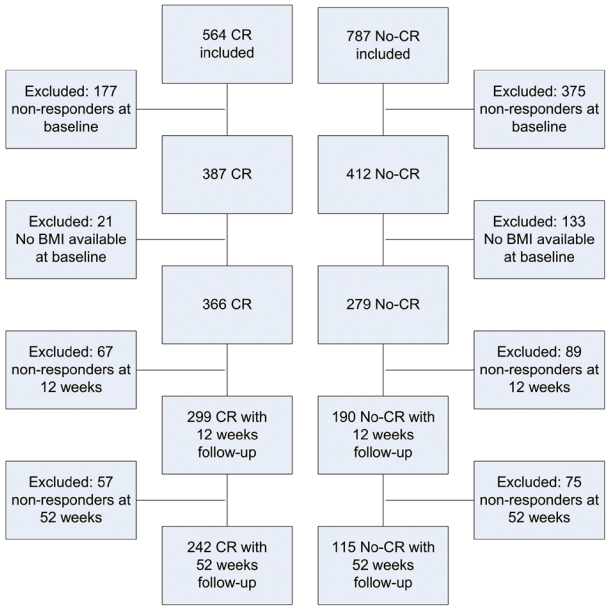

Figure 1. Patient flow diagram of the study sample. Abbreviations: BMI, body mass index; CR, cardiac rehabilitation group; no-CR, no cardiac rehabilitation group.

CARDIAC REHABILITATION

The Capri Cardiac Rehabilitation program provides standardized outpatient CR for patients with coronary artery disease in the Rotterdam area. The program focuses on improving physical fitness, self-confidence, and social integration of the participants. The multidisciplinary CR program is led by specialized physiotherapists, nurses, and social workers. The core of the program consists of 1.5 hours of group exercise sessions held 2 times per week over 12 weeks at a local sports facility. Besides the exercise program, both verbal and written instructions are provided on how to self-manage diet, smoking cessation, and stress management to improve adherence to lifestyle modification and help patients adopt a positive role in their own health. If necessary, individual consults with psychiatrists, psychologist, social workers, and dietitians are provided.

SUBJECTIVE HEALTH STATUS

The Short Form-12 questionnaire is widely used and measures subjective health status consisting of a physical component score (PCS) and a mental component score (MCS).[13] The mean score on both the PCS and MCS is 50 with a standard deviation of 10; a higher score means a better subjective health status. The Dutch version of the Short Form-12 scale was used, for which normative data from the Dutch general population were available.[13,14]

All CR patients received a Short Form-12 questionnaire before CR (T_0), 12 weeks after the start of CR (T_{12}), and after 1 year (T_{52}). The no-CR group received the same questionnaire at the same intervals.

FOLLOWUP

Before approaching patients at T_0, T_{12}, and T_{52}, survival status was assessed through the civil registry. All patients alive were sent a questionnaire and, if necessary, a reminder after 4 weeks.

STATISTICAL ANALYSIS

Analyses were carried out for patients who completed all 3 questionnaires: baseline, 12 weeks, and 52 weeks (complete case analyses). BMI was grouped according to the World Health Organization (WHO) guidelines: normal weight, 18.5 to 24.99 kg/m^2; overweight, 25 to 29.99 kg/m^2; and obese, $\geq$30 kg/m^2.[14] There were no patients with a BMI $<$18.5 kg/m^2. Categorical variables were summarized as percentages and continuous variables as mean $\pm$ standard error of the mean. Chi-square test and Student's *t* test were used. Univariate and multivariate regression analyses were performed using binary logistic regression. Because no standard cut-off was available, we chose to dichotomize the outcome on subjective health status (PCS and MCS). The highest tertile was used to indicate a better improvement in subjective health status, and the 2 lowest tertiles were used to indicate a worse improvement in subjective health status.

Adjustments were made for the following baseline characteristics: subjective health status, age, gender, education level, number of diseased coronary arteries found during PCI, smoking, treated diabetes mellitus, family history, cardiac history (previous myocardial infarction, previous coronary artery bypass grafting, and/or previous PCI), and depressive symptoms (a 2-item Patient Health Questionnaire score $\geq$2). Results were reported as OR and 95% CI. All statistical tests were 2-tailed and *P* values $<$ .05 were considered statistically significant.

RESULTS

PATIENT CHARACTERISTICS

The Table describes the baseline characteristics of all 357 patients with completed Short Form-12 questionnaires pre- and post-CR, and at the 1-year followup. The CR and no-CR groups were different on a number of characteristics. The CR group was, on average, 5 years younger than the no-CR group, had less patients who previously had a cardiac event than the no-CR group, and had more smokers. No differences were found between the CR and no-CR groups as to the distribution of the BMI categories or any of the other baseline characteristics.

PCS AND MCS IMPROVEMENT

The improvement in PCS and MCS between T_0 and T_{12} ($T_{0\text{-}12}$) and between T_0 and T_{52} ($T_{0\text{-}52}$) in PCS and MCS is presented in Figure 2. Both PCS and MCS improved at 12 weeks and at 52 weeks in the CR group, in contrast to the no-CR group for which subjective health status remained unchanged. After splitting up the subjective health status improvements for the 3 BMI categories, the improvements were predominantly present in the normal-weight group at the 1-year followup and in the overweight group directly after CR and at the 1-year followup. No improvements were found in the obese group.

ADJUSTMENT FOR BASELINE CHARACTERISTICS

After adjustment for baseline characteristics, the total CR group had greater improvement in subjective health status at 12 weeks as well as at 52 weeks compared with the no-CR group, with the highest improvement found in the PCS (Figure 3). In the normal-weight and obese groups, no difference was found between patients in the CR and no-CR groups in subjective health status improvement at 12 or 52 weeks. The overweight group demonstrated the best improvement; between baseline and 12 weeks of followup OR = 3.4, 95% CI 1.5 to 7.5, and between baseline and 1-year followup OR = 5.1, 95% CI 2.1 to 12.5.

Table

Patient Characteristics[a]

	CR n = 242 (68%)			No-CR n = 115 (32%)			Total CR/no-CR n = 357		
BMI Category	**Normal Weight n = 75 (31%)**	**Overweight n = 122 (50%)**	**Obese n = 45 (19%)**	**Normal Weight n = 36 (31%)**	**Overweight n = 59 (51%)**	**Obese n = 20 (17%)**	**CR n = 242 (68%)**	**No-CR n = 115 (32%)**	***P* Value**
Age, y	58 ± 10	59 ± 9	58 ± 9	66 ± 12	63 ± 11	62 ± 10	59 ± 10	64 ± 11	<.001
BMI, kg/m^2	23 ± 1	27 ± 1	33 ± 2	23 ± 2	27 ± 1	33 ± 3	27 ± 4	27 ± 4	.7
Male, n (%)	52 (69)	107 (88)	40 (89)	27 (75)	54 (92)	15 (75)	199 (82)	96 (83)	.9
History, n (%)									
CVA	1 (1)	2 (2)	0 (0)	1 (3)	3 (5)	0 (0)	3 (1)	4 (3)	.2
COPD	4 (5)	4 (3)	0 (0)	4 (11)	1 (2)	1 (5)	8 (3)	6 (5)	.4
Cardiac event[b]	9 (12)	15 (12)	4 (9)	6 (17)	15 (25)	4 (20)	28 (12)	25 (22)	<.05
AMI	6 (8)	9 (7)	1 (2)	6 (17)	7 (12)	4 (20)	16 (7)	17 (15)	<.05
PCI	8 (11)	10 (8)	3 (7)	5 (14)	11 (19)	2 (10)	21 (9)	18 (16)	.07
CABG	1 (1)	0 (0)	1 (2)	1 (3)	1 (2)	1 (5)	2 (1)	3 (3)	.3
Multivessel disease	24 (32)	44 (36)	15 (33)	15 (42)	26 (44)	10 (50)	83 (34)	51 (44)	.1
Risk factors, n (%)									
Smoking	29 (39)	51 (42)	21 (47)	13 (36)	18 (31)	3 (15)	101 (42)	34 (30)	<.05
Cholesterol	27 (36)	50 (41)	19 (42)	12 (33)	24 (41)	8 (40)	96 (40)	44 (38)	.8
Hypertension	26 (35)	41 (34)	24 (53)	9 (25)	17 (29)	12 (60)	91 (38)	38 (33)	.4
Diabetes mellitus	6 (8)	15 (12)	10 (22)	3 (8)	8 (14)	3 (15)	31 (13)	14 (12)	.9
Family history	41 (55)	78 (64)	25 (56)	12 (33)	25 (42)	8 (40)	144 (60)	45 (39)	<.001
Depression[c]	11 (15)	26 (21)	17 (38)	4 (11)	12 (20)	5 (25)	54 (22)	21 (18)	.4
Baseline HRQL									
PCS baseline	46 ± 8	46 ± 9	45 ± 9	46 ± 11	49 ± 9	46 ± 8	46 ± 9	48 ± 10	.06
MCS baseline	46 ± 10	44 ± 11	44 ± 12	49 ± 9	49 ± 11	47 ± 10	45 ± 11	49 ± 10	<.01

Abbreviations: AMI, acute myocardial infarction; BMI, body mass index; CABG, coronary artery bypass grafting; COPD, chronic obstructive pulmonary disease; CR, cardiac rehabilitation; CVA, cerebral vascular accident; HRQL, health-related quality of life; MCS, mental component score; no-CR, no cardiac rehabilitation group; PCI, percutaneous coronary intervention; PCS, physical component score.

[a]Data are reported as mean ± standard deviation unless otherwise noted.

[b]PCI, CABG, and/or AMI.

[c]Depression was defined as a score ≥2 on the 2-item Patient Health Questionnaire.

DISCUSSION

Patients postprimary PCI who participated in a standardized CR program had greater improvement in subjective health status at 12 weeks than patients who did not undergo CR. This improvement was sustained at the 1-year followup. The improvement was observed in patients with overweight BMI, but not in normal weight and obese patients.

The results of our study support previous findings that cardiac rehabilitation improves subjective health status post-CR after pPCI compared with those who did not

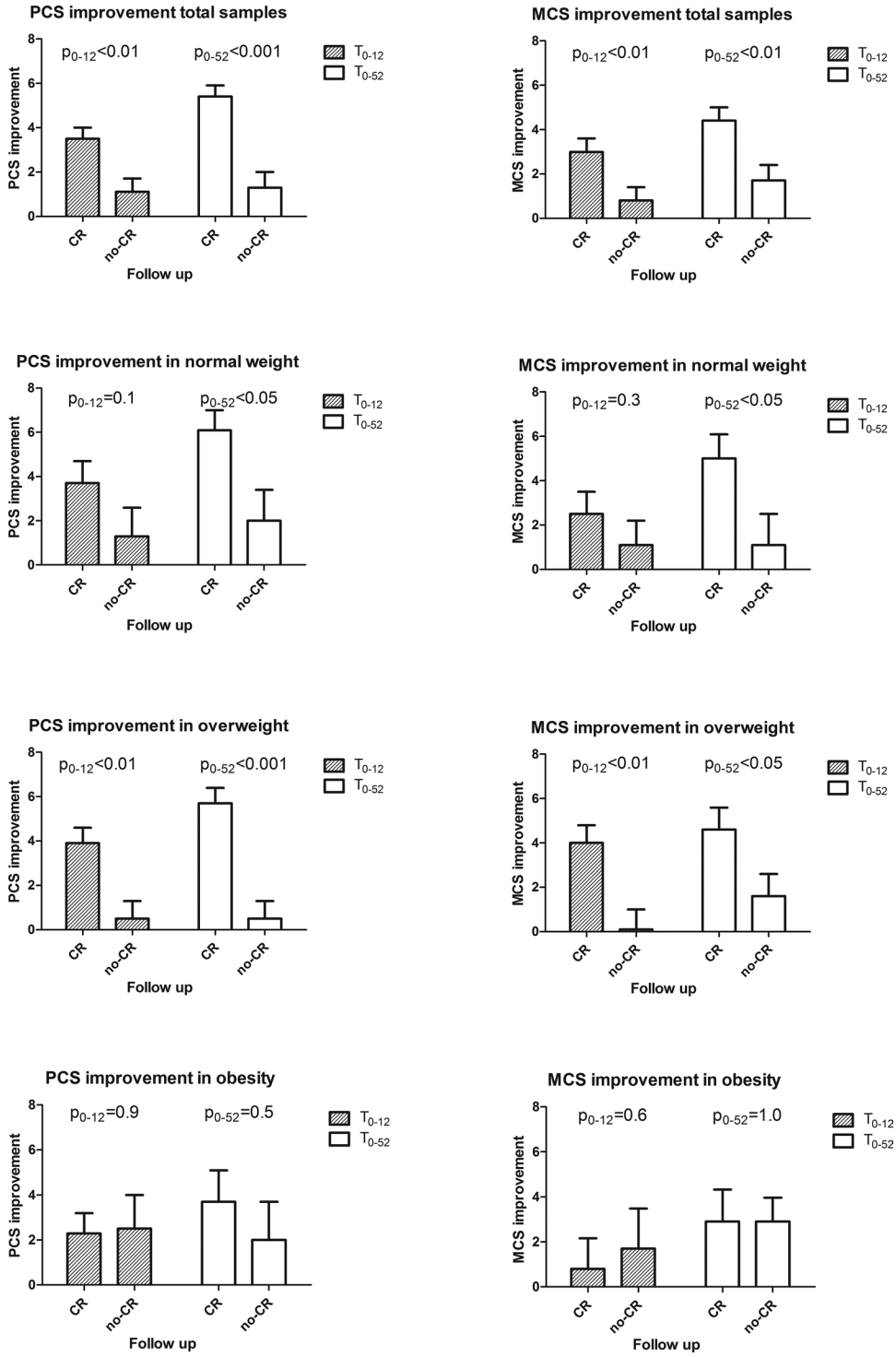

Figure 2. Changes in subjective health status for the CR and no-CR groups. Bars are mean scores and error bars represent standard deviations. $P_{0\text{-}12}$ is based on differences between CR versus no-CR for changes from $T_{0\text{-}12}$. $P_{0\text{-}52}$ is based on differences between CR versus no-CR for changes from $T_{0\text{-}52}$. Abbreviations: CR, cardiac rehabilitation group; MCS, mental component score; no-CR, no cardiac rehabilitation group; PCS, physical component score; $T_{0\text{-}12}$, changes in PCS or MCS between baseline and followup at 12 weeks; $T_{0\text{-}52}$, changes in PCS or MCS between baseline and followup at 52 weeks.

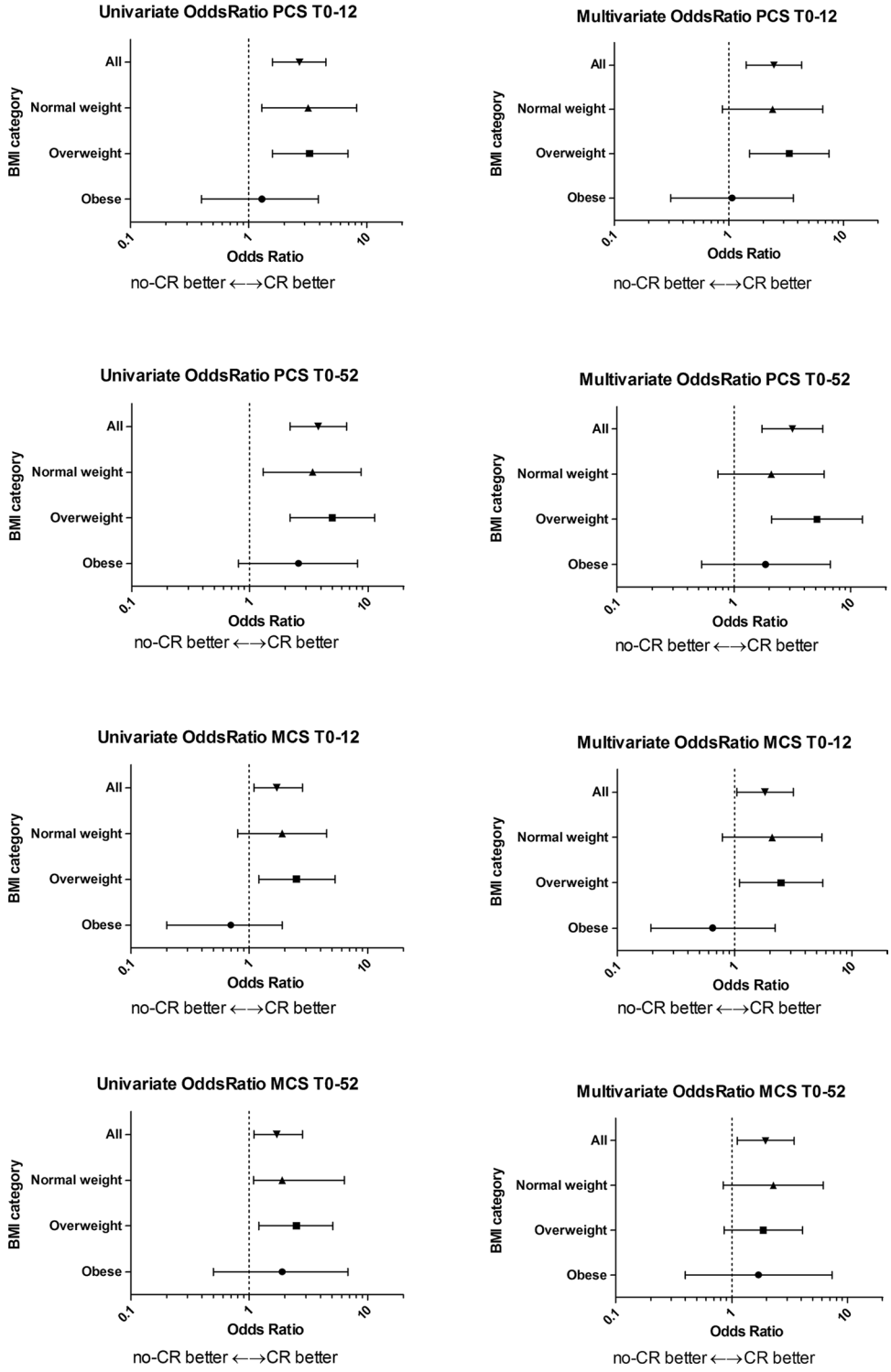

Figure 3. Association between CR versus no-CR groups and improvement in subjective health status for separate BMI categories. Univariate and multivariate ORs with 95% CIs for CR compared with no-CR for being in the tertile with the best improvement in subjective health status. Multivariate analysis adjusted for age, gender, education level, number of diseased coronary arteries found during PCI, smoking, diabetes mellitus, family history, cardiac history (previous myocardial infarction, previous coronary artery bypass grafting, and/or previous percutaneous coronary intervention), and depressive symptoms (a 2-item Patient Health Questionnaire score ≥2). Abbreviations: BMI, body mass index; CR, cardiac rehabilitation group; MCS, mental component score; no-CR, no cardiac rehabilitation group; PCI, percutaneous coronary intervention; PCS, physical component score; $T_{0\text{-}12}$, change in subjective health status between baseline and followup at 12 weeks; $T_{0\text{-}52}$, change in subjective health status between baseline and followup at 52 weeks.

undergo cardiac rehabilitation.[1,5,8,9,15] However, little was known about the association between BMI and subjective health status after CR, especially regarding whether benefits would be sustained after a longer followup. Earlier studies demonstrated that obese patients experienced significantly less benefit in aerobic capacity and subjective health status from CR,[16,17] but did not use a no-CR group. These studies recommended that more investigation was needed regarding methods to improve CR outcomes in obese patients. Our results support the findings of earlier studies, indicating that obese patients gain less benefit from CR. There were no significant differences between obese CR patients and obese patients who did not participate in a CR program. The additional value of this study was that we investigated the relationship between CR and subjective health status for different BMI categories separately and compared all the categories with the no-CR group.

Two previous publications used different cut points for obesity (BMI = 27.8 kg/m^2 for men and 27.3 kg/m^2 for women) rather than the WHO guidelines and found that CR improved subjective health status in obese patients.[4,7] Using these cut points in analyzing the present data would have resulted in 67 of our original 180 overweight patients to be classified as obese, and thus the overweight patients in our trials would have had the best benefit of CR regarding the subjective health status. Other trials have used a variety of instruments to assess functional status, which also complicates the comparisons. These studies demonstrated improved exercise capacity, weight loss, and better lipid profiles after CR in obese patients.

The key question is why outcomes in patients with different BMI classes were different in our sample. Obese patients in the CR group scored worse on the mental health score than the obese patients in the control group after 12 weeks of cardiac rehabilitation. At 1 year after ending CR, this difference had disappeared. It is possible that the cardiac rehabilitation program may have been a mental strain for them. In addition, the workload intensity of the cardiac rehabilitation exercises was defined on the basis of the heart rate achieved during exercise. Obese patients usually had lower workload intensity training because of their higher heart rate responses. Thus, although the obese patient group did the same exercises as other patients, the workload intensity was lower. Perhaps 12 weeks of this "usually lower" workload intensity training was not enough to improve subjective health status. This lower workload intensity training was also used for elderly patients and patients with comorbidities, such as rheumatoid arthritis or chronic obstructive pulmonary disease. Furthermore, 12 weeks may also not be long enough to reach the desired lifestyle changes. Because obese patients had to presumably change more lifestyle habits compared with normal-weight and overweight patients, they may have felt like they were restricted in everything that they are used to do, requiring significant time commitment and motivation, and leading to frustration. This could be associated with an initially poorer subjective health status, especially in mental health. Conversely, the overweight patients likely had to change fewer of their habits than the obese patients and, thus, it was easier for them to change, which could be associated with a better subjective health status. These observations suggest that obese patients may require a tailored CR program with lower intensity training for a longer period, and with interventions that focus on their specific situation and needs, as they are challenged with a greater number and more challenging goals, as an example, providing additional psychological interventions.

Every patient who undergoes PCI should be referred to a CR program according to the guidelines.[18] However, some clinicians do not refer all their patients with PCI and this results in lower participation rates.[19] Our CR group was 5 years younger, had less previous cardiac events, and more family history than the control group.

This study has some limitations. First, differences between baseline characteristics of the CR and no-CR groups could affect the outcomes. However, we adjusted for baseline characteristics. Second, the majority of patients were lost during followup. A third limitation is that BMI was only measured at baseline. Therefore, we were unable to investigate the association between changes in BMI and changes in subjective health status.

CONCLUSIONS AND FUTURE DIRECTIONS

In this study, obese patients did not benefit from CR regarding subjective health status. Subjective health status is an important prognostic factor,[10] and therefore it is important to optimize cardiac rehabilitation for this patient group. Future research is needed to identify strategies for improving outcomes in obese patients undergoing a CR program after an acute myocardial infarction and pPCI. Furthermore, there are needs to clarify whether obese patients would benefit from a prolonged CR program that is longer than 12 weeks, as well as the use of psychological interventions to change lifestyle for improving better subjective health status.

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