2015

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Kristin Kaple
Bowling Green State University

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Bowling Green State University

Human Movement, Sport, & Leisure Studies

Advisor: Dr. Todd Keylock

Second Reader: Dr. Amy Morgan

Abstract

People who suffer from a cardiac event can greatly benefit from cardiac rehabilitation (CR). However, CR services are underutilized[13]. To help increase participation rates, the effectiveness of a traditional hospital-based CR program was evaluated in terms of several important physiological variables. Methods: Community-dwelling adults, age ranging from 46 to 85 years (n=10), were asked to complete a hospital-based cardiac rehabilitation program, with several variables being assessed. At the first and final visits, participants were asked to complete a 6-minute walk test (6 MWT) with baseline measures of resting and exercise heart rates (HR); resting and exercise blood pressures (BP) were also measured. Results: Five of the 10 participants completed the program. A significant increase was found in the distance covered in the 6 MWT (pre $\bar{x}$=1116 ± 366.6 feet, post $\bar{x}$=1499 ± 482.0; p=0.021). In addition, a significant decrease was found in resting systolic BP (pre $\bar{x}$=152.8 ± 13.6 mmHg, post $\bar{x}$=139.6 ± 15.3; p=0.045). However, no differences were found in resting diastolic BP, or exercise BP and HR. Conclusion: Improvement in some, but not all, of the variables measured, shows that cardiac rehabilitation programs can be a valuable treatment to help improve the participants' health. Improving cardiorespiratory endurance and blood pressure can decrease the risk of future cardiac events.

Introduction

The benefits of cardiac rehabilitation (CR) in the treatment and prevention of cardiac disease are well established[2]. CR can help to improve clinical parameters (such as blood pressure or weight), reduce risk factors, and increase physical capacity[10]. Coordination, balance, and flexibility can also be improved with strength training and aerobic exercise[4]. A problem with CR is that too few people that need to participate actually do, and in the elderly population participation rates are even lower[8], even though this population may benefit the most from supervised exercise. It is well known that exercise helps in prevention of negative health occurrences, but reasons vary for why people do not utilize this resource that is recommended by health practitioners. Some of these issues include geographical isolation and transport issues[3]. CR usually takes place in a hospital or health-center setting.

When staff in a CR center want to determine the patient's progress, a six minute walk test (6 MWT) is done. This test is simply the distance walked within six minutes (6 MWD) under standardized conditions. The 6 MWT is considered to be the gold standard for measuring patient progress in a CR program. Therefore the purpose of this study is to determine whether or not a hospital-based CR intervention improves several physiological variables, including the 6 MWD, resting and exercise BP and HR, and body weight.

Cost Effectiveness

Cardiac rehabilitation can be thought of as a method of preventing future cardiac events, a potentially strong motivating factor for attendance[2, 3, 4, 8]. However, one possible reason for low attendance is cost. To assess the cost effectiveness of traditional CR, some studies have compared those to home-based programs. Home-based CR could be more cost effective due to not being in a hospital setting. One reason why this might increase participation rates related to cost is that the participants wouldn't have to pay transportation costs to get to the hospital. In the study *Home-based cardiac rehabilitation versus hospital-based rehabilitation: A cost effectiveness analysis,* by Taylor and colleagues, a cost analysis was done for each intervention, hospital-based and home-based CR. They concluded that over the nine months of the study the health care costs did not significantly differ between the two interventions[12]. "Given small differences between the groups in high cost items of cardiac investigations, rehospitalizations, and revascularizations, the overall healthcare costs of the home-based and hospital-based groups did not differ significantly"[12] (p. 199). However, in the home-based program, two of the participants purchased exercise equipment, therefore adding to the costs of that group.

Exercise Capacity

Exercise capacity is the maximum amount of exertion a person is able to tolerate. It is important to evaluate this especially in people who have heart disease, because their exercise capacity level is lower than someone without heart disease. They need to ensure they are increasing their exercise capacity at safe levels, which they are able to do with supervised exercise at a CR program. It has been found that CR programs are effective in improving exercise capacity[8, 10].

Six Minute Walk Test Analysis

In CR, the 6 MWT can help assess baseline and progression results. "The 6MWT is a more 'natural' form of exercise test"[5] (p. 727). The main outcome in this study will show any improvement in exercise capacity which is determined by an increase in the distanced walked after 12 weeks of supervised exercise[6]. Since many of the articles reviewed in this paper had a primary outcome of the 6 MWT, the validity and reliability of such a variable must be examined.

In the study, *Validation of the Treadmill Six-Minute Walk Test in People Following Cardiac Surgery*, by Olper and colleagues, the participants completed the 6 MWT on a treadmill and another down an 18 meter corridor. Results showed an increase in 6 MWD after completing the treadmill test. However, they believe this to be the result of a possible learning curve[9]. A learning curve can happen due to a familiarization with the machine, increasing the distance completed without an increase in fitness. Also, since the treadmill is motorized, it can help to propel a patient forward. According to the results, the authors concluded both types of 6 MWT to be valid and reliable[9]. In addition, the 6 MWT can normally be easily administered[9].

Typically, the older population will be the majority of the patients in CR. Numerous investigations examined whether this population is able to safely tolerate the 6 MWT after a cardiac surgery. Fiorina and colleagues, determined that the participants, aged 17 to 90 years, were able to easily tolerate the test, and that it proved feasible as well[5]. This suggests that even those in the older generations can still safely perform the 6 MWT.

In the study *The Retest Reliability of the Six-minute Walk Test in Patients Referred to a Cardiac Rehabilitation Programme*, the authors' aim was to determine the reliability of the 6 MWT. The subjects performed three 6MWT within a short time span. However, they found that within the short time frame of the three tests, reliability was not supported by the results due to poor reliability coefficients[6]. This conflicts with the Olper and colleagues study since the 6MWT was determined to be reliable. The reliability was determined to be inaccurate in this study due to the distance increase between each set of tests[6]. The increase in distance wasn't due to the CR intervention program, since all testing was completed within one week. With the increase in the distance covered in the short time frame in this study, it is possible that the participants' increase in the 6 MWT in the Olper study could be due to a learning curve as well.

Further research is needed to resolve the apparent conflicts between these studies. However, the simplicity of the test, with easy administration make the 6 MWT a practical tool to use in CR settings.

Methods

The researcher conducted recruitment at a local, northwest Ohio hospital. The hospital's IRB as well as a local university's Human Subjects Review Board approved the protocol prior to the start of data collection. All participants signed an informed consent before they began the study.

Participants came in to the CR center at the hospital, and the participant's date of birth and weight were recorded. After the participant had been sitting for approximately five minutes, a resting BP, and resting HR were recorded. After base line measurements were obtained, the participants were asked to complete a 6 MWT, where the distance covered and speed were calculated. Calculation of speed was determined by the total distance (feet) walked divided by 5280, divided by six, multiplied by 60, equaled miles per hour (mph) ([(distance/5280)/6]/60=mph). Exercise HR and BP was recorded immediately after the test, along with a five minute recovery heart rate and blood pressure. After the initial meeting, participants began their exercise program, which lasted approximately 12 weeks, three times a week for 75 minutes. The intensity and mode of exercise varied for each participant. Modes of exercise were typically a cycle ergometer, treadmill ergometer, and a NuStep Cross Trainer.

Initial intensity was based on the participant's speed during the 6 MWT. CR staff had each participant start the program on a treadmill. The initial intensity was determined by 70 percent of the calculated speed during the first 6 MWT. CR staff then increased intensity as the participant progressed throughout the program. When it was completed, participants were asked to come to the CR center to repeat all previous tests in the same order.

The basic characteristics of the participants are described in Table 1.

Results

The participants were recruited from the local hospital's phase one cardiac rehabilitation program. Out of the 10 hospital-based participants, only five participants completed the full program. Of the five who did not complete the program, reasons for dropping out included deciding to go back to work, and "having the ability of performing their own rehabilitation elsewhere". In addition, one of the five died during the study.

Values for pre-intervention participant characteristics are shown in Table 2, and post-intervention are located in Table 3.

T-tests were performed for the participants that completed the program, on the variables obtained, pre- and post- the intervention. Significance was set prior at $p<0.05$. Results are reported in Table 4.

Four out of the five participants fully completed the 6 MWT successfully in the both pre- and post- intervention. One participant had to terminate the test early, due to being lightheaded in the pre- test, and leg pain in the post- test.

Table 1

Participant Characteristics

Total	n=10 participants
Completed program	n=5 participants
Age of Completed	$\bar{x}$= 73.2 ± 8.98 years
Age of Not Completed	$\bar{x}$= 55.8 ± 11.05 years
Weight of Completed Pre Intervention	$\bar{x}$= 203.28 ± 43.32 lbs.
Weight of Completed Post Intervention	$\bar{x}$= 200.62 ± 45.29 lbs.

Note, n=Number, $\bar{x}$=Mean +/- SD

Table 2

Pre-Intervention Characteristics

ID	Lbs.	RBP (mmHg)	RHR (bpm)	6MWT (mph)	6MWT (feet)	ExHR (bpm)	ExBP (mmHg)	HRrecovery (bpm)	BPrecovery (mmHg)
#003	210.6	122/66	67	2.2	1170	76	148/64	68	130/68
#009	151	122/60	47	2.41	1275	58	144/58	46	128/60
#013	191.4	140/60	54	2	540	75	164/60	52	178/80
#017	270.2	164/84	64	2.75	1455	69	170/82	60	164/86
#020	193.2	150/60	70	2.6	1390	91	138/66	63	118/56
$\bar{x}$	203.28±38.75	139.60±18.19	60.4±9.61	2.39±0.30	1166±366.56	73.80±11.99	152.80±13.61	57.80±8.79	143.60±25.90

Note, ID=Participant Identification, Lbs.=Weight, RBP= Resting Blood Pressure, RHR=Resting Heart Rate, 6MWT=6-Minute Walk Test, ExHR=Exercise Heart Rate, ExBP=Exercise Blood Pressure, HR=Heart Rate, BP=Blood Pressure, $\bar{x}$=Mean +/- SD

Table 3

Post-Intervention Characteristics

ID	Lbs	RBP (mmHg)	RHR (bpm)	6MWT (mph)	6MWT (feet)	ExHR (bpm)	ExBP (mmHg)	HRrecovery (bpm)	BPrecovery (mmHg)
#003	205.7	116/64	66	2.9	1575	84	134/66	64	120/62
#009	146.6	120/60	53	3.6	1915	72	122/54	65	104/62
#013	187.2	102/70	59	1.3	675	75	140/60	61	124/64
#017	271.4	160/80	63	3.3	1755	77	164/70	69	158/84
#020	192.2	128/60	82	3	1575	90	138/78	78	124/70
x̄	200.62±45.29	125.20±21.61	64.60 ±10.88	2.82±0.89	1499±481.95	79.6±7.30	139.60±15.32	67.40±6.58	126.00±19.70

Note, ID= Participant Identification, Lbs=Weight, RBP=Resting Blood Pressure, RHR=Resting Heart Rate, 6MWT=6-Minute Walk Test, ExHR=Exercise Heart Rate, ExBP=Exercise Blood Pressure, HR=Heart Rate, BP=Blood Pressure, x̄=Mean +/- SD

Table 4

P-Values

Variable	P-value
Weight	0.0881
Resting BP(systolic)	0.1045
Resting HR	0.1599
6MWT Distance	0.0207*
6MWT Speed	0.2416
Exercise HR	0.2251
Exercise BP(systolic)	0.0451*
Recovery HR	0.0692
Recovery BP(systolic)	0.1621

*indicates statistically significant

Discussion

The 6 MWT is the most used timed walk test to measure functional endurance[1]. Many variables were analyzed to determine the effectiveness of a hospital-based cardiac rehabilitation program. There was a significant difference between the distance covered in the pre-and post-intervention 6 MWD. The five participants all improved and covered more distance in the post-intervention test. Therefore all participants were able to improve their functional endurance.

There are many benefits of increasing functional endurance, including partaking in activities for a longer duration, or perhaps performing tasks more quickly.

Along with improving endurance, other factors can be used to evaluate the effectiveness of the intervention. Blood pressure is an indicator of how hard the heart is working. The systolic blood pressure value refers to the pressure in the blood vessels during heart muscle contractions. During exercise, this value increases/decreases due to the body needing more oxygen. The results showed a significant decrease between pre- and post- rehabilitation systolic BP. In this study, four out of the five participants had a lower exercise systolic blood pressure after participating in 12-weeks of CR. However, there was no significant change in diastolic BP. Lowering systolic BP during exercise may decrease risk of several cardiovascular events, including MI (myocardial infarction) and CVA (cerebrovascular accident)[11].

One variable that did not reach statistical significance is between pre-and post-intervention weight. Four out of the five participants lost weight, while one gained weight. This is noteworthy as many CR patients are overweight or obese which itself is a risk factor for heart disease. Another variable that did not reach statistical significance is between pre- and post-intervention HR recovery. HR recovery after exercise is often related to a person's fitness level but is a less accurate indicator than the 6MWT or VO_{2max}. Other measures that were not statistically significant when comparing pre- vs. post-values were resting HR and BP, exercise HR, and 6 MWT speed.

Conclusion

Several key variables assessed in this study significantly improved, strongly suggesting the effectiveness of CR. The results show that participants' exercise systolic blood pressure, and endurance improved after completing the rehabilitation program. Since so few of the participants completed the program, as is typical of most programs, CR staff should focus on strategies to increase compliance for those that do enroll, and boost efforts to increase enrollment from the numbers of those who are eligible to enroll. However, this study was conducted at only one hospital. To better evaluate the effectiveness of cardiac rehabilitation programs, more hospitals and more participants should be included in future research.

Due to the low adherence rates, one direction CR staff may want to focus on is the development of a home-based CR program. Many researchers have already noticed this newer program can provide many of the same benefits as a hospital-based CR program. A program like this could help those who cannot afford to attend a CR program or have the means to travel to a hospital, progress in the same variables as a hospital-based CR program.

For this study, however, the participants were able to gain functional endurance/exercise capacity, and decrease systolic BP in a safe environment. As a result of these positive changes, the chance of them experiencing another cardiac event will likely decrease[11].

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