The Interrelationship of Psychosocial Risk Factors for Coronary Artery Disease in a Working Population: Do We Measure Distinct or Overlapping Psychological Concepts?

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There is growing evidence that psychosocial factors contribute to the risk of coronary artery disease. Commonly used psychometric scales share several features leading to questions about whether they reflect distinguishable concepts. Study participants were 822 employees of the Augsburg Cohort Study (mean age 40 years, 89% men). The authors analyzed the interrelationship between the following psychosocial measures by applying Pearson correlations and factor analysis to the Hospital Anxiety and Depression Scale (HADS), Type D Personality (DS14), the Maastricht Vital Exhaustion Questionnaire (VE), Social Support (F-SozU), the SF12 Health Survey, and Effort-Reward Imbalance. Although the full correlation matrix revealed low to medium associations supporting the notion that the applied psychometric scales show some conceptual overlap, factor analyses resulted in 13 distinguishable and interpretable factors, considerably reflecting the original psychometric scales. This strengthens the assumption that the psychometric scales used constitute distinct psychological concepts, in particular, depressive symptomatology and negative affectivity versus vital exhaustion.

Index Terms: *coronary artery disease, depression, psychometric factors, psychosocial risk factors, Type D personality, vital exhaustion*

Besides well-known biological and behavioral risk factors (eg, elevated blood pressure, unfavorable lipid profile, smoking, lack of physical exercise), there is growing evidence that psychological factors contribute to the pathogenesis and progression of coronary artery disease (CAD). Established psychosocial risk indicators for CAD include depression, anxiety, vital exhaustion, the Type D personality, and lack of social support.[1-8] Chronic and subacute life stress, defined as an accumulation of stressful life events over months, like high job strain, high effort combined with low reward, or overcommitment at work are also viewed as cardiovascular risk factors.[9-14] The entities assessed by various scales share some common features, described as decreased well-being because of excess fatigue, loss of vigor, loss of libido, hopelessness, depressed mood, sadness, listlessness, increased irritability, social inhibition or withdrawal, anxiousness, and sleep disturbances. This raises the question whether the scales used to ascertain the various psychosocial factors measure the same underlying construct or whether they assess different and distinguishable entities.

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Usually, epidemiological studies investigating the long-term association between psychosocial risk factors and CAD restrict questionnaires to one or a few psychological scales to avoid jeopardizing follow-up and participation. Thus, there is a paucity of data from large-scale studies that ascertain whether or not the commonly used psychometric scales reflect conceptually distinguishable entities. One of the few exceptions concerns the concepts of depression and vital exhaustion. However, the available data on whether the 2 concepts are distinct or share conceptual identity remain ambiguous.

Van Diest and Appels[15] recruited 12 exhausted and 10 non-exhausted apparently healthy men and investigated the prevalence of various mood states. Highly exhausted subjects scored significantly higher on self-reported excess of fatigue and loss of vigor, although "depressed" mood, the key symptom for depressive disorders, was hardly mentioned. It was concluded that men who are in a state of vital exhaustion do not automatically suffer from depression. The hypothesis that vital exhaustion is distinct from depression was further scrutinized by Kopp et al[16] in a representative, stratified nationwide sample in Hungary (n = 12,640). Although depressive symptoms and vital exhaustion correlated strongly (explained variance 38%), the 2 concepts were differentially associated with behavioral risk factors for cardiovascular events. However, in 143 patients, Wojciechowski et al[17] found strong and identical intercorrelations between 2 different depression scores and the Maastricht Vital Exhaustion Questionnaire at 4 different time points, and a factor analysis showed best fit with a one-factor model. Recently, Pedersen and Middel[18] reported that Type D patients were at substantially increased risk of suffering from vital exhaustion, and that Type D was also a significant predictor of vital exhaustion.

Given the scarcity of data on this issue, our primary aim was to elucidate in a large general population study whether or not a comprehensive battery of psychometric scales, namely, depression and anxiety, vital exhaustion, Type D personality, social support, subjective functional health, as well as effort, reward, and overcommitment at work, would reflect highly overlapping phenomena or separate entities. We raised the hypothesis that if the psychosocial parameters affirm to be distinct phenomena, the scales will show low to (at best) moderate intercorrelations and load on different and interpretable factors in exploratory principal component analyses.

METHODS

Study Sample

We invited about half of the regular staff of a European aircraft manufacturing plant located in South Germany to participate in a research project entitled "Health and Work." The recruitment procedure followed a random sampling strategy stratified for departments and job position in the company. The forms were completed in groups of 10 to 25 participants during the regular working time in rooms separate from the working place. Beyond paid working time and a personal feedback, no other incentive was offered. Analyses are based on records of 822 employees that participated in the written psychometric interview (accrual rate 71%). Because of the employment structure of the company, the resulting sample consisted predominantly of men (89%) between 15 and 61 years of age (mean 39.7 years ± 11.3). The majority of the sample was qualified skilled workers (n = 574, 71%), 14% were foremen (n = 114), 6% trainees (n = 47), about 4% skilled workers (n = 35), and about 4% supervisors or managers (n = 34). Eighteen individuals concealed their employment status. Based on the characteristics of the study sample (preponderance of men, age range), the present population might be considered generally as an at-risk population. All subjects participated voluntarily and gave written informed consent. The local institutional review board approved the study protocol.

Psychosocial Assessment

We administered the scales as part of 2 comprehensive questionnaires (general and medical items) in 2 sessions with a break of approximately 15 minutes. The comprehensive psychological assessment included: (1) the German version of the 14-item Hospital Anxiety and Depression Scale (HADS),[19-20] with subscales for anxiety (HADS-A) and depression (HADS-D); (2) the German version of the Type D Personality Inventory (DS14),[21-22] with subscales for negative affectivity (DS14-NA) and social inhibition (DS14-SI); (3) a translation of the 9-item short form of the Maastricht Vital Exhaustion Questionnaire (VE);[16] (4) the 14-item German social support questionnaire F-SozU;[23] (5) the German 12-item SF12 Health Survey (SF12) with subscales assessing mental and physical quality of life;[24-26] and (6) the scales required to ascertain Effort-Reward Imbalance status, namely Effort, Reward, and Overcommiment (OC), all in the German language.[27]

Statistics

We calculated Pearson product moment correlation coefficients to describe the interrelationships between all psychometric scales. We tested possible differences between Pearson's correlation coefficients of the VE, and HADS-D (measuring depressive symptomatology, anhedonia, and the absence of positive affect), and DS14-NA (measuring dysphoria, depressed mood, feelings of tension, and worry) fol-

lowing the procedure proposed by Williams[28] and Steiger[29] for the comparison of correlation coefficients providing t statistics. To assess the distinctiveness of the constructs evaluated by the various scales, we executed principal component analyses with orthogonal rotation using the varimax procedure (following the Kaiser Normalization). We inspected the Eigenvalues and scree plots to determine the number of factors. We examined internal consistency (reliability) of the resulting factors with Cronbach's alpha. In the first analysis, we focused on the conceptual relationship between depression, negative affectivity, and vital exhaustion by entering the items of the HADS-D scale (7 items), the DS14-NA score (7 items), and the VE (9 items). In a broader, more explorative analysis, we included the combined items of all used questionnaires to test for the factorial structure of all applied psychometric factors. We repeated factor analyses after standardizing applied items (z-transformation: mean = 0 and SD = 1). We carried out all analyses using SPSS software (version 11.0, SPSS, Chicago, IL).

RESULTS

Pearson Correlation Matrix. The full correlation matrix is depicted in Table 1. Only 1 nonsignificant result emerged in the entire correlation matrix: as intended from the construction of the SF12, the Physical (SF12-PSS) and Mental Summary Score (SF12-MSS) did not correlate. The highest correlations emerged between Effort or Reward and Effort-Reward Imbalance (r = .82 and r = –.80, both p < .001), because of the non-independence of the post-hoc computed imbalance score. All other independent psychometric scales showed medium to low associations. We observed the strongest intercorrelations between the HADS-D subscale, the DS14-NA subscale, the VE score, and the SF12-MSS (Table 1). The HADS-D scale and the DS14-NA scale showed a highly significant intercorrelation (r = .64, p < .001). Both scales also correlated considerably with vital exhaustion (HADS-D/VE: r = .57, p < .001; DS14-NA/VE: r = .60, p < .001).

To further elucidate whether the concept of VE is distinct from depressive symptomatology, we compared the correlation between the 2 scales that cover the measurement of depressed or dysphoric affect (HADS-D and DS14-NA) with the correlation between the HADS-D and VE. The analyses revealed a significant difference between the respective correlation coefficients, $t(801) = 2.9$, $p = .004$ (2-sided testing), indicating that HADS-D and VE indeed may represent distinct entities. In contrast, the difference in the correlation between the HADS-D and DS14-NA, and the correlation between DS14-NA and VE, did not reach statistical significance, $t(801) = 1.4$, $p = .16$ (2-sided testing). Because the DS14-NA subscale is designed to measure dysphoric mood as well as feelings of tension and worry, it could be a priori expected that the DS14-NA scale would correlate highly with both the HADS-D scale and with the HADS-A scale (DS14-NA/HADS-A: r = .54, p < .001). However, the correlation between DS14-NA and HADS-D was significantly higher than the correlation between DS14-NA and HADS-A, $t(801) = 3.96$, $p = .001$. The 2 HADS subscales also correlated considerably (r = .54, p < .001).

We observed shared variances in the range of 18–24% for the VE on the one hand and the HADS-A scale (r = .49, p < .001), the Effort-Reward Ratio score (r = .43, p < .001), and Overcommitment at work (r = .49, p < .001) on the other hand. Finally, the SF12-PSS explained about 13% of the variance only in the VE. All other relationships between the SF12-PSS and psychological factors explained even less than 7% of the respective variance.

Focused Factor Analysis (including HADS-D, DS14-NA, and VE). We included the 23 items of the HADS-D, DS14-NA, and VE to test the conceptual structure of exhaustion versus depression and negative affect. Three factors emerged explaining 15.9%, 15.5%, and 15.0% of the total variance (all Eigenvalues ≥ 3). A fourth factor only added 7.7% (Eigenvalue < 2). The main factor loadings are provided in Table 2. The first resulting factor consisted of all 7 items of the HADS-D scale. The second factor consisted of all 7 items of the DS14-NA scale. Six of the 9 items of the VE loaded together on a third factor. One further original VE item showed a very high loading on this factor, but loaded slightly higher on the first factor. The 2 remaining VE items, which related to sleep problems, formed a fourth factor. Another sleep-related original VE item also showed a high loading on this fourth factor, but loaded higher on the third factor. Reliability of the resulting factors was satisfactorily high with Cronbach's α = .80 (Factor I), α = .86 (Factor II), and α = .83 (Factor III). A reliability analysis including all 9 original VE items resulted in α = .84. The same results emerged after z-transformation (mean = 0, SD = 1) of the applied items.

Exploratory Factor Analysis. This comprehensive analysis included the items of all applied scales and revealed 18 factorial units. The first 13 factors appeared interpretable and explained 54% of the common variance. The Eigenvalues of these 13 factors were ≥ 2, whereas the remaining 5 factor units had Eigenvalues ≥ 1 and < 2. The results show that the majority, but not all, of these factor units represented the originally entered psychometric scales. The findings are summarized in Table 3. Again, standardization of all applied items (z-transformation) rendered the same results.

TABLE 1. Pearson Product Moment Correlation Coefficients

	HADS-D	HADS-A	DS14-NA	DS14-SI	VE	F-SozU	SF12-PSS	SF12-MSS	Effort	Reward	ERI
HADS-A	.554**										
DS14-NA	.636**	.535**									
DS14-SI	.267**	.372**	.460**								
VE	.567**	.487**	.602**	.295**							
F-SozU	–.347**	–.441**	–.421**	–.423**	–.272**						
SF12-PSS	–.214**	–.264**	–.205**	–.101**	–.361**	.154**					
SF12-MSS	–.564**	–.464**	–.648**	–.318**	–.604**	.344**	–.025				
Effort	.345**	.287**	.275**	.103**	.386**	–.089*	–.143**	–.313**			
Reward	–.337**	–.373**	–.338**	–.148**	–.381**	.192**	.202**	.381**	–.410**		
ERI	.399**	.370**	.353**	.157**	.434**	–.162**	–.208**	–.396**	.819**	–.797**	
OC	.416**	.342**	.354**	.158**	.489**	–.156**	–.195**	–.381**	.499**	–.288**	.452**

Note. HADS-D = Depression subscale of the Hospital Anxiety and Depression Scale; HADS-A = Anxiety subscale of the Hospital Anxiety and Depression Scale; DS14-NA = Negative Affectivity subscale of the DS14 Type D-Personality; DS14-SI = Social Inhibition subscale of the DS14 Type D-Personality; VE = Sum score of the Maastricht Vital Exhaustion Questionnaire; F-SozU = Sum score of the F-SozU Social Support Questionnaire; SF12-PSS = Physical Summary Score of the SF12 Health Survey; SF12-MSS = Mental Summary Score of the SF12 Health Survey; Effort = Extrinsic Effort score from the model of Effort-Reward Imbalance; Reward = Reward score from the model of Effort-Reward Imbalance; ERI = Effort/Reward ratio; OC = Overcommitment at work.
*$p < .05$; **$p < .001$.

TABLE 2. Summary of the Findings of the Focused Factor Analysis, Factor Structure, and Factor Loadings 30.40

Scale/item	Content	Factor 1	Factor 2	Factor 3	Factor 4
HADS-D #2	Can laugh and see the funny side of things (R)	.677			
HADS-D #1	Enjoy the things I used to enjoy (R)	.663			
HADS-D #6	Look forward with enjoyment to things (R)	.644			
HADS-D #7	Can enjoy a good book/radio/TV program (R)	.638			
HADS-D #3	Feel cheerful (R)	.626			
HADS-D #5	Lost interest in my appearance	.472			
VE #8	Discouraged	.452		.415	
HADS-D #4	Slowed down	.436			
DS14-NA #1	Makes a fuss about details		.759		
DS14-NA #3	Easily irritated		.722		
DS14-NA #5	Often in a bad mood		.709		
DS14-NA #7	Down in the dumps		.669		
DS14-NA #4	Gloomy view of things		.601		
DS14-NA #6	Tends to worry		.548		
DS14-NA #2	Feels unhappy	.471	.514		
VE #4	Feel weak all over			.813	
VE #7	Body is like a battery that is losing its power			.762	
VE #1	Often tired			.751	
VE #5	Feel more listless recently than before			.652	
VE #9	Wake up tired/exhausted			.528	.434
VE #6	Little things irritate more than they used to do			.411	
VE #3	Wake up repeatedly during the night				.836
VE #2	Difficulty falling asleep				.767
Eigenvalue		3.6	3.6	3.4	1.8
Variance (%)		15.9	15.5	15.0	7.7
Cronbach's α		.80	.86	.83	.66

DISCUSSION

In the present sample of 822 subjects from a working population, we measured a comprehensive battery of commonly used psychometric scales, which have repeatedly been linked to an increased risk for CAD, to determine whether or not they can be considered as distinct concepts. The answer may prove relevant for the design of clinical trials as well as development of targeted psychological preventive and rehabilitative programs and psychotherapeutic interventions in the field.[30] For instance, if researchers use a depression scale in lieu of a VE scale in prospective studies to provide the rationale for intervention studies (eg, the ENRICHD-trial), the tailored intervention to modify the risk factor depression may not necessarily affect the underlying state of VE. Thus, an increased understanding about the interrelation as well as the distinctiveness of the commonly used scales in a general at-risk population may help refine forthcoming interventional studies.

We hypothesized that, if the psychological parameters constitute distinct phenomena, a full correlation matrix would reveal only low to (at best) moderate relationships and that the psychological parameters would load on different and interpretable factorial units in factor analyses. The correlation matrix showed that the employed constructs shared (at best) up to 30–40% common variance, implying that they are in part related but not identical. This applies particularly for the SF12-MSS that aims to cover a wide range of subjective emotional and social health functioning (often interpreted as health-related quality of life and used as outcome variable). The SF12-MSS correlated considerably with several of the psychological scales, especially with the HADS-D, DS14-NA, and VE score ($r = -.56$ to $-.65$), but appeared not to substitute for any of them. This result is in line with the intention to reflect a general (summarized) status of self-reported mental health.[31]

As to the distinction between depression and VE, we found the HADS-D scale more closely related to the DS14-NA scale than to the VE score. Combined with the observation that a factor analysis of the items of the HADS-D, DS14-NA, and VE virtually regained the originally entered scales, we interpret this as a support for the notion that

TABLE 3. Summary of the Findings of the Exploratory Factor Analysis Including the Items of All Applied Scales

Factor number	Content	Number of items in factor	Eigenvalue	Variance (%)	Interpretation
#1	12 out of 14 F-SozU items	12	7.7	8.8	Social Support
#2	All 7 DS14-Social Inhibition items	7	4.9	5.6	Social Inhibition
#3	7 out of the 9 Vital Exhaustion items 2 SF12 items ("vitality" and "calmness") 1 HADS-A item	10	4.9	5.6	Exhaustion Except Sleep Problems
#4	5 out of 11 Reward items	5	3.5	4.0	Reward (monetary gratification + status control)
#5	5 out of the 6 Overcommitment items	5	3.4	3.9	Overcommitment
#6	All 6 SF12 items that are closest related to the Physical Summary Score	6	3.4	3.9	Physical Health Quality of Life
#7	4 HADS-A items 1 HADS-D item 2 DS14-NA items	7	3.8	4.4	(Anxiety)
#8	5 out of 7 DS14-Negative Affectivity items	5	2.9	3.4	Negative Affectivity
#9	5 out of the 6 Effort items 1 Overcommitment item ("time pressure")	6	3.3	3.8	Effort
#10	4 out of 6 SF12 items that are closest related to the Mental Summary Score	4	2.7	3.1	(Mental Health Quality of Life)
#11	4 out of 7 HADS-D items	4	2.3	2.6	(Depression)
#12	4 out of 11 Reward items	4	2.4	2.8	Reward (esteem reward)
#13	2 HADS-A 1 HADS-D	3	2.0	2.3	

Note. The remaining 5 "factors" only contained 1 or 2 items each (eg, the 2 sleep-related VE items "difficulties falling asleep" and "wake up repeatedly during the night" and the 2 reward items "job security" and "undesirable change in work situation" loaded together, respectively).

depressive symptoms, as well as dysphoric mood, are distinct from the concept of VE. In essence, the findings from our middle-aged, mainly male sample corroborate the data reported by Van Diest and Appels[15] and Kopp et al,[16] whereas they contrast the findings by Wojciechowski et al[17] in patients following a myocardial infarction. It is interesting that although the VE scale could be regained in the factor analysis, the 2 sleep-related VE items—"difficulties falling asleep" and "wake up repeatedly during the night"—loaded together on a separate factor. In related research, Kripke et al[32] recently determined the relationship between sleep duration and mortality in a sample of more than one million subjects.

When entering all items from all scales into an exploratory factor analysis, we retained most, but not all, of the originally entered psychometric scales. For example, the first resulting factor was composed of 12 out of the 14 social support items, representing a social support factor. Referring to the F-SozU score, the highest (negative) relationships were found with HADS-A ($r = -.44$) and DS14-NA and DS14-SI (both $r = -.42$), showing that a lack of social support is predominantly associated with increased anxiety, negative affectivity, and social inhibition. Especially the DS14-SI subscale but also the DS14-NA formed separate factor units, supporting the underlying assumption that Type D personality is composed of 2 conceptually distinct facets. This is in line with the intention of the constructor of the Type D concept.[18,22,33–34]

In the exploratory analysis including all items, all SF12 items that are most closely related to the SF12-PSS loaded on the same factor. Moreover, the scale showed very modest relationships with the psychological parameters. Only VE shared more than 10% of the common variance with the SF12-PSS. This result is in line with the SF12 Physical Health construct as a quality-of-life scale reflecting the amount of perceived physical health functioning, although

none of the psychological scales explicitly refer to bodily or physical health restrictions or complaints. In contrast to the SF12-PSS, not all the items that are related closest to the SF12-MSS composed one factor. Although 4 items formed a single factor, the 2 SF12 items "vitality" and "calmness" loaded highest on the "vital exhaustion" factor. Considering that the SF12-MSS is designed to serve as a general mental health quality-of-life and health functioning score, the result testifies that the SF12-MSS covers different aspects of emotional and social health functioning.

Concerning the psychosocial risk factors anxiety and depression, the factor analysis did not divide the 14 items into a highly homogeneous depression and anxiety scale. Although 1 resulting factor unified 4 out of the 7 originally HADS-D items, another factor unified 4 out of 7 HADS-A items and 3 items originating from other scales, and a third factor unified 2 HADS-A and 1 HADS-D item. A possible interpretation is that there exist distinct core depression and anxiety symptoms that can be separated easily and, simultaneously, both concepts share at least some common symptoms. An alternative interpretation would hypothesize a common nonspecific distress factor to which self-reported anxiety and depression symptoms covary to a considerable extent. Our findings are in line with several previous studies, reporting correlation coefficients of .40 to .74 between the 2 HADS subscales.[35,36] Spinhoven et al[37] came to the conclusion that the 2-factor solution may be defended on psychometric and theoretical grounds, although it appears to remain difficult to distinguish clearly between the constructs.

As to the assessment of work-related psychological risk factors, Siegrist et al suggested the Effort-Reward Imbalance model. In several epidemiological studies, an imbalance of high effort and low reward was prospectively related to CAD morbidity and mortality.[9–14] Our explorative factor analysis regained the 3 scales derived from the model of Effort-Reward Imbalance. Five out of 6 items of each of the Overcommitment and Effort scales formed separate factor units. In the present data, the 11 Reward items showed a 2-factorial solution that supports an earlier postulated 3-factor structure of the construct of occupational reward by Siegrist and coworkers covering (1) monetary/financial gratification, (2) status control/job security (forming a first reward factor), and (3) esteem reward (forming a second reward factor). Furthermore, the correlation matrix reveals that in 5 out of 8 possible cases, the relationship between the composed score expressing Effort-Reward Imbalance and any psychological scale was higher than the relationship between the respective psychometric scale and either the simple Effort or Reward score. This merely descriptive observation lends further support to the usefulness of the post-hoc computation of the Effort-Reward Ratio, as suggested by Siegrist et al.[27]

Despite a comprehensive battery of scales and a considerable sample size—2 strengths of this study—several caveats need to be considered. Our sample was not strictly population based, but representative for the predominantly male employees of the airplane manufacturing industry. Employees predominantly represent highly skilled workers from a Southern German cultural background. It remains unclear whether our findings can be generalized to other ethnic groups, different social classes, women, or clinical populations. Moreover, we did not control for other health variables such as physical exercise, tobacco abuse, and alcohol consumption. Although it is conceivable that these health factors are differentially associated with the psychological constructs, it is less likely that considering these health behaviors might essentially alter the general nature of our findings. Finally, our results should not be generalized to very young populations (younger than 20 years) or to elderly populations (older than 65 years).

Taken together, we assessed a broad range of psychometric scales in a large, representative sample of 822 employees of an aircraft plant. The scales claim to allow measurement of psychosocial risk factors prospectively linked with CAD. The correlational analyses between depression, negative affectivity, vital exhaustion, anxiety, social inhibition, social support, physical and mental health functioning as well as effort, reward, and overcommitment at work support the notion of an appreciable overlap between the different scales. However, our data confirm that in our middle-aged working population, the presently applied concepts should be considered as distinct psychological entities. Other conclusions might be drawn using other psychometric scales, as shown by Ketterer et al.[4] Also, Raynor et al[38] challenged the view that depression, hostility, and social support are different psychological concepts analyzing twin data. However, Frasure-Smith and Lespérance[8] recently revealed 3 underlying factors (negative affectivity, overt anger, and social support), applying several depression, anxiety, anger, and social support questionnaires in a prospective study over a 5-year period investigating cardiac-related mortality following myocardial infarction. Similarly, Blazer and Hughes[39] summarized that subjective support and depressive symptoms are interrelated but separate constructs, based on a study of 125 middle-aged and elderly adults suffering from a major depressive episode.

In sum, in future studies in the field, one scale should not be expected to substitute for another. The underlying correlations call for scientific scrutiny of the underlying psy-

chosocial construct best explaining variance in CAD before designing new behavioral intervention trials.

ACKNOWLEDGMENT

This work was supported by grants from the Swiss Federal Institute of Technology and the EADS GmbH, Werk Augsburg, Germany.

NOTE

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