the variable sets. However, in most applications the two sets are not treated symmetrically, but one of the sets is the predictor set and the other is the set of criterion measures. The method is used in analyzing several predictor variables and criterion variables simultaneously, and is particularly appropriate when the criterion variables are themselves correlated. In one sense, the canonical correlation analysis parallels the linear regression analysis: However, in canonical correlation analysis there are several criterion variables instead of one.

In a canonical analysis, variates, which are analogous to a dimension or a factor in a factor analysis, are computed from both sets of variables. Canonical loadings, in turn, reflect the degree to which the variable is represented by a canonical variate. Thus, canonical loadings are used for identifying the structure of the canonical relationships and for interpreting the substantive content of the canonical variate.

The canonical correlation analysis proceeds as follows. First, a canonical correlation matrix, consisting of a matrix of correlations between the criterion variables, between the predictor variables; and between criterion and predictor variables, is generated. Then, eigenvalues and eigenvectors are computed from the canonical correlation matrix, which aims at redistributing the variance in the original variables into very few pairs of canonical variates. Each of the pairs captures a large share of variance and is defined by linear combinations of predictor variables on one side and criterion variables on the other. Thus, canonical analysis seeks two linear combinations, one for the predictor set and one for the criterion set, such that their ordinary product-moment correlation is as large as possible. Once the eigenvalue is computed for each pair of canonical variates, canonical correlation is found by taking the square root of the eigenvalue. Canonical correlation is interpreted as an ordinary Pearson product-moment correlation, and the significance of one or more canonical correlations is evaluated using Bartlett's test with a χ^2 distribution. Finally, from the canonical variates, canonical variate scores can be computed for use in other analyses.

RESULTS

Table 1 shows mean values for the metabolic variables. The mean alcohol consumption rate was 176.8 ± 140 g/wk. Of 90 men, 32 (35.6%) reported smoking, 28 (31.4%) reported physical activity at a frequency of three times per

Table 1. Metabolic Variables

Variable	Mean ± SD	Range
SBP (mm Hg)	128.07 ± 13.16	94-166
DBP (mm Hg)	81.33 ± 9.05	62-100
TG (mmol/L)	1.54 ± 1.05	0.39-4.85
HDLc (mmol/L)	1.24 ± 0.34	0.61-2.33
Insulin (mU/L)		
Fasting	8.48 ± 6.27	2-31
Mean	41.67 ± 26.87	7.33-136.67
C-peptide (nmol/L)		
Fasting	0.73 ± 0.35	0.23-2.11
Net response	4.84 ± 1.58	1.29-8.66
Glucose (mmol/L)		
Fasting	3.30 ± 0.39	2.1-4.5
Mean	4.39 ± 0.90	2.43-6.63
WHR	0.94 ± 0.065	0.78-1.12
BMI (kg/m^2)	26.20 ± 3.991	20.05-39.07
PAI-1 (ng/mL)	20.46 ± 10.65	4.9-45.8

NOTE. Mean values are for the 3 measured values (0, 1, and 2 hours) during the OGTT; net response is the sum of the values measured at 1 and 2 hours after glucose ingestion minus the value beforehand.

week, and 22 (24.7%) were physically inactive. Furthermore, 7.8% of the subjects had a primary-school and 7.7% a secondary-school level of education, and 10% had graduated from high school, 4.4% from trade school, 31.1% from college, and 38.9% from a university.[13,14,17]

Intercorrelations (Pearson's r) between the metabolic variables, age, level of education, and life-style characteristics are presented in Table 2.[13,14,17] Metabolic variables correlated significantly with each other, with the exception of HDLc to SBP and DBP (Table 2). A low physical activity level was significantly correlated with each metabolic parameter; smoking correlated significantly with TG, HDLc, WHR, fasting and mean insulin, and fasting and net C-peptide response (Table 2). Age showed significant correlation only with DBP (Table 2).

Mean values for the psychosocial variables are presented in Table 3. Intercorrelations between the psychosocial variables ranged between .01 and .63, as previously shown.[14] The highest correlations were found between different components of hostility (r = .52 to .63, $P \leq .001$). The correlation matrix indicated that groups of closely intercorrelated psychosocial variables existed. Thus, psychosocial variables were subjected to a factor analysis (principal-components method with oblique quartimin rotation) to conceptually integrate the data. The ensuing factor scores were saved for use in further analyses. Four factors with eigenvalues above 1 emerged, explaining 70.8% of the total variance. Components of hostility, ie, cynicism, pessimism, and paranoia, loaded significantly on the first factor, and type A behavior with its subcomponents "speed and impatience" and "hard-driving and competitive" on the second factor. The third factor consisted of vital exhaustion and anger-out, and the fourth of anger-in and the "job-involvement" subcomponent of type A behavior. The non-significant correlations between the four factors ranged from .03 to .15.

To examine the associations between the psychosocial factors and IRS risk-factor clustering, canonical correlations between the set of four psychosocial factor scores and the set of parameters characterizing the IRS were performed. We performed the analyses first with the C-peptide

Table 2. Pearson Correlation Coefficients Between the Metabolic Variables, Age, Level of Education, and Life-style Variables

	Variable																
Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. SBP																	
2. DBP	.74‡																
3. TG§	.38‡	.43‡															
4. HDLc§	−.08	−.13	−.57‡														
Insulin																	
5. Fasting§	.44‡	.46‡	.52‡	−.45‡													
6. Mean§	.39‡	.47‡	.55‡	−.35‡	.80‡												
C-peptide																	
7. Fasting	.39‡	.46‡	.52‡	−.34†	.75‡	.67‡											
8. Net response	.36‡	.41‡	.54‡	−.24*	.65‡	.89‡	.56‡										
Glucose																	
9. Fasting§	.20	.30†	.09	−.12	.30†	.30†	.28†	.19									
10. Mean§	.32†	.44‡	.39‡	−.24*	.42‡	.63‡	.37‡	.56‡	.46‡								
11. WHR	.41‡	.52‡	.48‡	−.37‡	.65‡	.63‡	.58‡	.55‡	.24*	.46‡							
12. BMI	.42‡	.48‡	.44‡	−.24†	.72‡	.57‡	.65‡	.48‡	.32†	.37‡	.65‡						
13. PAI-1§	.43‡	.51‡	.39‡	−.26†	.59‡	.52‡	.57‡	.42‡	.32†	.34‡	.41‡	.59‡					
14. Age	.19	.24*	.07	.07	.00	.10	.04	.10	.12	.12	.01	.00	.09				
15. Alcohol consumption	.08	.07	−.04	.15	.08	−.01	.04	.11	.06	−.02	.15	.20	.01	.16			
16. Smoking	.00	.00	.38‡	−.39‡	.23*	.32†	.33†	.34†	−.01	.18	.29†	.18	.12	−.20	−.12		
17. Physical activity	−.21*	−.28†	−.43‡	.34‡	−.45‡	−.55‡	−.36‡	−.48‡	−.15	−.38‡	−.41‡	−.41‡	−.37‡	−.02	.00	−.19	
18. Level of education	−.07	.09	−.14	−.05	−.06	−.02	−.12	−.05	.02	.00	−.06	−.09	.10	−.10	−.06	.01	.15

*$P \leq .05$.
†$P \leq .01$.
‡$P \leq .001$.
§Logarithmic transformations were conducted.

Table 3. Psychosocial Variables

Variable	Mean ± SD	Range
Type A behavior		
Type A scale	5.50 ± 8.41	−16.91-22.46
Speed and impatience	0.60 ± 8.16	−17.08-24.64
Job involvement	2.39 ± 7.56	−16.31-17.85
Hard-driving and competitive	−3.31 ± 6.98	−15.40-15.40
Hostility		
Cynicism	18.83 ± 4.18	10-30
Pessimism	16.64 ± 2.94	10-23
Paranoia	14.14 ± 3.28	8-23
Anger		
Anger-in	21.22 ± 4.33	11-32
Anger-out	20.44 ± 3.91	13-36
Vital exhaustion	40.79 ± 10.87	21-74

net response and the mean values for insulin and glucose in combination with other IRS parameters, and then with the fasting levels replacing the response and the mean values.

Bartlett's test showed that the first three canonical variate pairs accounted for the significant relationships between the two sets of variables (Table 4). The canonical loadings of the first pair of canonical variates indicated that a combination of different type A components and hostility in the psychosocial set was significantly associated with low blood pressure, low TG and high HDLc, and low PAI-1 antigen levels in the IRS parameter set (canonical $r = .50$, $\chi^2(36) = 59.1$, $P = .008$), as variables with loadings at or above .30 were considered to contribute significantly to the variate.[31] The canonical loadings of the second canonical variate pair showed that high levels of vital exhaustion and anger-out were related to elevated TG and diminished HDLc, increased WHR, augmented mean insulin and C-peptide net response during the OGTT, and elevated PAI-1 antigen level in the IRS parameter set (canonical $r = .39$, $\chi^2(24) = 36.8$, $P = .046$). Finally, the canonical loadings of the third pair of canonical variates indicated that high levels of hostility followed by low levels of anger-in and job involvement in the psychosocial set were related to elevated SBP and high TG in the IRS parameter set (canonical $r = .38$, $\chi^2(14) = 23.2$, $P = .052$).

Table 4. Canonical Correlations Between Psychosocial Factors and IRS Parameters

Factor/Parameter	Canonical Loadings* 1st Pair	2nd Pair	3rd Pair
Psychosocial factor			
Type A behavior	.50	−.10	−.25
Hostility	.49	−.04	.87
Vital exhaustion and anger-out	.18	.98	−.05
Job involvement and anger-in	.68	−.19	−.42
IRS parameter			
SBP	−.40	.04	.69
DBP	−.54	.15	.23
TG†	−.36	.49	.36
HDLc†	.32	−.34	.22
C-peptide net response	.29	.58	.28
Insulin mean†	.05	.54	.12
Glucose mean†	.03	−.13	.17
WHR	−.15	.38	.26
PAI-1†	−.42	.43	.22
Canonical correlation	.50	.39	.38
P	.008	.046	.052

*Loadings ≥ .30 contribute significantly to the canonical correlation.
†Logarithmic transformations were conducted.

The associations remained statistically significant when partial correlations were computed between the pairs of canonical variate scores, after adjustments for BMI, age, level of education, smoking, alcohol consumption, and physical activity ($r = .49$ between type A behavior and the IRS set; $r = .27$ between vital exhaustion, anger-out, and the IRS set; and $r = .36$ between hostility, anger-in/job involvement, and the IRS set). Furthermore, the associations remained statistically significant even when restricting the analyses to normotensive subjects only ($n = 69$: $r = .54$, .42, and .25 between type A behavior, vital exhaustion/anger-out, and hostility combined with anger-in/job involvement and the IRS parameter sets).

Finally, when we performed the analyses with fasting insulin, C-peptide, and glucose concentrations replacing the response and the mean values measured during the OGTT in the IRS parameter set, we found that the associations became nonsignificant.

DISCUSSION

The present study shows first that psychosocial stress–related factors and clustering of risk factors comprising the IRS are closely correlated. These findings are in line with the proposition that although genetic predisposition may play an important role in the development of insulin resistance and subsequent metabolic disorders, environmental factors are often necessary or may even be of major importance.[3] Moreover, these results support the use of the recently emphasized multivariate approach in the study of IRS risk-factor clustering.[33]

Second, the results did not reveal just one pattern of association between the two sets of variables, but indicated that different stress-related factors are likely to show different clustering profiles. No clinical or metabolic abnormalities were found in subjects scoring high on components of type A behavior and hostility, meaning that normotension, low TG and high HDLc, and low PAI-1 antigen levels were related to a psychological combination denoting a type A life-style. In contrast, high hostility scores in combination with low scores of anger-in and job involvement were associated with elevated SBP and high TG concentration, and high scores on vital exhaustion and anger-out were related to high WHR, elevated C-peptide response during the OGTT, hyperinsulinemia, dyslipidemia, and increased plasma PAI-1 antigen level. Adjustment for BMI, age, level of education, and health-related life-style factors including smoking, alcohol consumption, and physical activity did not alter the associations. Restricting the analyses to healthy normotensive subjects only did not alter the associations either, excluding the possible confounding effect of borderline hypertension. Thus, although hostility and vital exhaustion had partly overlapping but clearly different clinical and metabolic correlates, their combination represented a full-blown IRS.

According to previous literature, type A behavior, hostility, and vital exhaustion may reflect qualitatively different

aspects of perceived stress in which control and coping are the key words. Evidence from various sources suggests that a struggle to control lies behind type A behavior, which is elicited from susceptible individuals by an appropriately challenging environmental circumstance.[34] Struggle for control also characterizes hostility, which is motivated by a demand for continuous attentive observation of the environment,[35] whereas vital exhaustion reflects a response to chronic stress that prevails after a loss of environmental control has occurred.[18]

The different ways of controlling and coping with stress appear to differ also in terms of pathophysiological and metabolic profiles.[3,4,6,7,36-38] The existing evidence is mainly based on animal research results suggesting two extremes of reaction patterns. Struggle for control arouses the classic defense, or fight or flight response pattern,[36,38] with subsequent activation of the sympathetic nervous system, increased secretion of catecholamines, increases in blood pressure, cardiac output, and blood glucose, and a high plasma level of free fatty acids.[7,38,39] Loss of control provokes a response pattern typical of a defeat or conservation-withdrawal reaction.[37,38] Björntorp[3,4] has hypothesized that the defeat type of reaction is characterized by altered activity of the pituitary-adrenocortical axis, and by metabolic changes, including signs of the IRS. It should be noted that the defense reaction may provide a short-term mechanism protecting the body from an emergency and thus does not necessarily provoke pathophysiological metabolic aberrations.[40] However, in a state of chronic activation of the defense reaction, the ensuing control of metabolism may become impossible, leading to signs of insulin resistance.[7] Thus, a question can be raised as to whether type A behavior and hostility correspond to the defense-type response pattern, with the situation-specific type A corresponding to the adaptive, short-term reaction, and hostility with an underlying continuous tendency toward environmental control corresponding to the state of chronic activation of the defense reaction. Vital exhaustion with apparent loss of control and helplessness may be analogous to the defeat-type response pattern.

There are limitations to our study. We examined middle-aged male volunteers working at managerial levels. However, the psychosocial and IRS variables measured showed normal or expected distributions, suggesting that the associations found do not reflect any biases in selection. Further studies are still needed to strengthen the external validity of the findings. Although statistical significance does not mean biological significance and should be considered when evaluating the associations from a clinical point of view, it has been suggested that a cluster of even mild abnormalities may lead to significant arterial damage.[41] However, our data may underestimate the association between psychosocial factors and IRS risk-factor clustering, since we restricted the analyses to healthy normotensive and unmedicated borderline hypertensive subjects; in a less-fit population, psychosocial factors and IRS risk-factor clustering may be even more closely correlated. The cross-sectional nature of this study and the bidirectional nature of the canonical correlation analysis, precluding causal and temporal inferences, should also be considered in interpreting the present findings. Thus, the possibility that IRS parameters may also influence behavior should not be forgotten. Nor should it be forgotten that the present findings allow no causal or temporal inferences as to the role of psychological stress within the constructs of type A, hostility, and vital exhaustion. However, the voluminous literature on type A behavior and hostility underscores the motivational aspects of stress within these constructs,[42] whereas feelings of excess fatigue, loss of energy, increased irritability, and demoralization within the construct of vital exhaustion are often attributed to some long-standing problem that a person is not able to solve, or to a real or symbolic loss.[18] Vital exhaustion is thus interpreted as being an outcome of a psychological stress process.[18]

Finally, it is worthwhile noting that the constructs of type A, hostility, and vital exhaustion are not unambiguously homogeneous,[13,21] and a critique has been made of some of their measures, especially the JAS for type A. The rationale for choosing the psychosocial measures for the present study was the evidence of the validity of these measures in a Finnish population: JAS-based type A behavior has, for instance, been associated with the prevalence of coronary heart disease in a random sample representing the actively employed middle-aged Finnish population,[43] a sample paralleling the sample of the present study. The occasionally questioned validity of the type A construct and inconsistent data on the validity of the JAS should be kept in mind in evaluating the association of type A behavior with a favorable metabolic profile. A multimethod, dimension-oriented approach might be fruitful to further illuminate the relationship between psychosocial factors and IRS risk-factor clustering.

In summary, these data have shown that psychosocial stress–related variables and IRS risk-factor clustering are correlated. The present study did not address the possible mechanisms underlying these associations, but stress-induced adrenaline, growth hormone, and cortisol responses may all be involved.[44-46] Hautanen and Adlercreutz[23] have recently demonstrated that in the normotensive subjects of the present study, WHR, hyperinsulinemia, and dyslipidemia components of the IRS appeared to be associated with a subtle hypocortisolism. The current findings thus underscore the importance of further investigation of the potential role of stress and related personality and behavioral factors in metabolic alterations.

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