



# Predictors of adherence to home-based cardiac rehabilitation program among coronary artery disease outpatients in China

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## Abstract

**Background** Cardiac rehabilitation (CR) has proven beneficial for patients with coronary artery disease. However, adherence to CR programs is the key to the health improvement in those patients. Identifying predictors for adherence, which is very much unknown in China, would be valuable for effective rehabilitation. This study aims to determine the adherence to home-based CR programs in Chinese coronary artery disease patients and determine predictors of adherence. **Methods** The current study included 1033 outpatients with coronary heart disease in the First Medical Center of Chinese PLA General Hospital in Beijing from July 2015 to June 2017. Participants were given an exercise prescription and took part in home-based exercise training lasting for 3–24 months. A questionnaire was used to evaluate the completion of the CR program, understanding of the program, motivation of the patients, and family/peer support. **Results** Two thirds of the patients adhered well to the home-based CR program. Elder patients ( $\geq 65$ -year-old) adhere to the program better, while men adhered better than women. Patients who used to exercise ( $B = 6.756, P < 0.001$ ), understood the program ( $B = 0.078, P = 0.002$ ), with stronger motivation to participate ( $B = 0.376, P < 0.001$ ), and received better family support ( $B = 0.487, P < 0.001$ ) also adhere better to the program. **Conclusions** Understanding the program, self-motivation of patients, and family support help to keep patients engaged in a home-based CR program. Improvement of family support by educating both patients and families may be helpful in improving adherence to home-based CR programs.

**Clinical Trial Number:** ChiCTR1800016625

*J Geriatr Cardiol* 2019; 16: 749–755. doi:10.11909/j.issn.1671-5411.2019.10.003

**Keywords:** Adherence; Cardiac rehabilitation; Coronary artery disease

## 1 Introduction

Exercise training (ET) has been shown to improve exercise tolerability, decrease lipid concentrations,<sup>[1,2]</sup> alleviate symptoms,<sup>[3,4]</sup> boost psychosocial satisfaction,<sup>[5,6]</sup> as well as reduce mortality,<sup>[7]</sup> ET is considered as an important primary treatment and secondary prevention method for patients with coronary artery disease (CAD). However, despite an increasing number of patients with CAD, participation in official cardiac rehabilitation (CR) programs based on ET in hospitals remains poor,<sup>[8]</sup> due to obstacles such as distance and other healthcare factors.<sup>[9]</sup>

The home-based program was considered as a possible

solution to the low participation in center-based CR programs. Several researchers showed that home-based CR was effective and as safe as hospital-based CR.<sup>[10]</sup> Grace SL, *et al.*<sup>[11]</sup> also suggested that patients in general were likely to prefer home-based rehabilitation. However, adherence to home-based CR is controversial. Jolly K, *et al.*<sup>[12]</sup> showed a higher adherence of patients in home-based CR programs, while Mckelvie RS, *et al.*<sup>[13]</sup> reported reduced compliance in the home-based group compared with the group in supervised training. Different strategies of home-based CR programs and regional diversity also contribute to this controversy. Meanwhile, patients allocated to home-based CR cited a different spectrum of reasons of nonadherence compared with center-based CR.<sup>[12]</sup>

Presently in China, CR is in its infancy and CR centers are very limited. With a low doctor/patient ratio, home-based CR might offer a more practical solution than center-based CR. Thus, the study of the current status of home-based CR and what can be done to improve compliance is important.

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**Received:** October 10, 2019

**Revised:** October 22, 2019

**Accepted:** October 26, 2019

**Published online:** October 28, 2019

In this study, we explored adherence to home-based CR in CAD outpatients visiting the First Medical Center of Chinese PLA General Hospital in Beijing, China and evaluated factors affecting participants' adherence to the home-based CR program.

## 2 Methods

### 2.1 Study population

From July 2015 to June 2017, 1908 adult outpatients with coronary heart disease were invited to join the home-based CR program in the First Medical Center of Chinese PLA General Hospital. A total of 875 patients declined to join in the study. The final cohort enrolled comprised 1033 patients, with one patient lost during follow-up.

### 2.2 Study procedure

The study lasted for 24 months. At the beginning of the study, patient characteristics were reviewed and recorded. A cardiopulmonary exercise test (CPET) was performed to evaluate exercise intolerance and cardiopulmonary functions, psychological status was also assessed by questionnaires. Based on CPET results, a cardiologist gave an exercise regimen to the participants. Participants in the program were followed up from 3 to 24 months. At the end of the study, all participants were evaluated for CR adherence, program comprehension or understanding the program, self-motivation, family support, and CAD peer support via a questionnaire. The protocol complied with the Declaration of Helsinki and was approved by the ethics committee of the First Medical Center of Chinese PLA General Hospital (S2015-127-01), written informed consent was obtained from all participants.

### 2.3 Assessment procedures

#### 2.3.1 Cardiopulmonary exercise testing

The symptom-limited CPET was performed using an electronically operated cycle ergometer (Schiller cs-200, Switzerland) following a fixed-ramp protocol: a load-free warm-up for two minutes, starting at 10 watt, increasing by 25 watt per two minutes. The test was given at least one hour after meals with medications taken as prescribed. Pedaling was maintained at 55–65 round/min. Patients were encouraged to exercise to exhaustion or until meeting discontinuation indications. Absolute indications for discontinuation included the patient's request to stop and acute cardiac events such as suspicion of myocardial infarction, moderate to severe angina, hypotension, signs of poor perfusion, severe shortness of breath, and serious arrhythmias.

Relative indications included electrocardiographic changes, worsening chest pain, severe fatigue, dyspnea, significant hypertension, and less serious arrhythmias. The test was also terminated if the subject could not continue pedaling at a frequency > 50 round/min or Borg Scale > 18.

A 12-lead electrocardiogram was monitored throughout the duration of the test, rating of perceived exertion (PRE) on the original Borg scale was recorded at the end of each stage. Oxygen consumption ( $\text{VO}_2$ ) and carbon dioxide production ( $\text{VCO}_2$ ) were measured every ten seconds. The  $\text{VO}_2$  peak was defined as the average oxygen consumption of the last fifteen seconds of pedaling. Minute ventilation (VE)/ $\text{VCO}_2$  relationship (VE/ $\text{VCO}_2$  slope) was measured by plotting VE against  $\text{VCO}_2$  obtained during every ten seconds of exercise. Maximum heart rate ( $\text{HR}_{\text{max}}$ ) was defined as the highest heart rate achieved while pedaling the cycle ergometry.

#### 2.3.2 Home-Based Exercise Training Adherence Questionnaire

The Home-Based Exercise Training Adherence Questionnaire (HETAQ) was developed and used to assess barriers to home-based CR adherence. The HETAQ is composed of seventeen items divided into five subscales and five other items to obtain more detail informations. One subscale measures adherence and the other four are factors affecting adherence. The subscales are divided by: (1) completion of home-based CR, with six items, two of which are totaled for the adherence score; (2) patient's perception, with one item; (3) patient's motivation, with three items; (4) family support, with five items; and (5) CAD peer support, with two items. The possible total score of each scale ranges from 0 to 100. The higher the score, the greater the scale and vice versa. Patients with an adherence score of over 60 was considered adhering well to the home-based CR program.

#### 2.3.3 Psychological questionnaires

Generalized Anxiety Disorder 7 (GAD-7)<sup>[14]</sup>: GAD-7 is a self-reported questionnaire for screening and symptom severity measurement of GAD, which has seven items, which measures the severity of various symptoms. Assessment is indicated by a total score derived by adding together the scores for all seven items. Higher GAD-7 scores correlate with disability and functional impairment (such as work productivity and health care utilization).

Patient Health Questionnaire 9 (PHQ-9)<sup>[15]</sup>: PHQ is a multiple-choice self-report inventory used as a screening and diagnostic tool for mental health disorders of depression, anxiety, alcohol use, eating, and somatoform disorder. PHQ-9 is a tool specific to depression that scores each of

the nine DSM-IV related criteria based on the mood module from the original Primary Care Evaluation of Mental Disorders. Higher scores indicate a greater degree of depression.

## 2.4 Exercise regimen

An exercise regimen was decided based on the American College of Sports Medicine Guidelines for Exercise Testing and Prescription (9<sup>th</sup> edition) follows the target heart rate (HRT)/heart rate at the anaerobic threshold principle.<sup>[16]</sup> The HRT equals resting heart rate plus 60%–70% of the difference between the maximum heart rate and the resting heart rate. If the HRT is higher than the heart rate at anaerobic threshold, the heart rate at anaerobic threshold is taken as the final target in the ET. The ET includes aerobic exercise, stretching exercise, resistance training and balance training. The aerobic exercise (fast walking or cycling) lasts for thirty minutes to meet the HRT according to the prescription beginning with a 5-minute warm-up and followed by a 5-minute cool-down. The aerobic and stretching exercises are required 5–6 times a week, while resistance and balance training are required 2–3 times a week.

## 2.5 Statistical analysis

Statistical analysis was performed using SPSS 17.0 for Windows (SPSS, Chicago, IL, USA). Continuous parameters were presented as mean  $\pm$  SD. Categorical variables presented as numbers and proportions. For continuous variables, groups were compared using the Student's *t*-test or Wilcoxon's rank-sum test based on distribution. Categorical variables were compared using the Chi-square test. Correlations of adherence score and continuous variables were analyzed using Pearson's correlation analysis. Predictors of adherence were clarified using stepwise multiple linear regression. A *P*-value of  $< 0.05$  was of statistical significance.

## 3 Results

### 3.1 Patients' characteristics

Demographics, clinical background, medical prescriptions, cardiopulmonary function, and psychological status of the study participants at the beginning of the study are shown in Table 1. The average age was 55.96 years. About three-quarters of the patients were male (73.3%). More than half (53.4%) of the patients exercised at home before the CR program began. More than two-fifths of the cohort had hyperlipidemia, two-fifths had hypertension and one-fifth had diabetes mellitus (DM). At the beginning of the study, the baseline metabolism equivalents of the participants averaged 4.35. Less than one-fifth of the participants showed

**Table 1. Patients' characteristics.**

Characteristics	Total (n = 1033)
Age, yrs	55.96 $\pm$ 10.50
Age < 65	820 (79.4%)
Age $\geq$ 65	213 (20.6%)
Gender	
Male	757 (73.3%)
Female	276 (26.7%)
Employment	
Office/Mental work	277 (26.8%)
Manual labor	756 (73.2%)
Exercise history	
Exercise history (+)	552 (53.4%)
Exercise history (–)	481 (46.6%)
BMI, kg/m <sup>2</sup>	26.30 $\pm$ 3.24
Obesity (+), BMI > 30	123 (11.9%)
Obesity (–), BMI $\leq$ 30	910 (88.1%)
Hypertension	
Hypertension (+)	442 (42.8%)
Hypertension (–)	591 (57.2%)
Diabetes mellitus	
Diabetes mellitus (+)	204 (19.7%)
Diabetes mellitus (–)	829 (80.3%)
Hyperlipidemia	
Hyperlipidemia (+)	429 (41.5%)
Hyperlipidemia (–)	604 (58.5%)
CPET	
METS	4.35 $\pm$ 1.30
Peak VO <sub>2</sub> , mL·kg <sup>-1</sup> ·min <sup>-1</sup>	1.41 $\pm$ 0.44
Heart rate reserve, beats/min	29.64 $\pm$ 19.57
Peak oxygen pulse, mL O <sub>2</sub> /beat	11.10 $\pm$ 4.14
VO <sub>2</sub> AT, mL·kg <sup>-1</sup> ·min <sup>-1</sup>	16.02 $\pm$ 24.39
VE/VCO <sub>2</sub>	26.33 $\pm$ 3.84
$\Delta$ VO <sub>2</sub> / $\Delta$ WR, mL·min <sup>-1</sup> ·W <sup>-1</sup>	11.51 $\pm$ 3.04
GAD-7	2.43 $\pm$ 2.54
PHQ-9	3.60 $\pm$ 2.64

Data are presented as means  $\pm$  SD or *n* (%). AT: anaerobic threshold; BMI: body mass index; CPET: cardiopulmonary exercise test; GAD-7: Generalized Anxiety Disorder 7; METS: metabolism equivalents; PHQ-9: Patient Health Questionnaire 9; VCO<sub>2</sub>: carbon dioxide production; VE: ventilation; VE/VCO<sub>2</sub>: minute ventilation/carbon dioxide production relationship; VO<sub>2</sub>: oxygen consumption;  $\Delta$ VO<sub>2</sub>/ $\Delta$ WR: oxygen consumption /work rate relationship.

symptoms of anxiety (16.4%), while more than one-third of the participants were depressed to some extent (34.8%).

### 3.2 Factors affecting patients' adherence to a home-based CR program

About two thirds (66.5%) of the patients adhered well to

the home-based CR program. Patient-identified and subjective factors possibly affecting adherence to the program are shown in Table 2. Better program comprehension, stronger self-motivation of the patient, and increased support from the family and other patients led to better adherence to the CR program. Elder patients showed better compliance than their younger counterparts, while men complied better than women. People who were used to exercising more than twice a week before the program adhered better to the CR program. Patients with DM or hyperlipidemia scored higher in adherence. There was no significant difference in adherence to the CR program between white-collar and blue-collar workers. No correlation was observed between CR adherence and baseline body mass index or psychological status. Multivariate analysis identified family support, age, gender, exercise history, program comprehension and patient motivation as independent adherence predictors (Table 3). After standardizing the data, family support ( $B = 0.374$ ,  $P < 0.001$ ) demonstrated stronger influence on adherence to the program than comprehension ( $B = 0.086$ ,  $P = 0.002$ ) or motivation ( $B = 0.187$ ,  $P < 0.001$ ) of the patients themselves.

#### 4 Discussion

Adherence varies in different CR programs around the world. Attendance at the center-based CR was reported as unsatisfactory, with a dropout rate of between 24% and 50%.<sup>[17,18]</sup> Regarding adherence to home-based exercise, opinions are divided. Some studies showed that compliance to home-based training was reduced compared with supervised training,<sup>[13]</sup> while others found that adherence to home-based tele-monitored CR in patients with heart failure increased.<sup>[19]</sup> Results of the present study show that about two-thirds of the CAD patients followed the home-based CR program satisfactorily. The difference in adherence might be a result of different home-based training strategies and different means of adherence measurement in various studies.

Compared with center-based rehabilitation adherence, which can be assessed simply by session attendance, home-based rehabilitation adherence is more difficult to measure. Various methods to measure adherence have been tried. Daily telephone contact was chosen for short-term home-based CR adherence assessment,<sup>[19]</sup> but was neither feasible nor welcomed for long-term programs. Diaries were used for monitoring weight or certain self-care behaviors among heart failure patients,<sup>[20]</sup> and heart rate monitoring has been used to assess whether the participants have exercised or not.<sup>[21]</sup> In the present study, we developed a questionnaire to

**Table 2. Correlation between adherence score and objective or subjective factors.**

Factors	Adherence score	t or r	P-value
Age, yrs			
Age < 65	62.53 ± 32.23	-2.603	0.009*
Age ≥ 65	69.01 ± 33.00		
Gender			
Male	67.32 ± 30.86	-5.428	0.000*
Female	54.39 ± 34.91		
BMI, kg/m <sup>2</sup>			
Obesity (+), BMI > 30	60.57 ± 34.66	1.200	0.230
Obesity (-), BMI ≤ 30	64.31 ± 32.17		
Type of work			
Office/Mental work	63.09 ± 33.62	-0.467	0.640
Manual labor	64.15 ± 32.07		
Exercise history			
Exercise history (+)	70.99 ± 27.52	-7.631	0.000*
Exercise history (-)	55.69 ± 35.69		
Hypertension			
Hypertension (+)	65.89 ± 31.12	-1.736	0.083
Hypertension (-)	62.35 ± 33.41		
Diabetes mellitus			
Diabetes mellitus (+)	72.86 ± 27.84	-4.946	0.000*
Diabetes mellitus (-)	61.66 ± 33.17		
Hyperlipidemia			
Hyperlipidemia (+)	68.47 ± 29.57	-3.960	0.000*
Hyperlipidemia (-)	60.60 ± 34.05		
CPET			
METS		0.023	0.508
Peak VO <sub>2</sub> , mL·kg <sup>-1</sup> ·min <sup>-1</sup>		0.008	0.804
Heart rate reserve, beats/min		-0.003	0.936
Peak oxygen pulse, mL O <sub>2</sub> /beat		0.078	0.018*
VO <sub>2</sub> AT, mL·kg <sup>-1</sup> ·min <sup>-1</sup>		0.018	0.613
VE/VCO <sub>2</sub>		0.149	0.000*
ΔVO <sub>2</sub> /ΔWR, mL·min <sup>-1</sup> ·W <sup>-1</sup>		-0.037	0.276
GAD-7		-0.015	0.629
PHQ-9		-0.058	0.065
Program comprehension		0.316	0.000*
Patient motivation		0.425	0.000*
Family support		0.538	0.000*
Peer support		0.284	0.000*

Data are presented as means ± SD. \*P-value < 0.05 was of statistical significance. AT: anaerobic threshold; BMI: body mass index; CPET: cardiopulmonary exercise test; GAD-7: Generalized Anxiety Disorder 7; METS: metabolism equivalents; PHQ-9: Patient Health Questionnaire 9; VCO<sub>2</sub>: carbon dioxide production; VE: ventilation; VE/VCO<sub>2</sub>: minute ventilation/carbon dioxide production relationship; VO<sub>2</sub>: oxygen consumption; ΔVO<sub>2</sub>/ΔWR: oxygen consumption /work rate relationship.

investigate both adherence to the home-based CR and the relationship between compliance and certain potentially influential factors. Although the self-reported questionnaire

**Table 3. Factors in the multi-variant linear regression model.**

Factors	B	Standardized B	P-value	95% CI	
				Lower	Upper
Family support score	0.487	0.374	0.000*	0.411	0.563
Exercise history	6.756	0.104	0.000*	3.471	10.041
Gender	8.319	0.113	0.000*	4.620	12.017
Age	0.337	0.109	0.000*	0.182	0.491
Patient motivation	0.376	0.187	0.000*	0.264	0.488
Program comprehension	0.078	0.086	0.002*	0.029	0.126

\*P-value < 0.05 was of statistical significance. B: beta coefficient.

results may be overestimated due to socially desirable responses, this influence should be insignificant since Kayaniyl S, *et al.*<sup>[22]</sup> proved that self-reported and site-verified rates of program attendance were highly concordant. Moreover, short face-to-face interviews and telephone contacts were included in our study as auxiliary methods to the questionnaire to help improve the reliability of self-reporting. Additionally, application of heart rate monitors in some patients also improved accuracy of the assessment.

Besides of verifying facticity of the self-reporting contents, the above auxiliary methods also played a role in supervision that helps improve adherence to CR. Furthermore, this study enrolled patients in a top-level hospital where patients tended to follow doctors' instructions more willingly, which would more or less contribute to the relatively better adherence to CR in this study.

The Cardiac Rehabilitation Barriers Scale is often used to assess barriers to CR enrollment and adherence.<sup>[23]</sup> However, it mainly focuses on perceptions of the patient, providers, and health system level and does not include the influence of family and peers, who might play a more important role in the adherence to CR outside a hospital setting. Thus, in our study HETAQ was developed and applied to assess not only comprehension and motivation of the patients, but also included support from family and peers. The support the patients actually received and the subjective need of such supports reported by patients themselves were considered. Like Jones M, *et al.*,<sup>[24]</sup> we also found that a better perception of the program and a stronger motivation of patients led to better adherence to the home-based program; Moreover, family support was even more important than the motivation of patients themselves. Unexpectedly, peer support did not matter significantly. Thus, educational guidance that includes the whole family, instead of only the patients, at the beginning of the training program would be more immediate and effective in improving training adherence than would building peer relations.

In this study, elder participants showed a better program completion than the young, which was consistent with pre-

vious observations.<sup>[25]</sup> Some younger participants pointed out in the questionnaire that they had little time for the training because of work, while most of the elder patients were retired and had more free time for training. Kato N, *et al.*<sup>[26]</sup> proved that being employed was a predictor of poor adherence. Considering that people with CAD are younger than before and that the span of employment is longer, a modified style of CR for working people might be helpful. Some younger patients did not consider themselves in need of a training program at all, indicating the necessity of enhanced education classes for younger population. Concurring with other study results, women were less likely to adhere to the CR than men.<sup>[27]</sup> Individuals who were used to exercise tended to do better in completing the program, suggesting that more attention should be paid to women and more sedentary patients both in the CR and during follow-up.

As for patients with DM, adherence was discrepant in different CR programs. With DM as a comorbidity, patients tended to be physically less active and more prone to drop out in some studies,<sup>[28,29]</sup> while in other research those with DM had similar,<sup>[30]</sup> or even better adherence.<sup>[31]</sup> In our study, patients with DM tended to comply better, but this is without statistical significance after adjusted with multivariate analysis. These diverse findings might result from different cut-off points for the definition of good adherence from various studies.

Previous studies indicated that psychological status affected outcomes of CAD patients and adherence to CR.<sup>[27,32,33]</sup> However, in this study, depression or anxiety was not observed to be associated with the adherence score, indicating that basic psychological status had no significant influence on adherence. A more comprehensive assessment of psychological status might help to clarify whether psychological status may affect adherence.

As mentioned above, the adherence assessment was self-reporting via a questionnaire. Although short face-to-face interviews and telephone contacts were applied to minimize the self-reporting bias, objective assessment such as heart

rate monitoring would be more reliable. Due to data limitations, we did not evaluate financial or other possible factors in this study. This was single-centered study, and may not be generalizable to other areas. Studies that include multi centers in different regions of the country would be beneficial in understanding broader compliance to home-based CR and in improving health outcomes throughout China.

## Acknowledgments

This study was supported by the National Key R&D Program of China (2018YFC2000600). We are indebted to all the study coordinators, investigators and data entry operators including Chun-Xue LIU, Lian TANG, Long-Fang XING, Hai-Yan LI, Yan-Yan WEI, Xiao-Yan LI, Xiao-Lin YANG, Yan-Yan YAO and Xin WANG, and patients who participated in the study. All authors had no conflicts of interest to disclose.

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