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Factors influencing change in walking ability in patients with heart failure undergoing exercise-based cardiac rehabilitation

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ABSTRACT

Objectives: Exercise-based cardiac rehabilitation (CR) is an effective intervention for patients with heart failure (HF), in which one of the main targets is to increase physical capacity. In the HF population this is traditionally assessed using distance covered during a walking test. This study aims to establish the extent to which change in walking ability, in HF patients attending CR, is determined by patient characteristics and service provision.
Methods: The study utilised routine clinical data from the National Audit of Cardiac Rehabilitation to perform a robust analysis. Change, in metres, between pre- and post-CR six-minute walk tests was calculated. Multivariate linear regression models were used to explore the relationship between patient characteristics, service-level variables, and change in metres walked.
Results: Complete and valid data from 633 patients was analysed, and a mean change of 51.30 m was calculated. Female gender (−34.13 m, $p = 0.007$), being retired (−36.41 m, $p = 0.001$) and being married/in a relationship (−32.54 m, $p = 0.023$) were all significant negative predictors of change. There was an additional negative relationship with body mass index (BMI) whereby for every unit increase in BMI, predicted change reduces by 2.48 m ($p = 0.006$).
Conclusions: This study identified significant patient-level characteristics strongly associated with limited improvement in walking ability following CR. Improving physical capacity is a core component of CR, therefore services should aim to account for baseline characteristics identified in this study as part of tailoring the CR intervention around the individual. Pre- and post-CR physical capacity assessments, which constitute minimum standards for CR, are worryingly low and should be given high priority.

1. Introduction

Cardiac Rehabilitation (CR) is a clinically effective intervention for patients with Heart Failure (HF) with published clinical guidance for implementation of an exercise-based rehabilitation programme [1–3]. A summary of clinical trials on exercise-based CR in HF confirms a reduced risk of overall and HF-specific hospitalisation with clinically important improvement in the quality of life [1]. However, despite extensive evidence for CR, eligible patients are missing out on CR with fewer than 20% of HF patients accessing such services in the UK. Across Europe the number of programmes offering CR to patients with HF is increasing and in the UK over 90% of programmes have a CR referral process for patients with HF [4]. Data from the UK National Heart Failure Audit suggests that 7% to 20% of patients with a diagnosis of HF are referred to CR from either general wards or cardiology wards with wide variation in referrals between hospitals. Survival analysis of patients with HF, based on referral to CR, demonstrated improvements of 12% compared to patients not referred to CR [5].

One of the key targets for CR programmes is to increase the physical capacity of patients, which is best achieved through tailored and supervised exercise training [1,6]. In order to quantify the benefits of exercise training for patients, numerous filed tests of walking capacity have emerged which allow clinicians and patients evaluate change in walking capacity. One of the most popular walk tests for patients with low capacity is the six-minute walk test (6MWT) which requires patients to continuously walk at their own preferred pace, until they are either unable to continue, or the maximum time of 6 min is met. At the end of the test, the distance walked is measured in metres, and recorded [7].

Studies have tried to develop expectations around meaningful clinically important difference (MCID) which has led to estimates varying between 14 and 32 m, depending on the underlying pathology [8–10]. There is a lack of clarity about which factors influence walk test distance, and uncertainty around their interpretation when using the 6MWT. This

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is important to clarify as these factors may help explain why so few patients start CR without undergoing an exercise test.

The study aim is to establish the extent to which change in walking ability, in patients HF attending CR, is determined by clinical service and patient characteristics.

2. Methods

This cohort study was reporting following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [11].

2.1. Six-minute walk test

In this study physical capacity is operationalised as walking ability. Patients perform this test once at the start of the exercise programme, and repeat it on completion of CR.

2.2. Data

The source of data is the National Audit for Cardiac Rehabilitation (NACR) database which is created through routine anonymised data entry from 226 cardiac rehabilitation centres across England, Wales and Northern Island. The data is entered by CR professionals approved by their local Caldicott Guardian, and the data is hosted by the NHS Digital. The data collection is under 251 exemption which allows collection of data without consent, however patients can opt out. The NACR captures the entire pathway of CR, from presenting event in hospital through to rehabilitation in the community. The analysis included all cases where a diagnosis of HF led to a new referral to cardiac rehabilitation between January 2013 and December 2016. Cases were deemed eligible where both a pre- and post-rehab 6MWT had been completed.

2.3. Outcome measure

The study explores predictors of change, in metres, between the pre- and post-CR 6MWT. The change was calculated by subtracting the first six-minute walk test result from the second. As there is no agreement on the MCID for the 6MWT, we have opted to measure the outcome linearly, in metres, which will also allow us to quantify the strength of this relationship [9].

2.4. Predictors

Age, gender, ethnicity, height, BMI, smoking status, baseline fitness, diabetes, depression, blood pressure, cholesterol and number of comorbidities were included as known predictors of fitness/physical performance. In addition, duration of CR; time between referral and invite to CR; and participation in early rehabilitation (e.g. whilst still an inpatient) were included as service-level factors that have also been shown to influence performance. Finally, marital status; employment status; waist measurement; angina; arthritis; asthma; COPD; anxiety; having a psychologist and/or physiotherapist employed at the CR centre; and the number of hours a psychologist and/or physiotherapist is contracted to work per week were included as additional hypothesized factors influencing performance.

The presence of diabetes, angina, arthritis, asthma and COPD were ascertained from the patient's medical history. Abnormally high scores on the Hospital Anxiety and Depression Scale (HADS) were used to identify patients with anxiety and/or depression as this was thought to be a more accurate indicator of the patient's mental health status at the time of CR.

2.5. Statistical analysis

The analysis explored initial associations between variables and the outcome, change. Independent *t*-test and one-way ANOVA were used to compare the means of the categorical variables. Pearson's rank correlation coefficient was used to investigate association of the continuous variables.

This initial analysis gave an indication of which variables may or may not yield a significant relationship, however all variables were then entered into a multiple stepwise backward linear regression model to investigate if these relationships were upheld in multivariate analysis. All models were tested for fitting assumptions [12].

The structure of the four steps of the model is summarised in Table 1. Predictors' inclusion in the final model were based on 95% confidence intervals and a p value of <0.05.

3. Results

The study population is summarised in Fig. 1 with 633 patients included in analysis. The mean change between pre- and post-CR 6MWT was 51.30 m.

Table 2 summarises the predictor variables which yielded a significant p value. Table 3 summarises the final results of backward stepwise linear regression. The final model included 97 patients. Smoking status was the only variable that was omitted from the original model as descriptive statistics revealed that only 5% of the population identified as current smokers, which was too small a number for the regression model to operate.

Female gender, raised BMI, being retired, being in a relationship, and having a higher baseline performance were all significant negative predictors of change. The contracted number of hours of the centre psychologist was found to be a significant positive predictor. Importantly none of the comorbidities data or the number of comorbidities featured as a statistical determinant of walk test outcome.

The largest effect size that was observed is being retired, which predicted a change of 36.41 m less than those who were employed. This is closely followed by female gender, predicted to achieve 34.13 m less of a change than males; and those currently married or in a relationship predicted to achieve 32.54 m less than those who identify as single. There is a negative linear relationship between BMI and change, such that for every unit increase in BMI, a patient is predicted to achieve 2.48 m less. A similar relationship exists with baseline performance, whereby for every metre achieved at baseline, a patient will achieve 0.26 m less on the follow up 6MWT. However, the number of hours a psychologist is contracted with the CR programme creates a positive linear relationship whereby for every hour a psychologist is employed, a patient will achieve a further 1.83 m of change.

4. Discussion

This is the first study which investigates factors influencing walking performance in HF patients using multivariate analysis. It is of importance due to the need to be able to appropriately interpret the results of walking tests in this population, especially with increasing numbers of HF patients now accessing CR. This study revealed that having a psychologist involved in CR delivery had a significant positive influence on the patients' change in walking ability, with a positive correlation between the psychologist's contracted number of hours, and the size of the change. This relationship is already noted in patients with traditional CR conditions, where psychological interventions have not only been found to alleviate psychological symptoms [13] but have also been linked to reduced event recurrence and even mortality [14,15]. The significance of this relationship in HF patients adds strength to the argument for psychological input throughout all CR programmes.

Table 1
Structure of stepwise regression model: predictors of change on six-minute walk test post-CR.

1. Socio-demographic factors	2. Cardiac risk factors	3. Patient medical status	4. Service level factors
Age	Smoking status	Number of comorbidities	Duration of CR
Gender	Diabetes	Angina	Time between referral & invitation to CR
Ethnicity	Baseline walking ability	Arthritis	Undertook early CR
BMI	Systolic blood pressure	Asthma	Psychologist employed
Height	Diastolic blood pressure	COPD	Psychologist contracted hours
Waist size		Anxiety	Physiotherapist employed
Marital status		Depression	Physiotherapist contracted hours
Employment status			

CR: cardiac rehabilitation.

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