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Type D Patients Report Poorer Health Status Prior to and After Cardiac Rehabilitation Compared to Non-Type D Patients

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Abstract

Background Type D personality is an emerging risk factor in coronary artery disease (CAD). Cardiac rehabilitation (CR) improves outcomes, but little is known about the effects of CR on Type D patients.
Purpose We examined (1) variability in Type D caseness following CR, (2) Type D as a determinant of health status, and (3) the clinical relevance of Type D as a determinant of health status compared to cardiac history.
Methods CAD patients ($n=368$) participating in CR completed the Type D Scale, the Short-Form Health Survey 36 pre- and post-CR, and the Hospital Anxiety and Depression Scale pre-CR, to assess health status and depressive and anxious symptomatology, respectively.
Results The prevalence of Type D decreased from 26.6% to 20.7% ($p=0.012$) following CR, but Type D caseness remained stable in 81% of patients. Health status significantly improved following CR [$F(1,359)=17.48$, $p<0.001$], adjusting for demographic and clinical factors and anxious and depressive symptoms. Type D patients reported poorer health status [$F(1,359)=10.40$, $p=0.001$], with the effect of Type D being stable over time [$F(1,359)=0.49$, $p=0.48$]. Patients with a cardiac history benefited less from CR [$F(1,359)=5.76$, $p=0.02$]. The influence of Type D on health status was larger compared to that for cardiac history, as indicated by Cohen's effect size index.
Conclusions Type D patients reported poorer health status compared to non-Type D patients pre- and post-CR. In the majority of patients, CR did not change Type D caseness, with Type D being associated with a stable and clinically relevant effect on outcome. These high-risk patients should be identified in clinical practice and may require adjunctive interventions.

Keywords Cardiac rehabilitation · Coronary artery disease · Health status · Type D personality

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Introduction

Cardiac rehabilitation comprises an important adjunctive treatment option for patients with coronary artery disease (CAD) once they are medically stable, with benefits extending from improvements in well-being [1, 2] and health status [3] to clinical outcome [4], including enhanced survival [5]. However, subgroups of patients may not benefit optimally from cardiac rehabilitation, with clinical

factors, such as comorbid chronic kidney disease [6], type II diabetes [7], and obesity [8], and psychological factors, such as depressive mood states [9], having been shown to moderate the effectiveness of cardiac rehabilitation.

Personality comprises another potentially important determinant of health outcomes following cardiac rehabilitation, which to date has received little attention. Preliminary evidence indicates that hostile patients may experience more benefits from cardiac rehabilitation in terms of reductions in anxiety and improvement in quality of life [10]. Type D personality is an emerging risk factor in cardiovascular disease that has been shown to predict adverse health outcomes in CAD [11, 12], peripheral arterial disease [13], chronic heart failure [14], patients with life-threatening arrhythmias [15], and patients treated with revascularization procedures [16]. Type D is defined by the two normal and stable personality traits Negative Affectivity [17] and Social Inhibition [18]. Patients with this personality disposition often feel sad, have a gloomy view of life, and at the same time do not express these emotions in social interactions because of fear of disapproval or rejection by others [19].

Type D personality has been associated with adverse prognosis at 5 years follow-up, despite optimal medical treatment and participation in cardiac rehabilitation [11]. However, the latter study did not include assessments pre- and post-cardiac rehabilitation. Two recent studies focused on Type D within the cardiac rehabilitation setting. One showed that Type D patients benefit from cardiac rehabilitation in terms of improved health status and a reduction in depression and anxiety [20]. However, analyses were performed in a small sample ($n=55$) of patients, with the authors not adhering to the standardized fashion for determining Type D caseness. The other study showed that 81% of patients remained stable in Type D caseness after attending cardiac rehabilitation [21].

The objectives of the current prospective study, using a between-subjects design, were (1) to determine variability in Type D caseness following cardiac rehabilitation, (2) to examine whether Type D personality is a determinant of health status in patients attending cardiac rehabilitation, and (3) to evaluate the clinical relevance of Type D personality as a determinant of impaired health status compared to cardiac history prior to the referral event.

Method

Study Design and Participants

Consecutive patients with established heart disease referred to the cardiac rehabilitation program at the Rotterdam Organization for Cardiac Rehabilitation, The Netherlands, between March 2004 and October 2005, participating in the identification of subgroups of heart patients that may not benefit optimally from cardiac rehabilitation (HEARTCARE) study, comprised the sample for the current study. Patients with chronic heart failure (due to participation in another study within the institution) and those with insufficient knowledge of the Dutch language to be able to complete questionnaires were excluded, leaving 519 patients eligible for participation. Of these patients, 111 were lost to follow-up, and 29 patients did not complete baseline assessment. In addition, 11 patients were excluded from analyses because of too many missing data on questionnaires. Final analyses were based on 368 patients (response rate=71.2%). Patients were asked to complete a set of psychological questionnaires at baseline and at 3-month follow-up (i.e., prior to and after completion of the rehabilitation program). The study was set up as a between-subjects design, and not as a randomized controlled trial, because it was not possible to have a waiting list control group in the current cardiac rehabilitation setting.

The study protocol was approved by the medical ethics committee of the Erasmus Medical Center, Rotterdam. The study was conducted according to the Helsinki Declaration, and every patient provided written informed consent.

Contents of Rehabilitation Program

The program was multi-factorial comprising an introductory module, physical exercise component, modules on risk factors, stress management, diet, medication, weight loss, and smoking cessation, with the possibility of having individual counseling by a psychiatrist, psychologist, or social worker if requested by the patient.

Materials

Demographic and Clinical Variables

Demographics included gender, age, educational level, marital status, and employment status. Clinical variables, obtained from the patients' medical records, included initial diagnosis, cardiac history prior to the referral event (i.e., previous myocardial infarction, coronary artery bypass graft surgery, or percutaneous coronary intervention), prescribed medications, smoking, and risk factors (i.e., hypercholesterolemia, hypertension, diabetes, family history, renal insufficiency, chronic obstructive pulmonary disease, and liver insufficiency).

Type D Personality

The Type D Scale (DS14) was administered to assess Type D personality [22]. This 14-item questionnaire comprises two subscales, Negative Affectivity and Social Inhibition, each consisting of seven items. Items are answered on a

five-point Likert scale, ranging from 0 (false) to 4 (true). A standardized cut-off score ≥10 on both subscales is used to classify individuals with a Type D personality [22]. A previous study confirmed that it is the interaction of both traits, rather than the single traits, that incurs an increased risk of adverse health outcomes [23]. Recently, the cut-off score of ≥10 for both subscales has been confirmed as the most optimal by means of Item Response Theory in samples from the general population, CAD patients, and hypertensives [24]. Both of the DS14 subscales of Negative Affectivity and Social Inhibition have good internal consistency (Cronbach's α=0.88/0.86), are stable over a 3-month period (r=0.82/0.72), and are independent of mood and health status [22]. In the current sample, the 3-month test–retest reliability for the Negative Affectivity and the Social Inhibition components were 0.64 and 0.74, respectively. A recent study in post-myocardial infarction patients confirmed the stability of Type D personality during an 18-month period and that Type D is not confounded by disease severity and mood states [25, 26].

Depressive and Anxious Symptomatology

The Dutch version of the Hospital Anxiety and Depression Scale (HADS) was used to assess depressive and anxious symptomatology [27, 28]. Both subscales consist of seven items that are answered on a four-point Likert Scale, ranging from 0 to 3. A cut-off score of ≥8 for each subscale represents probable clinical levels of anxiety and depression [29]. Test–retest reliability over a 3-week period for the subscales and the total scale are good ($0.86<r<0.91$) [28]. The dimensional structure and reliability of the HADS has shown to be stable across medical settings and age groups [28].

Health Status

The Dutch version of the Short-Form Health Survey (SF-36) was administered to assess generic health status [30, 31]. Items are answered according to standardized response choices and contribute to eight subscales: Physical Functioning (ten items), Social Functioning (two items), Role Limitations due to Physical Functioning (four items), Role Limitations due to Emotional Functioning (three items), Mental Health (five items), Vitality (four items), Bodily Pain (two items), and General Health (five items). Raw scores were transformed to scale scores according to standard scoring procedures. Subscale scores range from 0–100, with higher scores indicating better levels of functioning. For the Bodily Pain subscale, a higher score denotes the absence of pain. The validity and reliability of the Dutch SF-36 are good [31]. The mean alpha coefficient across groups from the Dutch general population, migraine patients, and cancer patients and across scales was 0.84 [31].

Statistical Analyses

Discrete variables were compared with the chi-square test and continuous variables with Student's t test for independent samples. Analyses were adjusted for multiple comparisons by means of a Bonferroni correction (α/number of comparisons). The McNemar test was used to examine whether Type D and non-Type D proportions were equally distributed pre- and post-cardiac rehabilitation. Secondary analyses were conducted to determine whether the two subcomponents of Type D personality, Negative Affectivity, and Social Inhibition, changed following cardiac rehabilitation.

To examine differences in health status between Type D and non-Type D patients prior to and after cardiac rehabilitation, we used multivariate analysis of variance (MANOVA) with repeated measures in order to adjust for multiple comparisons, given that the SF-36 comprises eight subscales. Multivariate analysis of covariance (MANCOVA) with repeated measures was performed to adjust for the effect of potential confounders on the relationship between Type D personality and health status. In MANOVA as well as MANCOVA, baseline Type D personality classification was entered as a between-subjects factor and health status as a within-subjects factor. Age, gender, smoking, cardiac history prior to the referral event, comorbidity (chronic obstructive pulmonary disease, diabetes, or renal insufficiency), anxiety, and depressive symptoms at baseline were selected as covariates a priori based on the literature. Post-hoc paired-samples t tests were conducted to determine differences in domains of health status for Type D and non-Type D patients separately.

Secondary analyses were conducted on the subsample of patients for whom information was available on individual counseling to determine whether these patients differed on health status prior to and following cardiac rehabilitation from patients who did not receive individual counseling. To evaluate the clinical relevance of Type D personality compared to cardiac history prior to the referral event as a determinant of impaired health status pre- and post-cardiac rehabilitation, effect sizes were calculated, using Cohen's d [32, 33]. Cohen's d represents the differences between means (i.e., Type D vs. non-Type D; cardiac history vs. non cardiac history prior to the referral event) divided by the pooled standard deviation. An effect size ranging from 0.00 to 0.20 is negligible to small, 0.20 to 0.50 small to moderate, 0.50 to 0.80 large, and >0.80 very large [33]. Cardiac history prior to the referral event was chosen as comparison, since this variable previously has been shown to moderate the effectiveness of a behavioral intervention in vitally exhausted patients undergoing a percutaneous coronary intervention [34]. A post-hoc power analysis showed that, with an assumed effect size of 0.20, α=0.05, and a power of 95%, a sample size of 327 patients was

required to detect statistical differences in SF-36 scores pre- and post-cardiac rehabilitation (repeated measures design, within-between interaction). This assumption was met, since analyses were based on 368 patients. All statistical tests were two-tailed, and $p<0.05$ was used to indicate statistical significance. Statistical analyses were performed using SPSS 14.0 for Windows (SPSS Inc., Chicago, IL, USA).

Results

Patient Characteristics

Completers ($n=368$) and non-completers ($n=151$) of the cardiac rehabilitation program did not differ on baseline demographic and clinical characteristics. There were also no statistically significant differences in the prevalence of

Type D personality for those non-completers with data on Type D status ($n=111$) and completers ($n=368$; $\chi^2=0.08$, $p>0.05$).

The prevalence of Type D personality was 26.6%. Patient baseline characteristics, stratified by Type D, are presented in Table 1. No differences were found between Type D and non-Type D patients on baseline demographic and clinical characteristics and the type of cardiac rehabilitation-components attended.

Changes in Type D Caseness and Components Following Cardiac Rehabilitation

There was a 5.9% reduction in the number of patients with a Type D personality from 26.6% prior to cardiac rehabilitation to 20.7% post-cardiac rehabilitation ($\chi^2=6.30$, $p=0.012$). A change in Type D caseness was found in 19% of patients, with caseness remaining stable in 81%. Of the 19% crossing

Table 1 Baseline characteristics stratified by Type D personality

	Total sample ($n=368$)	Type D ($n=98$)	Non-Type D ($n=270$)	p^a
Socio-demographics				
Males	290 (78.8)	73 (74.5)	217 (80.4)	0.22
Age, mean (SD)	58.1 (10.2)	57.4 (10.3)	58.3 (10.2)	0.45
Having a partner	330 (89.7)	87 (87.8)	244 (90.4)	0.47
Clinical variables				
Cardiac event prior to referral event[b]	299 (81.3)	79 (80.6)	220 (81.5)	0.85
Diabetes mellitus	54 (14.7)	16 (16.1)	38 (16.3)	0.59
Dyslipidemia	185 (50.3)	55 (56.1)	130 (48.1)	0.18
Hypertension	122 (33.2)	32 (32.7)	90 (33.3)	0.90
Renal impairment	4 (1.1)	2 (2.0)	2 (0.7)	0.29
Chronic obstructive pulmonary disease	28 (7.6)	7 (7.1)	21 (7.8)	0.84
Currently smoking	32 (8.7)	12 (12.2)	20 (7.4)	0.15
Medication				
β-Blockers	286 (77.7)	75 (76.5)	211 (78.1)	0.74
ACE inhibitors	215 (58.4)	56 (57.1)	159 (58.9)	0.77
Calcium antagonists	42 (11.4)	13 (13.3)	29 (10.7)	0.50
Nitrates	118 (32.1)	27 (27.6)	91 (33.7)	0.26
Statins	298 (81.0)	83 (84.7)	215 (79.6)	0.27
Aspirin	277 (75.3)	78 (79.6)	199 (73.7)	0.25
Diuretics	66 (17.9)	17 (17.3)	49 (18.1)	0.86
Cardiac rehabilitation components[c]				
Introduction	144 (44.4)	41 (50.0)	103 (42.6)	0.24
Risk factors	251 (77.0)	69 (82.1)	182 (75.2)	0.19
Dietary advice	238 (73.0)	67 (79.8)	171 (70.7)	0.11
Medication	196 (59.0)	54 (64.3)	142 (57.3)	0.26
Physical exercise	327 (98.8)	83 (100)	244 (98.4)	0.24
Stress-management	61 (18.4)	15 (17.9)	46 (18.6)	0.88
Smoking cessation	26 (7.83)	8 (9.5)	18 (7.3)	0.50
Weight loss	53 (16.0)	13 (15.5)	40 (16.1)	0.89
Individual counseling	48 (14.5)	18 (21.4)	30 (12.2)	0.04

Results are presented as n (%) unless otherwise stated.

[a] p values adjusted for multiple comparisons.

[b] Coronary artery bypass grafting, myocardial infarction, or percutaneous coronary intervention.

[c] Due to missing data for 36–44 patients, analyses were conducted on available data.

over, 6.5% crossed over from non-Type D to Type D, whereas 12.5% crossed over from Type D to non-Type D. Of the 81% maintaining their caseness over time, 66.9% and 14.1% were consistently categorized as non-Type D and Type D, respectively. No statistically significant differences were found between patients crossing-over and remaining stable on Type D caseness on the cardiac rehabilitation components attended ($7.25 < \chi^2 < 0.08$, all $ps > 0.05$). Hence, the cross-over from Type D to non-Type D and vice versa could not be attributed to differences in participation in the various cardiac rehabilitation components. Generally, in the subsample of patients for whom information on individual counseling was collected ($n = 331$), there was no statistically significant difference in health status pre- and post-rehabilitation between patients receiving and not receiving individual counseling [$F(1,329) = 0.91$, $p = 0.34$]. The main effect for individual counseling and the interaction effect for time by individual counseling were significant [$F(1,329) = 12.76$ and $F(1,329) = 8.60$, both $ps < 0.01$]. After controlling for possible confounders, the main effect for time did not remain significant [$F(1,323) = 1.21$, $p = 0.27$]. In addition, the interaction for time by individual counseling, as well as the main effect for individual counseling, were no longer significant [$F(1,323) = 1.31$, $p = 0.25$ and $F(1,323) = 1.12$, $p = 0.29$, respectively].

To determine whether the Type D subcomponents changed following cardiac rehabilitation, we conducted a MANOVA with repeated measures. There was a significant main effect for time for Social Inhibition and Negative Affectivity [$F(1,367) = 6.48$, $p = 0.01$ and $F(1,367) = 35.35$, $p < 0.001$, respectively], indicating that there was a decrease in scores over time. After controlling for possible confounders, using MANCOVA with repeated measures, the main effect for time lost significance for Negative Affectivity [$F(1,360) = 0.29$, $p = 0.59$]. Covariates did not interact with time [$0.05 < F(1,360) < 2.30$, all $ps < 0.05$]. The main effect for time for Social Inhibition remained significant [$F(1,360) = 6.74$, $p = 0.01$] in adjusted analysis. The time by

cardiac history was also significant, indicating that patients who experienced a cardiac event prior to the index event [$F(1,360) = 12.54$, $p < 0.001$] reported changes in Social Inhibition. Post-hoc paired t tests showed that both Social Inhibition [from 9.44 ± 5.62 to 8.13 ± 6.14; $t(367) = 2.55$, $p = 0.01$] as well as Negative Affectivity [from 8.90 ± 5.89 to 8.22 ± 6.09; $t(367) = 5.95$, $p < 0.001$] decreased significantly. However, the clinical relevance of these decreases were negligible to small for Negative Affectivity ($d = 0.11$) and small for Social Inhibition ($d = 0.22$), as indicated by Cohen's effect size index.

Type D Personality as a Determinant of Health Status Pre- and Post-Cardiac Rehabilitation (Unadjusted Analysis)

MANOVA with repeated measures demonstrated a significant within subjects effect for time [$F(1,366) = 222.63$, $p < 0.001$], indicating that health status, as assessed by the SF-36, improved over time. The time by Type D interaction was not significant, showing that Type D personality exerted a stable effect on health status over time [$F(1,366) = 1.43$, $p = 0.23$]. However, patients with a Type D personality reported significantly poorer health status [$F(1,366) = 80.80$, $p < 0.001$] compared to non-Type D patients. Mean scores (SD) on health status pre- and post-cardiac rehabilitation stratified by Type D personality are presented in Table 2.
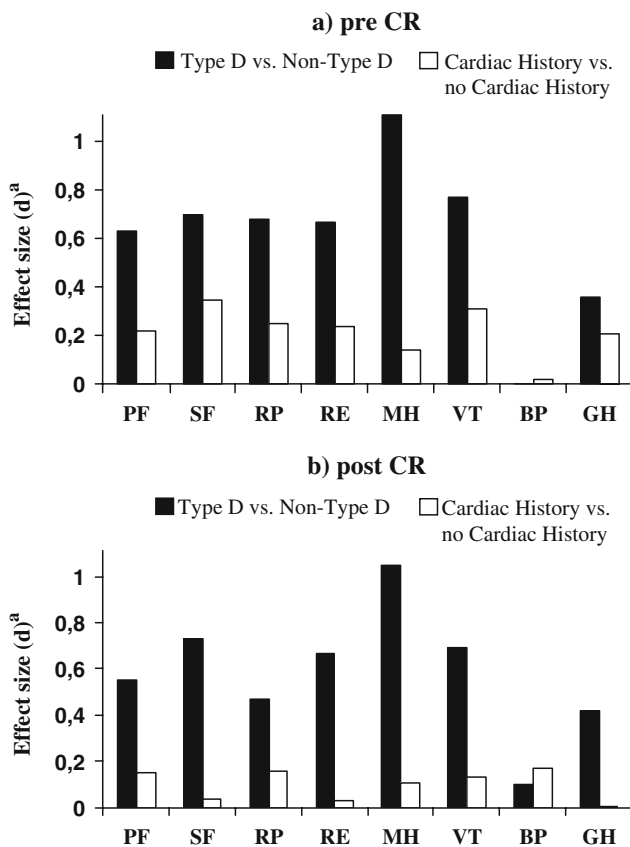
Type D Personality as a Determinant of Health Status Pre- and Post-Cardiac Rehabilitation (Adjusted Analysis)

MANCOVA with repeated measures showed a main effect for time [$F(1,359) = 17.48$, $p < 0.001$], indicating an overall improvement in health status over time when correcting for potential confounders. Furthermore, the interaction effect for time by cardiac history prior to the referral event was significant, denoting that patients with a prior cardiac history reported impaired health status pre- and post-cardiac rehabilitation compared to patients without a cardiac history prior to

Table 2 Mean (SD) SF-36 scale scores stratified by Type D personality

	Pre-CR		Post-CR	
	Type D	Non-Type D	Type D	Non-Type D
Physical Functioning	61.12 (19.73)	73.12 (18.63)	75.41 (21.03)	84.81 (15.50)
Social Functioning	56.82 (25.50)	71.98 (20.06)	71.94 (22.19)	85.68 (17.37)
Role limitations due to Physical Functioning	11.48 (11.48)	34.72 (38.43)	54.46 (38.18)	71.98 (36.87)
Role limitations due to Emotional Functioning	38.10 (39.11)	64.51 (39.78)	65.14 (40.45)	85.83 (26.72)
Mental Health	56.22 (17.42)	75.21 (16.99)	65.04 (16.28)	81.25 (15.14)
Vitality	47.65 (17.54)	62.10 (19.17)	57.20 (17.63)	69.65 (18.27)
Bodily Pain	56.42 (15.55)	56.49 (17.27)	49.33 (14.96)	50.59 (11.36)
General Health	60.63 (15.18)	66.07 (15.21)	61.63 (20.04)	69.54 (18.67)

A higher score represents better health status, with a higher score on Bodily Pain indicating the absence of pain.

CR Cardiac rehabilitation, *SD* standard deviation

a) pre CR

■ Type D vs. Non-Type D   □ Cardiac History vs.
                                no Cardiac History

b) post CR

■ Type D vs. Non-Type D   □ Cardiac History vs.
                                no Cardiac History

Fig. 1 Clinical relevance of Type D personality and cardiac history prior to the referral event as determinants of health status pre- and post-cardiac rehabilitation. Effect sizes are expressed as Cohen's d, with values ranging from 0.00 to 0.20 being negligible to small, 0.20 to 0.50 being small to moderate, 0.50 to 0.80 being large, and >0.80 being very large. *PF* Physical Functioning, *SF* Social Functioning; *RP* Role limitations due to Physical functioning, *RE* Role limitation due to Emotional functioning, *MH* Mental Health, *VT* Vitality, *BP* Bodily Pain, *GH* General Health

the referral event [$F(1,359)=5.76$, $p=0.02$]. Comorbidity, age, gender, smoking, anxiety, and depressive symptoms did not interact with cardiac rehabilitation [$0.001<F(1,359)<2.32$, $p>0.05$]. The time *by* Type D was not significant, indicating that Type D had a stable effect on health status over time [$F(1,359)=0.49$, $p=0.48$]. The between-subjects effect for Type D personality remained significant, showing that Type Ds and non-Type Ds differed on self-reported health status [$F(1,359)=10.40$, $p=0.001$] as measured by the SF-36.

Paired samples t tests for Type D patients demonstrated improvements on six subscales of the SF-36 [$-10.96<t(97)<-5.08$, all ps<0.001], except for General Health [$t(97)=-0.548$, $p=0.59$]. In addition, Type Ds reported an increase in Bodily Pain [$t(97)=3.24$, $p=0.002$] over time. Non-Type D patients reported improvements on seven out of eight subscales [$-10.68<t(269)<-3.31$, $p≤0.001$], but they also reported an increase in Bodily Pain [$t(269)=4.82$, $p<0.001$].

Clinical Relevance of Type D Personality Versus Cardiac History Prior to the Referral Event

The effect sizes for Type D personality and cardiac history prior to the referral event, as denoted by Cohen's effect size index (d), for all eight SF-36 scale scores pre- and post-cardiac rehabilitation are presented in Fig. 1. At baseline, the effect sizes for Type D personality were moderate to large for five of the eight subscales of the SF-36. The effect size was very large for Mental Health but small to moderate for General Health and negligible to small for Bodily Pain (Fig. 1a). The results remained identical at follow-up, except for Role Problems due to Physical limitations, where the effect size decreased to small to moderate. The effect sizes for cardiac history prior to the referral event at baseline were small to moderate, except for Mental Health and Bodily Pain. For these two subscales, the effect sizes were negligible to small. At follow-up, all effect sizes for cardiac history prior to the referral event were negligible to small (Fig. 1b).

Discussion

This study showed that there was a 5.9% reduction in the number of patients with a Type D personality following cardiac rehabilitation, although the majority of patients (i.e., 81%) remained stable within their Type D caseness. The Type D subcomponent Social Inhibition changed over time, whereas Negative Affectivity remained stable, but the clinical relevance of the change in Social Inhibition was negligible to small, as indicated by Cohen's effect size index. Generally, Type D patients reported poorer health status prior to and after attending a multifactorial cardiac rehabilitation program compared to non-Type D patients. Both Type D and non-Type D cardiac patients attending cardiac rehabilitation reported benefits in terms of health status, as assessed by the SF-36. Personality did not moderate the effects of rehabilitation, as indicated by the non-significant interaction effect for Type D *by* time, showing that Type D exerted a stable effect on health status over time. Cardiac history prior to the referral event was shown to moderate the effects of cardiac rehabilitation, with patients with a previous history reporting impaired health status, as assessed by the SF-36, compared to patients without a cardiac history prior to the referral event. The impact of Type D on health status was clinically relevant compared to cardiac history prior to the referral event, as indicated by Cohen's effect size index.

The findings of the current study are in line with previous studies in patients with peripheral arterial disease [13], treated with revascularization procedures [16, 35], and patients with chronic heart failure [14], showing that Type D patients

report poorer health status compared to non-Type D patients despite both personality taxonomies benefiting from medical treatment. In the present study, we found a non-significant interaction effect for Type D personality by time, indicating that personality did not moderate the effects of cardiac rehabilitation on health status but exerted a stable effect on health status over time. In a mixed group of cardiac patients attending cardiac rehabilitation, patients with a Type D personality were also shown to report poorer health status, but this study only evaluated health status at one time point [19].

In the current study, patients with a cardiac history prior to the referral event reported impaired health status compared to patients without a cardiac history. These findings are in line with the Exhaustion Intervention Trial (EXIT), which showed that percutaneous coronary intervention patients with a cardiac history prior to the referral event were less likely to benefit from a behavioral intervention program designed to improve symptoms of vital exhaustion [34]. Secondary analyses indicated that, in particular, patients with two or more previous cardiac events prior to the index percutaneous coronary intervention benefited less from the intervention. Taken together, these findings point to the need for individually tailored interventions for those patients in whom risk factors tend to cluster together [36]. In addition, they underline that cardiac rehabilitation should be offered to patients at the time of their first cardiac event, as they may be more likely to benefit and adopt life style changes at this time than when the disease has become chronic [37].

We also found a reduction in the number of patients with a Type D personality, although the decrease comprised 5.9%. In addition, once categorized as Type D or non-Type D, the majority of patients (i.e., 81%) maintained their caseness despite receiving cardiac rehabilitation. These findings are in line with those of Binder and colleagues [21] and Karlsson and colleagues [20], although the latter study deviated from the standard criteria for determining Type D personality, as originally proposed by Denollet [22]. Taken together, some patients may cross over from Type D to non-Type D status, but unfortunately, this only occurs in a minority of patients, with some patients also crossing over from non-Type D to Type D status. The cross-over from Type D to non-Type D status might also be attributed to measurement error in the instrument. However, it is important to bear in mind that the present cardiac rehabilitation program was not specifically designed to target Type D personality. Future studies are warranted to determine whether interventions targeting Type D are effective in improving patient-centered as well as clinical outcomes in patients with this personality profile.

Limitations of the current study comprise the use of a generic rather than a disease-specific instrument for the assessment of health status, as disease-specific instruments are likely to be more sensitive to tap changes following cardiac rehabilitation [38]. Incorporation of such instruments might provide better insight into the facets that may not change following cardiac rehabilitation. Nevertheless, we were able to demonstrate changes in a generic measure of health status. Third, we were not able to control for markers of disease severity (e.g., left ventricular ejection fraction), as this information was not standardly noted in the cardiac rehabilitation records. Although the relationship between Type D and health status might be confounded by disease severity, this seems unlikely given that Type D personality has been shown not to be confounded by disease severity in post infarction patients [25, 26]. Fourth, we did not have data on Type D status for all patients dropping out of the program, with the possibility that patients dropping out may be more likely to have a Type D personality. However, we found no differences in the subsample where this information was available. In addition, information on the reason for referral to rehabilitation was not consistently available. Furthermore, the current study lacked a control group, which hampers interpretation of the findings. Although it would have been possible to introduce a waiting group, this was not possible in the current cardiac rehabilitation setting. Finally, patients diagnosed with chronic heart failure were excluded from the study. Therefore, results cannot be generalized to this patient group.

Strengths of the study include the large sample size, with a post hoc power analysis confirming that the study was sufficiently powered to test the objectives. Further, we used a prospective design with repeated measures of health status and standardized, validated, and psychometrically sound instruments. Finally, we adjusted statistically for demographic and clinical factors known to influence health status in CAD.

From a clinical point of view, this study provides further evidence for the adverse impact on health outcomes and stability of Type D personality. In addition, the findings show that the effect of Type D personality on health status was not only statistically significant but also clinically relevant. As indicated by Cohen's effect size index, the effect sizes for Type D personality ranged from small to very large both pre- and post-cardiac rehabilitation, with most effect sizes falling within the range of moderate to large. In contrast, the effect sizes for cardiac history prior to the referral event ranged from negligible to moderate at baseline, whereas at follow-up, all decreased to negligible to small. These findings are consistent with a previous study showing that Type D personality was clinically relevant compared to gender and age as determinants of vital exhaustion [39]. Despite the majority of patients remaining Type D or non-Type D post-rehabilitation if typified as such prior to rehabilitation and Type D exerting a stable effect on health status over time, Type D patients experienced improvements in health status, as assessed by

the SF-36, although their reported health status remained below par compared to that of non-Type D patients. Taken together, this suggests that Type D patients benefit from rehabilitation in terms of improved health status but that this subgroup of patients need adjunctive interventions to standard rehabilitation, as they still experience poorer health status than non-Type D patients. The target of such intervention should not be to alter personality but to enhance the coping mechanisms of Type D patients.

These high-risk patients could be identified when referred for cardiac rehabilitation with the use of the DS14, as advocated previously [40]. Given that poor health status is associated with adverse prognosis [41], behavioral interventions in addition to cardiac rehabilitation may be warranted for Type D patients. Supplementary interventions could focus on the pathways that link of Type D personality to adverse health outcomes. On the behavioral level, self-management appears to be of importance in this particular group, with a recent study showing that Type D patients diagnosed with chronic heart failure are less likely to consult their cardiologist or heart failure nurse despite reporting more symptoms and experiencing these as worrisome [42]. Relaxation therapy, social skills training, cognitive behavioral therapy, and learning how to deal with negative emotions could comprise likely adjunctive interventions to reduce the cardio-toxicity of Type D personality. Furthermore, therapists involved in intervention trials targeting Type D should be experienced and sensitive to establishing and maintaining a safe environment for these patients, as they are not likely to express and share their emotions without these premises.

In conclusion, the present study demonstrated that cardiac patients with a Type D personality report impaired health status prior to and following cardiac rehabilitation, in comparison with non-Type D patients. Changes were seen in Type D caseness following cardiac rehabilitation, but for the majority of patients once categorized as Type D or non-Type D, they maintained their caseness despite receiving cardiac rehabilitation. Type D personality was also shown to have a stable effect on health status over time. The impact of Type D personality on health status was not only statistically significant but also clinically relevant. Taken together, these findings show that additional intervention is warranted in this high-risk subgroup. Incorporation of psychological factors in general and personality factors in particular in research and clinical practice might enhance secondary prevention in patients with established CAD.

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