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Effect of Blood Flow Restriction Low Resistance Exercise on Functional Capacity in Coronary Artery Disease Patients: A Randomized Control Trial

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Abstract

Background: *coronary heart disease (CHD) is the leading cause of mortality. Although fewer individuals are dying from CHD, more people are living with the condition and may require assistance to manage their symptoms and prognosis.* ***Objective:*** *to determining the effectiveness of blood flow restriction low resistance exercise on the patients with coronary artery disease.* ***Methodology:*** *A randomized control trial that was performed on 100 patients referred for (cardiac rehabilitation unite, consultation) to the AL-Najaf Center for Cardiac Surgery and Cardiac Catheterization. Patients were selected through non probability (purposively) and were randomly assigned into two groups of (50) patients in each one. The study group have been exposed to blood flow low resistance restriction exercises by the researcher. The group that has not been exposed to blood flow low resistance restriction exercises by the researcher are considered the control group. the study started from period 8th march 2023 to 28th Jun 2023.* ***Results:*** *The results of the study showed that there is a significant difference between the study group and the control group pre use the blood flow restriction low resistance exercise and post use the exercise.* ***Conclusion:*** *The study reported that patients in the study group receiving resistance to blood flow restriction low resistance exercise highly enhanced functional capacity compared to the control group.* ***Recommendation:*** *recommend the use of blood flow restriction low resistance exercises on patients with coronary arteries disease, because the study has proven that the exercise is effective and responds to cardiac functional capacity.*

Keywords: *coronary artery disease, blood flow restriction low resistance exercises, functional capacity*

Introduction

Coronary artery disease (CAD), also known as coronary heart disease (CHD), ischemic heart disease (IHD), and atherosclerotic heart disease, is the most prevalent kind of cardiovascular disease in adults (43% of all cardiovascular disorders), it is also the main cause of death in the globe[1]. Atherosclerotic coronary artery disease (CAD) is characterized by a wide variety of clinical symptoms, including asymptomatic subclinical atherosclerosis and its consequences, including

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angina pectoris (PA), acute myocardial infarction (MI), and sudden cardiac death (SCD)[2]. Although cases of atherosclerotic CAD with a monogenic etiology have been described, the etiology of CAD is incredibly heterogeneous. CAD is thought to have a complex multifactorial etiology, as it results from the interaction of many genetic and environmental factors (such as diet, physical activity, smoking, and other comorbidities)[3]. Recent years have witnessed a huge increase in the use of blood flow restriction (BFR) treatment, a regulated form of vascular occlusion paired with low resistance training or exercise. The understanding of BFR's physiologic mode of action has advanced along with public awareness of BFR. This has revealed several advantages besides muscle growth, such as increased bone density, cardiovascular fitness, and muscular endurance [4]. During physical activity or as part of ischemic preconditioning, the blood flow restriction low resistance (BFRLR) technique involves applying high pressure with a tourniquet, to the proximal part of the limb (arm or leg) in order to reduce arterial blood flow and shut down venous blood flow [5]. In terms of primary prevention, regular exercise reduces the risk of cardiovascular disease and cardiac dysfunction capacity. Endothelial dysfunction, which begins many years before coronary sclerosis, is the initial stage of a vicious cycle that leads to overt atherosclerosis, severe coronary artery disease (CAD), plaque rupture, and, ultimately, myocardial infarction. As opposed to this, consistent physical exercise appears to be useful in the primary prevention of CAD and functional capacity through the regulation of traditional risk variables [6].

Methodology

A randomized control trial that was performed on 100 patients referred for (cardiac rehabilitation unite, consultation) to the AL-Najaf Center for Cardiac Surgery and Cardiac Catheterization. Patients were selected through non probability (purposively) and were randomly assigned into two groups of (50) patients in each one. The study group have been exposed to blood flow low resistance restriction exercises by the researcher. The group that has not been exposed to blood flow low resistance restriction exercises by the researcher are considered the control group. The study was not initiated until approval was obtained for ethical considerations. The criteria for the selection of the study sample were: Inclusion Criteria included Patients with coronary artery disease, Patient consent and readiness to enter the program, Optimum medical treatment (patient compliance to medication and diet) and Adult patient with 18-69 year. regarding the exclusion criteria included Unstable and dependent patients, Patients with left ventricle systolic dysfunction, Patients immediately after cardiac surgery or catheter intervention, Patients who have lost one or both limbs, Patient with sever heart failure and Patient with irregular heartbeat. The measurement of effect the blood flow restriction low resistance exercise on functional capacity in coronary artery diseases patients through used of The six-minute walking test to measure functional capacity, and Borg scale checklist for to measurement dyspnea. Data obtained from the patients with coronary artery disease by the interview questionnaire forma which include smoking status, body mass index, Diseases Duration, past medical history and past surgical history. It was used to assess patient's 6MWT checklist and Borg scale to measure the change, during the period measurement. which are

applied on the pre and post the blood flow restriction resistance exercise. Use band elastic while restricting the blood flow from the thighs area and start the movement by extending the leg and bending and same method but restricting the blood flow from the humerus to both hands and start pulling and extending the hand. The exercise is repeated 20 times within a minute. The exercise is repeated 20 times within a minute, and this exercise continues 5 times during the day for 5 days during the week.

Statistical Analysis

The data of the present study is analyzed through the application of two statistical approaches which may assist the determination of the results. The study of these approaches include (Descriptive Statistics: Tables Frequencies, Percentages, Mean of Score, and Persons' correlation. Also Inferential Statistical: (The Friedman test, Mann–Whitney U test)[7 8].

Result

Table (1) Distribution of Socio-Demographic Characteristics for both Study and Control Groups

'Variables	Categories	Statistics	Grouping	
			Control	Study
Age	31 - 40	F.	7	9
		%	14.0%	18.0%
	41 - 50	F.	17	15
		%	34.0%	30.0%
	51 - 60	F.	16	15
		%	32.0%	30.0%
	61 - 70	F.	10	11
		%	20.0%	22.0%
Mean + S.D.			51.42	51.16
			9.49	10.13
Gender	Male	F.	49	47
		%	98.0%	94.0%
	Female	F.	1	3
		%	2.0%	6.0%
Total			50	50
Level of Education	Doesn't read and write	F.	1	3
		%	2.0%	6.0%
	Read & write	F.	6	11
		%	12.0%	22.0%
	Primary school	F.	11	16
		%	22.0%	32.0%
	Intermediate school	F.	14	5
		%	28.0%	10.0%

	Secondary school	F.	8	6
		%	16.0%	12.0%
	Institute graduate	F.	8	6
		%	16.0%	12.0%
	University graduate	F.	2	3
		%	4.0%	6.0%
Total			50	50
Monthly Income	<= 600000	F.	32	41
		%	64.0%	82.0%
	600001 - 900000	F.	9	1
		%	18.0%	2.0%
	900001 - 1200000	F.	7	6
		%	14.0%	12.0%
	1200001 - 1500000	F.	2	2
		%	4.0%	4.0%
Mean + S.D.			509400	374700
			400246.9	386111.4

Table (1) shows the patient demographic characteristic, %= percentage, freq. = frequency, S.D. = Standard Deviation

Table (1) regarding Age the mean of patients age in control and study group is (51.42 ,51.16) respectively. Concerning Gender, the most of patients in both groups is male (98%) control patient (94%) study patients. Regarding of level education 28% of participant in control group with intermediate school while 32% of participant the study group primary school. Concerning monthly income, the majority of participant in control and study groups with less than 600000 DI (64%,82%) respectively.

Table (2) The Distribution of the Clinical Characteristics for both Study and Control Groups

Variables	Categories	Statistics	Grouping	
			Control	Study
Smoking	Active	F.	30	31
		%	60.0%	62.0%
	Passive	F.	11	9
		%	22.0%	18.0%
	None	F.	6	8
		%	12.0%	16.0%
	Ex-smoker	F.	3	2
		%	6.0%	4.0%
Total			50	50
Disease Duration	<= 5	F.	33	26
		%	66.0%	52.0%
	6 - 10	F.	17	22

			%	34.0%	44.0%
		16+	F.	0	2
			%	0.0%	4.0%
Mean + S.D.				4.84	5.76
				2.27	3.32
BMI		Normal	F.	4	2
			%	8.0%	4.0%
		Overweight	F.	22	17
			%	44.0%	34.0%
		Obesity	F.	24	31
			%	48.0%	62.0%
Mean + S.D.				29.56	30.95
				3.36	3.43
Chronic Diseases	Hypertension	Yes	F.	49	50
			%	98.0%	100.0%
		No	F.	1	0
			%	2.0%	0.0%
	DM	Yes	F.	30	22
			%	60.0%	44.0%
		No	F.	20	28
			%	40.0%	56.0%
	PVD	Yes	F.	26	20
			%	52.0%	40.0%
		No	F.	24	30
			%	48.0%	60.0%
	CABG	Yes	F.	2	1
			%	4.0%	2.0%
		No	F.	48	49
			%	96.0%	98.0%
	CC	Yes	F.	33	31
			%	66.0%	62.0%
		No	F.	17	19
			%	34.0%	38.0%
Total				50	50

Table (2) shows the patient clinical characteristic, %= percentage, freq. = frequency, S.D. = Standard Deviation, BMI=Body Mass Index, DM=Diabetic Mellitus, PVD= Peripheral Vascular Disease, CABG= Coronary Artery Bypass Graft, CC=Cardiac Catheterization, Normal value to BMI=(18-24normal), (24-29 over weight), (30+ obese).

Table (2) Shows the majority smoker participants in control and study groups were active smoker (60%,62%) respectively. Regarding disease duration demonstrated control and study groups participants the mean (4.84, 5.76). concerning the body mass index, the control and study groups participants the mean (29.56, 30.95) obesity body. Shows the hypertensive the study sample of both control and study groups participants (98%,100%) respectively. Regarding the diabetic to control groups 60% of participant and the study groups participants were that 56% from not suffering

diabetic. Shows the control groups participants were suffering from peripheral vascular disease 52%, and study groups participant 60% are not. Present The control groups participants were 98% procedure to coronary artery bypass graft, while the study groups participants 98% are not. Shows the both groups participant's procedure cardiac catheterization in control and study groups (66%,62%) respectively.

Table (3) the functional capacity Assessment of Patient Dyspnea Level (Borg Scale) in Period of Measurements for both Study and Control Groups.

Borg Scale			Statistics	Control	Study
Period of Measurement	Pre-Test	Mild	F.	6	2
			%	75.0%	25.0%
		Moderate	F.	29	22
			%	56.9%	43.1%
		Sever	F.	15	26
			%	36.6%	63.4%
		Mean		6.4	6.64
		S.D.		0.99	1.60
	Post-Test 1	Mild	F.	6	5
			%	54.5%	45.5%
		Moderate	F.	28	33
			%	45.9%	54.1%
		Sever	F.	16	12
			%	57.1%	42.9%
		Mean		5.52	5.50
		S.D.		1.69	1.54
	Post-Test 2	Mild	F.	5	10
			%	33.3%	66.7%
		Moderate	F.	28	35
			%	44.4%	55.6%
		Sever	F.	17	5
			%	77.3%	22.7%
		Mean		5.60	4.70
		S.D.		1.58	1.59
	Post-Test3	Mild	F.	3	38
			%	7.3%	92.7%
		Moderate	F.	28	12
			%	70.0%	30.0%
		Sever	F.	19	0
			%	100.0%	0.0%
		Mean		5.76	2.34
		S.D.		1.49	1.55

Table (3) demonstrate dyspnea level in period of measurement to study and control groups. % = percentage, S. D= standard deviation, Normal value Borg scale (mild= 0-3, moderate=4-7,

sever=8-10)

Table (**3**) show to pre-test in Borg scale the control groups participants 75% mild dyspnea level, while study group participants 63.4 % sever dyspnea level. with mean to both control and study groups (6.4, 6.64). The post-test1 demonstrated control group participants 57.1% Sever dyspnea level. while the study group participants 54.1% Moderate dyspnea level. with mean to both control and study groups participants (5.52, 5.5). In post-test appeared the control group participants 77.3% sever dyspnea level, while study group participants 66.7% mild dyspnea level. with mean to both control and study groups participants (5.6 ,4.7). While post-test3 evidence the control groups participants 100% sever dyspnea level, and the study groups participants 92.7% mild dyspnea level. with mean to both control and study groups participants (5.76 ,2.34). Gave to Borg scale indicate about study groups participants during period has measurement enhancement while the control group participants are not enhancement during period measurement see table (3).

Table (4) Assessment of Patient Walking Distance (6MWT) in Period of Measurements for both Study and Study and Control Groups

Walking Distance			Statistics	Control	Study
Period of Measurement	Pre-Test	<= 50	F.	19	14
			%	57.6%	42.4%
		51 - 100	F.	31	36
			%	46.3%	53.7%
		Mean		55.6	58.94
		S.D.		6.19	9.60
	Post-Test 1	51 - 100	F.	50	36
			%	58.1%	41.9%
		101+	F.	0	14
			%	0.0%	100.0%
		Mean		65.88	97.08
		S.D.		7.90	11.55
	Post-Test 2	51 - 100	F.	50	0
			%	100.0%	0.0%
		101+	F.	0	50
			%	0.0%	100.0%

	Mean		77.44	124.56
	S.D.		7.97	14.57
Post-Test 3	51 - 100	F.	44	0
		%	100.0%	0.0%
	101+	F.	6	50
		%	10.7%	89.3%
	Mean		91.86	164.66
	S.D.		12.36	24.13

Table (4) demonstrate assessment walking distance in period of measurement to control and study groups. % = percentage, S. D= standard deviation, 6MWT = Six Minutes Walking Test, unite measure =meter.

Table (4) demonstrate pre-test control group participants 57.6% less 50 meter in 6MWT, while group study participants is walking distance 53.7% from (51-100) meters in 6MWT. with mean to both control and study groups (55.6, 58.94). The post-test 1 control group participants in distance walking 58.1% from (51-100) meter in 6MWT, while study group participants are walking distance 100% more Than 101 meter in 6MWT. with mean to both control and study groups (65.88 ,97.08). In post-test 2 present control groups participants walking distance 100% from (51-100) meter in 6MWT, while study group participants walking distance 100% more than101 in 6MWT. this with mean to both control and study groups (77.44 -124.56). Whereas post-test 3 all control group participants is 100% walking distance from (51-100) meter in 6MWT, most of study group participants walking distance 89.3% more than 101 in 6MWT. with mean to both control and study groups (91.86-164.66). The participants in study groups notes that there elevated in levels walking distance during the period measurement in 6MWT walking test, whilst participants in control group is not go to enhancement walking distance during period measurement in 6MWT walking test.

Table (5) Comparison of Patient's Walking Distance (6MWT) of Control Group between Pre and Posttest1, Posttest2, and Posttest3

	Period of Measurement	**Mean**	**S.D.**	**Mean Rank**	**Friedman Test (Chi-Square)**	**d.f.**	**P-value**
Walking Distance	Pre-Test	55.60	6.194	1.00	149.705	3	0.000
	Post-Test1	65.88	7.902	2.01			
	Post-Test2	77.44	7.970	2.99			
	Post-Test3	91.86	12.359	4.00			

Table (5) shows comparison walking distance to control group with period of measurement. S. D= standard deviation, d.f.=difference, unite measure =meter, p.value=0.05, walking distance

The table (5) show the comparisons between pre, post1, post2 and post3 test with control groups participants there is a significant walking distance at p.value (0.05) that's result mean the

participants in control groups with slightly enhancement.

Table (6) Comparison of Patient's Walking Distance (6MWT) of Study Group between Pre and Posttest1, Posttest2, and Posttest3

	Period of Measurement	Mean	S.D.	Mean Rank	Friedman Test (Chi-Square)	d.f.	P-value
Walking Distance	Pre-Test	58.94	9.601	1.00	150.0	3	0.000
	Post-Test1	97.08	11.551	2.00			
	Post-Test2	124.56	14.570	3.00			
	Post-Test3	164.66	24.127	4.00			

Table (6) shows comparison walking distance to study group with period of measurement. S. D= standard deviation, d.f.=difference, unite measure =meter, p.value=0.05, walking distance

The table (6) demonstrate the comparisons between pre, post1, post2 and post3 test with study groups participants there is a significant walking distance at p.value (0.05) that's result mean the participants in study groups with highly enhancement.

Table (7) Comparison of Patient's Dyspnea Level (Borg Scale) related (6MWT) of Control Group between Pre and Posttest1, Posttest2, and Posttest3

	Period of Measurement	Mean	S.D.	Mean Rank	Friedman Test (Chi-Square)	df	P-value
Borg Scale	**Pre-Test**	6.40	0.990	3.04	31.981	3	0.000
	Post-Test1	5.52	1.693	2.18			
	Post-Test2	5.60	1.578	2.26			
	Post-Test3	5.76	1.492	2.52			

Table (7) demonstrate comparison dyspnea level related (6MWT) to Control Group with Period of Study. S. D= standard deviation, d.f.=difference, p.value=0.05

The table (7) present the comparisons between pre, post1, post2 and post3 test with dyspnea level to control groups participants 6mint walking test there is a significant difference Borg scale at p.value (0.05) that's result mean the participants in control groups were slightly enhancement.

Table (8) Comparison of Patient's Dyspnea Level (Borg Scale) related (6MWT) of Study Group between Pre and Posttest1, Posttest2, and Posttest3

	Period of Measurement	Mean	S.D.	Mean Rank	Friedman Test (Chi-Square)	d.f.	P-value
Borg Scale	**Pre-Test**	6.64	1.601	3.92	135.0	3	0.000
	Post-Test1	5.50	1.542	2.82			
	Post-Test2	4.70	1.594	2.22			
	Post-Test3	2.34	1.547	1.04			

Table (8) demonstrate comparison dyspnea level related (6MWT) to study Group with Period of Study. S. D= standard deviation, d.f.=difference, p.value=0.05, Normal value Borg scale (mild= 0-3, moderate=4-7, sever=8-10)

The table (8) show the comparisons between pre, post1, post2 and post3 test with dyspnea level to study groups participants 6MWT walking test there is a significant difference Borg scale at p.value (0.05) that's result mean the participants in study groups is enhancement.

Table (9) Comparison of Patient's Walking Distance (6MWT) of Study and Control Groups between Pre and Posttest1, Posttest2, and Posttest3

Period of Measurement		Grouping	Mean Rank	Sum of Ranks	Mann-Whitney Test	P-value
Walking Distance	**Pre-Test**	Control	46.13	2306.50	1031.50	0.124
		Study	54.87	2743.50		NS
	Post-Test 1	Control	25.99	1299.50	24.50	0.000 S
		Study	75.01	3750.50		
	Post-Test 2	Control	25.50	1275.00	0.00	0.000 S
		Study	75.50	3775.00		
	Post-Test 3	Control	25.54	1277.00	2.00	0.000 S
		Study	75.46	3773.00		

Table (9) demonstrate comparison walking distance of control and study group with period of measurement. NS = Non-Significant, S = Significant, Walking distance

The table (9) present comparison of participants walking distance(6MWT) that there is non-significant difference both groups control and study in pre- test, while there is a significant difference between groups in post1, post2 and post3.

Table (10) Comparison of Patient's Dyspnea Level (Borg Scale) related (6MWT) of Study and Control Groups between Pre and Posttest1, Posttest2, and Posttest3

period of measurement		Grouping	Mean Rank	Sum of Ranks	Mann-Whitney Test	P-value
Borg Scale	Pre-Test	Control	47.28	2364.00	1089.0	0.250
		Study	53.72	2686.00		NS
	Post-Test 1	Control	50.56	2528.00	1247.0	0.983
		Study	50.44	2522.00		NS
	Post-Test 2	Control	58.13	2906.50	868.5	0.007 S
		Study	42.87	2143.50		
	Post-Test 3	Control	71.97	3598.50	176.5	0.000 S
		Study	29.03	1451.50		

Table (10) demonstrate dyspnea level related (6MWT) of control and study groups with period of measurement. p.value=0.05, Normal value Borg scale (mild= 0-3, moderate=4-7, sever=8-10)

The table (10) show the comparisons between pre, post1, post2 and post3 test with Borg scale to control and study groups participants there is non-significant difference to pre -test and post test1.whlist there is a significant difference at p. value 0.05 in post-test2 and post-test 3 to both groups.

Discussion

The functional capacity for coronary artery disease (table 3, 4, 5, 6, 7, 8, 9,10).

This part contains many variables, including distance walking test, Borg scale and Dyspnea. Regarding of functional capacity, the results of current study showed that a significant improved in post-test the heart capacity to performance the function for study group than the control group. Regarding functional capacity, the presented study result corresponded with the study done by article objective "to evaluate risk for cardiac diseases by functional capacity" the functional capacity Simpler objective tests such as the 6-min walk test (6MWT) are these is very useful for cardiac capacity and test cheap and efficient [9].The current study consisted with article, entitle" Impact of Exercise Training Interventions on Flow-Mediated Dilation in Adults: An Umbrella Review.", reported that those with cardiovascular conditions should consider engaging in high-intensity aerobic training to improve endothelial function [10]. The article, entitle "Exercise-based cardiac rehabilitation for coronary heart disease: a meta-analysis" reported that, this confirms that participation in exercise-based cardia rehabilitation by patients with coronary heart disease receiving contemporary medical management reduces cardiovascular mortality, recurrent cardiac events [11].The findings of a study mentioned above conducted with article, entitle "Exercise Training and Interventions for Coronary Artery Disease" showed that Exercise attenuates certain pathophysiological processes of this disease, such as endothelial dysfunction or the vulnerability of atherosclerotic plaques, and produces improvements in functional capacity and muscle strength, among others [12]. The article, entitle" Association Between Exercise Capacity and Health-Related Quality of Life During and After Cardiac Rehabilitation in Acute Coronary Syndrome Patients: A Sub study of the OPTICARE Randomized Controlled Trial" confirm that pre, during, and post cardiac rehabilitation, a higher exercise capacity was associated with a higher score on the global and physical domains of Health-Related Quality of Life [13]. Hence, patients who improved in 6MWT distance also improved. The result of current study was consistent with a study done that objective "to evaluate heart rate after recovery and cardiac rehabilitation to acute coronary syndrome stated that the patients undergoing a cardiac rehabilitation programme after acute coronary syndrome", increased heart rate recovery after a 6MWT, especially at 3min, was positively correlated with 6MWT distance and improved well-being [14].The heart rate recovery raw data seem more sensitive than post-exercise heart rate variability analysis for monitoring functional and autonomic improvement after acute coronary syndrome [15 16]. The study concluded that the most of the sample are more knowledge about exercise that mention for in article more the coronary artery patient him had fair knowledge about exercise more than healthy person [17]. This study found that more patients with coronary artery disease had fair knowledge overall about exercise than did healthy people. As a result, improving quality of life adds to cardiac capacity[18]. The researcher confirms that the patients under the blood flow low resistance restriction exercises had a high physical activity that leading to improvement functional capacity. The researcher noticed that there is a significant improvement compared to the control group, as a result of the application of the cardiac rehabilitation program for patients with coronary arteries disease. The blood flow low resistance restriction exercise very useful to functional capacity, to improve endothelial function to

the heart and to adaptation to the disease.

Conclusion

The study reported that patients in the study group receiving resistance to blood flow restriction low resistance exercise a highly enhanced functional capacity compared to the control group.

Recommendation

Recommend the use of blood flow restriction low resistance exercises on patients with coronary arteries disease, because the study has proven that the exercise is effective and responds to cardiac functional capacity

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