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Original Article

Effect of Aerobic Exercise training on Insulin Resistance among Non-Diabetic Heart Failure Patients

Eman AbdelRazik AbdelHakim[(1)], Aml S. Abdelbaky[(2)] Amal H. Mohamed [(3)], Shaimaa F. Kamel [(4)], Hend Elham Mohammed [(5)]

[1,2] Lecturer of Medical-Surgical Nursing, Faculty of Nursing- Minia University, Egypt.
[3] Assistance. Prof. of Community Health Nursing, Faculty of Nursing, Minia University, Egypt.
[4] Lecturer of Hematology, Internal Medicine Department. Faculty of medicine. Minia University. Egypt.
[5] Assistant Professor of Medical-Surgical Nursing, Faculty of Nursing- Minia University, Egypt.

ABSTRACT

Insulin resistance (IR) is more particular to exist in patients with heart failure and is strongly in relation to level of physical activity. Aerobic exercises have been shown to ameliorate the insulin signaling through different molecular mechanisms. **Aim:** Evaluate the effect of aerobic exercise training on insulin resistance among non-diabetic heart failure patients. **Design**: A quasi-experimental. **Setting**: The research was performed at Cardio-thoracic Surgery Hospital at New Minia City which affiliated to main Minia University Hospitals. **Subjects**: A purposive sample of eighty patients with chronic heart failure were recruited and assigned into either study group or control group (40 patients for each group). **Tools of data collection:** Patient interview questionnaire and Insulin resistance assessment. **Results**: The mean scores of waist circumference measurements for the study group decreases significantly from 96.9±11.2, at baseline to, 84.2±6.76 post 12 -week of aerobic exercises training when compared to the control group which is relatively constant. Moreover, there were a statistically significant decrease in the results of the laboratory investigations indices for IR post-12-week of aerobic exercises training in study group as compared to control group. **Conclusion**: Aerobic exercises have a favorable effect on controlling the prognostic determinants of IR which was obvious in the improvement of anthropometric measurements and laboratory investigations. **Recommendations:** Conducting training program about aerobic exercise is an essential treatment for IR to improve ongoing surveillance and monitoring relying on preventing the raising of IR and its issues among heart failure patients.

Keywords: Aerobic exercises, Insulin resistance, Non-diabetic heart failure patients.

Introduction:

Heart failure (HF) is the most critical health hazards around the globe as well as is the primary cause of hospitalization, with high morbidity as well as death rates and poor practical ability as well as poor quality of life (QOL) **(Son et al., 2022).** HF is a status in which the myocardium cannot reach the whole body's need for blood as well as oxygen also is connection with difficult and various factors **(Saotome et al., 2019)** Approximately 64.3 million

individuals were suffering from HF globally in 2017. The health care costs of HF worldwide in 2012 represented 30.7$ billion in the United States (USA), which is expected to rise to 127%, or around 69.8$ billion, amounting to approximately 244$ in 2030 **(Savarese et al., 2022).**

Insulin is the basic hormone that regulates levels of glucose in the blood and cellular metabolism in human tissues. Insulin resistance (IR) is a difficult status associated with a decrease in the physiologic reaction of target tissues to insulin stimulation, specifically the liver, muscle, as well as the adipose tissue. Hyperinsulinemia and decreased tissue sensitivity to insulin are the results of IR, which reduces glucose absorption and oxidation. Increase the level of blood glucose, dyslipidemia, increase blood pressure, visceral obesity, high level of uric acid in the blood, rising inflammatory markers, endothelial disabilities, as well as prothrombic condition are among the metabolic side effects of IR that can affect diabetic and non-diabetic populations as well it can be temporary or chronic. According to recent evidence, more than 84 million adults in the USA have IR **(Freeman & Pennings, 2022; Zhao et al., 2023)**. Another research mentioned that, by 2045 the prevalence of IR relying on impaired glucose tolerance (IGT) test in individuals aged between 20– 79 years is expected to raise to 8.3% of the global population, which accounted to be 587 million individuals **(Hassan et al., 2022).** In Egypt, a recent research highlighted that, IR in the general population were in the range of 10 to 25% **(Shawky et al., 2020)**.

Heart failure patients may have both systemic as well as cardiac IR. HF is linked with generalized IR and associated with the presence of minimal glycemic profile alteration. Moreover, IR raise the dangerous of HF even post controlling the traditional causes and plays a great role in non-diabetic patients with compromised HF. IR is in relation to cardio-myocyte enlargement and rigidity, stimulation of insulin-dependent growth receptors as well as the growth hormone-same receptors (receptors for growth factor-1), raise reaction to angiotensin II, as well as enhancing growth of the intravascular volume and retention of the sodium **(Costa et al., 2022).**

Several molecular mechanisms discuss the association among IR and cardio-vascular disease (CVD), such as atherosclerosis, vascular function, hypertension, and macrophage accumulation. Neuro-hormonal changes like sympathetic activation with inflammation, as well as raise consumption of oxygen, limited exercise, and intrinsic alternative in muscle tissue, involve the state of IR, which causes structural changes in the heart for example raising size of left atrial, mass of left ventricular, and abnormalities in trans-mitral velocity that could come before HF diagnosis **(Ormazabal et al., 2018; Patel et al., 2016)**. Evidence has suggested the main causes of IR are genetic problems of proteins include in the insulin reaction flow, severe inadequate nutrition, and excessive visceral fat. IR takes place as part of the cardiovascular as well as problems of metabolism group in most patients **(Saotome et al., 2019).**

Systemic IR can be identified through the " model of homeostasis evaluate for IR (HOMA-IR: normal; less than 1.6, IR; more than 2.5)", as it is a suitable as well as broad applicable approach utilized in practice of the day. Other laboratory studies are needed for the diagnosis of IR, like plasma glucose, insulin, insulin-glucose ratio, lipoprotein IR index, triglycerides, total cholesterol, low-density as well as high-density of lipoprotein cholesterol, and hemoglobin A1c (HbA1c), as well as; body mass index (BMI), circumference of waist as well as the hip **(Son et al., 2022; Yang et al., 2022)**

Regular exercise is a cornerstone of the treatment of IR. Aerobic exercise is a rhythmic and continuous movements of large muscle groups, leading to an increase in heart rate and breathing to supply oxygen to the body's working muscles **(ACSM, 2018)**. Aerobic exercise can be performed at various intensities and durations, involving moderate-intensity continuous (MIC) exercise or (HIIT) high-intensity interval training **(Gibala et al., 2019).** Convincing evidence discovered that sustainable aerobic exercise training helps in controlling hypertension, promoting insulin sensitivity, improving glucose tolerance, and increasing glucose uptake by at least 40%, as well as playing an important role in lipoprotein profile and improving weight management. Additionally, aerobic exercises lower the risk of developing IR by increasing levels of high-density lipoprotein (HDL), lowering triglyceride (TGL) degree, as well as the maintaining a normal level of blood pressure. They also reduce all-reasons death by decreasing the dangerous of coronary heart problems, stroke, as well as cancer of the colon. Aerobic exercise also decrease inflammation as well as maintain tissues from stress of oxidative **(Zhao et al., 2023; Freeman & Pennings, 2022).** Extensive research reveals that aerobic exercise leads to a greater enhancement of aerobic capacity with cardiopulmonary and metabolic fitness **(Maleki, et al., 2019)**

Significance of the research:

Heart failure remains the common leading reasons of death globally in the both countries developed as well as developing. HF accounts for more than 5 million patients in the US, which is estimated at nearly 40 billion US dollars in annual health care costs. Patients with HF have various degrees of activity and mobility limitations and lower cardiorespiratory fitness. IR is an incident metabolic issues in patients with HF, estimated between 33percent to 70percent **(Yang et al., 2022).** In Egypt, recent research highlighted that, 65.4% of participants has been diagnosed to be IR which confirmed by HbA1c **(Hassan et al., 2022)**.

Sustainable aerobic exercises can ameliorate or prevent the onset of IR by increasing energy expenditure and improving muscle insulin sensitivity, as these types of exercises afford tremendous benefits and are an irreplaceable part of the overall strategy for controlling IR in HF patients (**Savarese et al., 2022).** This research was performed to investigate the effect of a regular aerobic exercise training on IR. The researchers noted that no prior studies have been conducted in this particular area regarding the impact of aerobic

exercise training on IR in non-diabetic heart failure patients. Nonetheless, the researcher suggests that this type of intervention can yield significant benefits if implemented appropriately, resulting in improved patient outcomes.

Aim of the study

This study aimed to evaluate the effect of aerobic exercise training on insulin resistance among non-diabetic heart failure patients

Research design

A quasi-experimental (both groups control as well as study) design was used in the current research. This method includes the designing of a comparison group and often utilized when it is impossible to randomize subjects to intervention and control groups **(Iwahori et al., 2022).**

Research hypothesis:

H1: Aerobic exercise training will have a positive effect on reducing IR among non-diabetic HF patients.

Research setting

This research was operated in the cardiac inpatient department (located in the second floor) which consisted of 5 rooms (each room contains 6 beds) and out-patient clinic for follow up phase that is contained four rooms for patients' examination and follow-up and present in grounded floor at New Minia City on Cardio-thoracic Surgery Hospital and is affiliated to Minia University hospital in Egypt.

Sample of the research:

Purposive sample of 80 hospitalized chronic HF patients, were recruited and allocated into two groups as followed; study (aerobic exercises) group (forty patients) and control group (forty patients)

Allocation of study and control participants:

Patients who were eligible for recruitment were provided formal consent and assigned as 1:1 to either the study (n=40) or Control (n=40) groups.

Sample size:

The required representative sample size was determined based on the flow rate of the cardiac department last year, Open Epi version 3, eighty patients to obtain the following equation's % confidence interval and 5% error **(Dean, Sullivan, & Soe, 2015).**

$$\text{Sample size } n = [Np(1-p)] / [(d\ 2/Z\ 2\ 1-\alpha/2*(N-1) + p*(1-p)]$$

Description:

N: Population size

p: Population's prevalence

d: control of confidence

Considering that there are 480 in the entire population.

14.5% of patients with HF, with a 5% dropout rate.

Inclusion criteria:

Hospitalized patients who recently diagnosed with chronic HF and patient's age from 40 to 70 years

Exclusion criteria: -

- Patients who are unable to exercise safely and effectively due to a physical or cognitive impairment
- Untreated diagnosed mental health problem, such as schizophrenia, except depression or anxiety
- Unstable Angina
- Unstable Atrial or Ventricular Arrhythmia not currently receiving treatment
- Acute Pericarditis/Myocarditis
- Non-cardiac diagnosis requiring acute treatment
- Patient suffer from diabetes mellitus.

Data Collection Tools:

Two tools were utilized to gather pertinent data needed for the actually research

Tool 1: Patient interview questionnaire:

It was developed by the researchers post revising more and different review of literatures and it involved 3 main parts:

- **1st part concerned with evaluate socio-demographic characteristics of the participated patients** including age, gender, educational level, occupation, place of residence, and marital status.
- **2nd part concerned with baseline ordinary physical activity (before implementing aerobic exercise training) of participated patients;** was described that if the patient was not active, if performed ordinary activity from one to two times per week, if performed ordinary activities from three to five times per week or if the patient performed ordinary activities more than five times per week.

Scoring system:

Each item had a score that ranged from one if the patient wasn't active, two if the patient performed ordinary activities 1-2 times per week, three if the patient performed from three to five times, weekly also more than five times in the week which take score four.

- **3rd part concerned with anthropometric measurements** that concerned with Waist Circumference (WC), the hip circumference (HC) as well as waist to hip ratio (WHR) and body mass index (BMI) **(Cerqueira et al., 2022; Rosberg et al., 2022)** that were measured three times during study period (at baseline assessment, after 8 weeks of study and the last one after 12 weeks of study period)

Scoring system:

- WC: Normal for men is less than or equal to 94 cm and for women is less than or equal to 80 cm
- HC: 94-105 cm for male and from 97-108 cm for female
- WHR: for male equal one or less and for female 0.8 or less
- BMI is normal when equal 18.5-24.9 kg/M2, and considered Overweight when equal 25.0-29.9 kg/M2, and considered obesity when equal 30.0-39.9 kg/M2 as

well as BMI is extreme obesity when equal 40.0 kg/M2**.**

Tool II: Insulin resistance assessment: It covers two main parts:

The first part concerned with assessment of clinical manifestations of insulin resistance this part was created by researchers after reviewing of literature (Babushkina et al., **2017)** and it was included**:** A waist line over forty inches in male and thirty-five inches in female and skin patches –dark and velvety skin named acanthosis nigricans on the neck, groin, as well as armpits.

Scoring system: Each item had a score that ranged from one if the patient had the symptom to zero if they had none. Measured patients' symptoms two times during study period in the first assessment (at baseline) and after 12 weeks

The second part concerned with laboratory investigation indices of IR as Fasting Blood Sugar, HOMA-IR, lipid profile including cholesterol level, TGL, HDL-C, LDL-C, as well as Lipoprotein IR Index (LP-IR) and they were evaluated three times during study period (at bassline assessment, after 8 weeks and after 12 weeks).

Scoring system

Laboratory Investigation indices of insulin resistance	Normal range
• Fasting Blood Sugar	Less than100mg/dl
• Insulin (mIU/L)	3–8 uIU/mL (18–48 pmol/L)
• HOMA-IR	Less than 1
• Insulin: Glucose Ratio	less than 0.3.
• HBA1c Test	Less than 5.7%
Lipid profile	
• Total cholesterol,	lower than 200 mg/dL.
• Triglycerides,	Less than 150 mg/dL
• HDL-C	35 to 65 mg/dL for men, 35 to 80 mg/dL for women
• LDL-C	less than 100 mg/dl
• LP-IR, Lipoprotein Insulin Resistance Index	0-100

Content validity: The research tools were evaluated by a five- panel of Medical-Surgical nursing and community nursing professionals with higher than 10 years of experience in this field to evaluate the clarity, feasibility, as well as the applicability of the research tools.

Reliability was evaluated by Alpha Cronbach's test. Reliability of the 1st tool was (0.69) and the outcomes of the 2nd tool was (0.86). The instruments coefficient revealed that this test was enough reliable.

Pilot study:

It was conducted on ten percent of the overall the participants (8 participants) to evaluate the applicability as well as acceptability of the tools, examine the feasibility of work's field; and knowing any potential issues that the researcher could encounter as well as obstruct the gathering of data. No modifications were made. The trial sample was used in the basic sample.

Ethical Consideration

All formal letters were given from the responsible authorities to conduct this study. The research was taken from the Ethics Committee on Faculty of Nursing at Minia University after reviewing the research protocol. There was no dangerous for study participants during the conduction of the research. All sample signed the informed consent and they were told of the study's purpose, method, advantages, nature, and follow-up. They also had the freedom to leave the study at any moment and without explanation. Through the coding of all data and the protection of the acquired

data, the confidentiality and anonymity of each subject were guaranteed and Plagiarism was avoided and intellectual property rights were maintained.

Study fieldwork

Study Field work included three phases' preparatory, implementation, and evaluation

Preparation Phase:

The actually research was begun by preparing of various data gathering tools after review of the previous and current literature in the field of the research by using textbooks, journals, researches, periodicals, as well as the internet to have a clear picture of all dimensions related to the topic of research.

Before data were collected, the researchers visited the cardio-thoracic hospital to coordinate and formulate plans for recruitment. This phase assisted in guiding, planning, and developing the study procedure, in addition to obtain formal written acceptance which was approved in the time of one-month pre conducting the research. Gathering of study data was done 2 days every week during the morning shift. The data gathering was done over a period of twelve weeks that began from December 2021 to February 2022 which was divided in to eight weeks after patients training and four weeks later as follow up. The data was collected from the "study group" after completing the "control group".

Implementation phase: Participants were allocated to the current study during their stay in the cardiac inpatient department at cardio-thoracic hospital, the researchers started with a rapport session with the patients for establishing a good therapeutic relationship and illustrated the aim as well as nature of the research to every participant individually. the researchers began a gathering of data by utilizing the three parts of tool one through face-to-face interview that was taken one time during the study period.

Anthropometric measurements were collected by the researchers from each participant in both groups and were assessed three times during study period. (1): Body weight (kg) as well as height (m) were evaluated while patients were wearing light clothing and without shoes. (2): The BMI was identified by dividing weight in kg by height in m^2. Regarding to the BMI levels, (3): The WC was evaluated with a tape at the high point level midway among the lowest rib as well as iliac crest to the nearest 0.1 cm. (4): The HC was measured at the level of the trochanters (5): The WHR was calculated by dividing the waist measurement by the hip measurement.

Laboratory tests: A venous blood sample was obtained from each participant in both groups post supine rest for at least twenty min, a sample was received from the radial or antecubital vein to assess the following **(1) fasting blood sugar test** 3-5 ml blood were collected in a vacutainer containing gel clot activator after fasting for about 8 to 12 hours (usually overnight), (2) **HBA1C test:** blood test was used to measures the mean level of blood sugar over the past 2:3 months. The HBA1C test was done at any time of day (pre or post the eating), levels between 5.7% and 6.4% was

suggested that the patient's cells weren't as sensitive to insulin as they should be, and suggested prediabetes while level higher than 6.5% is considered diabetes, **(3) HOMA-IR**: 3 mL blood was collected following overnight fasting for eight to twelve hours to evaluate the plasma glucose as well as concentrations of the insulin. HOMA-IR was calculated as fasted concentration of plasma insulin (mIU/L) × fasted concentration of plasma glucose (mmol/L)/22.5, patient with HOMA-IR levels ≥2.5 was considered to have IR, (4) **lipid profile**: total cholesterol, TGL, HDL-C, and LDL-C. The 1st three were evaluate utilizing enzymatic technique and, while LDL-C was described by utilizing the Fried Ewald formula.

Educational training about Aerobic exercise for study group:

- Patients in both groups were taken routine hospital care while the researchers started the protocol application and teach the patients in study group that were allocated to the actually research during their hospital stay after finishing acute stage.
- The researchers had trained the participated patients in the study group about the Aerobic exercise to confirm the patient's ability to make these exercises at home post discharge from the hospital. Training program was consisted of 5 sessions (the first two sessions were theoretical and the last three sessions were practical). The time of every session lasted thirty to forty-five minutes according to the participants awareness, in the 1st two sessions each participant was instructed individually regarding IR definition, its risk factors, symptoms, methods of diagnosis and treatment with focusing on aerobic exercises and its effect for non- diabetic heart failure patients by using video clips and printed booklet which was formulated by the researchers post revising relevant literature review as **(Apostolopoulos, et al., 2022) & (Arapça, et al., 2019)** and it was designed in a simple Arabic language that was developed and supported with photos and illustrations to help the patients and their caregivers understanding the content. The booklet composed of (insulin resistance (definition, causes, manifestation, difference between insulin resistance & diabetes mellitus, complications, diagnosis and methods of treatment) and exercise and heart failure, importance of exercises for patients with HF, types of exercise for patients with heart failure and phases of aerobic exercise for HF patients. Booklet was given to each participant in study group or the patient's caregiver, and after finished the study period the teaching program was given to control group.
- The last three sessions were the demonstration and re-demonstration of performing aerobic exercise that was done especially in the first two weeks during hospitalized period to ensure that the participants and their care-givers can follow this procedure perfectly after discharge from hospital, and during the follow-up period.
- For performing aerobic exercise in hospital, the standard twelve -lead electrocardiogram as well as blood pressure were frequently documented pre, during and post exercise.

types of exercises were depending upon personnel interests as well as their abilities. Each practical session contained 10 minutes of warm-up, thirty minutes of aerobic activity (for example walking as well as cycling) and 10 minutes of cool-down. The duration and intensity of the exercise were progressively increased throughout the 12-week period, according to the tolerance of each patient. The researchers instructed the patient about the indication for stopping the exercises which included chest discomfort composed of angina, life- arrhythmias threatening, depression ST-segment as well as a fall in systolic blood pressure from the preceding stage equal or more than20 mm Hg. After that, the researchers evaluated the patients to confirm their skills in this practice via the hospitalization period, the researchers followed patients via telephone interviews that was held every two weeks via the research period. Control group were instructed to control their usual style of their life. All participants in both groups were instructed not to change their usual diet.

Evaluation phase:

The follow-up and evaluation phase for both groups (study and control) was completed by face-to-face interviews using part three of tool I and part two of tool III at baseline, 8-weeks, and 12-weeks after applying the aerobic exercise for the study group to evaluate the effect of aerobic exercise on anthropometric measurement, laboratory investigations, and lowering IR so that the researchers encouraged the participants to attend follow-up appointments.

Statistical analysis

The statistical package for social sciences (SPSS) version 27 was used to arrange, classify, and analyze the collected data. For qualitative data were expressed as frequency and percentage. While quantitative variables were presented as mean and standard deviations. Inferential statistics such as paired t-test, chi-square test, and correlation r-test were used. When the p-value was less than 0.05 statistical significance was assumed.

Results of the research:

Table (1) reveals that the mean age for both the study and control groups were 53.5±9.1 and 54.7±9.6 respectively in which 45%, 35% respectively of the study participant; their age ranged between 50 to 59 years. According to gender, 72.5%, and 60% of both groups are male, meanwhile, 27.5% are able to read and write. In addition, 55%, and 52.5 % of the two groups are from urban areas. Moreover, 45% and 42.5% of both groups are married. Regarding their occupation, 27.5% of study group has **s**killed worker and 30% of control group has government work. There are no statistical significant differences between the study groups regarding data of socio-demographic.

Figure 1: illustrates that, 52.5% and 50% respectively of both groups; their ordinary physical activity ranges between one to two times/week pre-conducting aerobic exercise.

Figure 2: Illustrates that, 80% of study group become normal BMI post 12-week of aerobic exercises**,** in comparing with 47.5 % of the control group are obese.

Table 2. displays that, the mean scores of WC measurements for the study group decreases significantly from 96.9±11.2 at baseline to 84.2±6.76 post 12-week of aerobic exercises compared with the control group which is relatively constant. Concurrently, HC mean score of the study group reduced significantly from 118.8±13.9 at baseline to 102.3±20.5 post 12-week of aerobic exercises, by contrast to the control group has a significant increase from (119 ±13.9) at baseline to (120±15.8) post 12-week of aerobic exercises. In respect to, the waist-to-hip ratio, there is a significant reduced in mean score from 1.6±0.2 baseline to 0.656±0.94 post 12-week of aerobic exercises, compared with the control group. There are highly statistical significance differences between both groups regarding to the anthropometric measurement.

Table 3: depicts that, there was a slight decrease in the scores of the waistline over forty inches in male and thirty-five inches in female, as well as, the skin patches of IR in the study group from (50 % and 27.5%) respectively at baseline to (45% and 30%) respectively post 12-week of aerobic exercises, while, there is a significant increase in the control group from (60% and 80%) respectively at baseline to (80%, 90%) respectively post 12-week. There are a highly statistical significance differences among the two groups regarding the clinical manifestation of IR.

Table 4. represents statistical significant decrease in the results of the laboratory investigations indices for IR post- 12-week of aerobic exercises in study group compared with control group, there are statistical significant increase in the laboratory investigations indices for IR with a statistical significant differences between both groups.

Table 5: demonstrated that, there are statistical significant decrease in the results of the lipid profile indices for IR except HDL-C has statistical significant increase post 12-week of aerobic exercises among study group, compared with control group, there are statistical significant increase in all lipid profile indices for IR. There are statistical significant differences among the two groups in relation to lipid profile indices for IR.

Table 6: represents a statistical significant positive correlation between BMI and all laboratory investigations indices for IR among the study group patients except HDL-C has a negative correlation. Contrast to, the control group, there are statistical significant positive correlation between BMI and all laboratory investigations indices for IR.

Table 7: represents that, there are statistical significant positive correlation between WC and all laboratory investigations indices for IR among the study group patients except HDL-C has a negative correlation. Contrary to, the control group, has a statistical significant positive correlation between WC and all laboratory investigations indices for IR.

Table 1. Percentage Distribution of the Socio-Demographic Characteristics of the Study patients (n = 80)

Variables	Study group n=40		Control group n=40		Chi-Square	P
	N	%	N	%		
Gender						
Male	29	72.5	24	60.0	1.39	0.237
Female	11	27.5	16	40.0		
Age						
40-49	13	32.5	13	32.5	20.5	0.901
50-59	18	45.0	14	35.0		
60-69	6	15.0	9	22.5		
70 and more	3	7.5	4	10.0		
Mean ± SD	53.5±9.1		54.7±9.6			
Educational levels					1.54	0.908
Illiterate	11	27.5	10	25.0		
Read and write	11	27.5	11	27.5		
Diploma	10	25.0	10	25.0		
University and above	8	20.0	9	22.5		
Residence						
Rural	18	45.0	19	47.5	0.050	0.823
Urban	22	55.0	21	52.5		
Marital status:						
Single	8	20.0	5	12.5	1.72	0.632
Married	18	45.0	17	42.5		
Divorced/ separated	6	15.0	10	25.0		
Widow	8	20.0	8	20.0		
Occupation						
Retired	4	10.0	3	7.5	0.841	0.933
Skilled worker	11	27.5	9	22.5		
Government employee	10	25.0	12	30.0		
Farmer	8	20.0	7	17.5		
House wife	7	17.5	9	22.5		

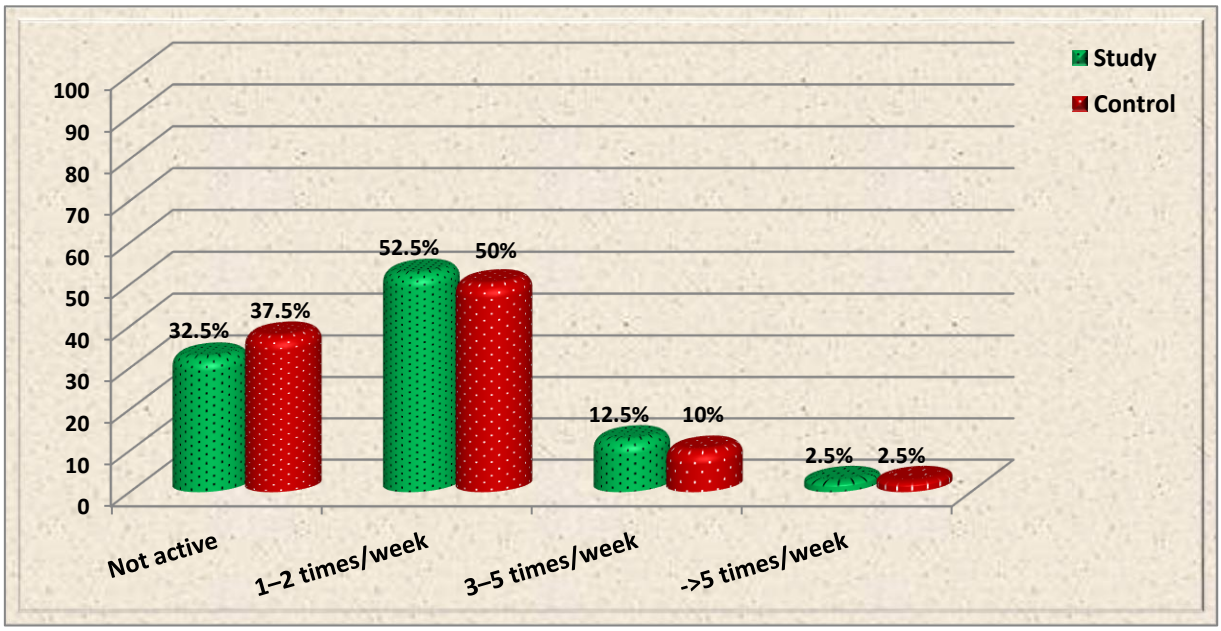

Figure 1: Percentages Distribution of the Two Groups Regarding to Their Baseline Ordinary Physical Activity (n = 80)

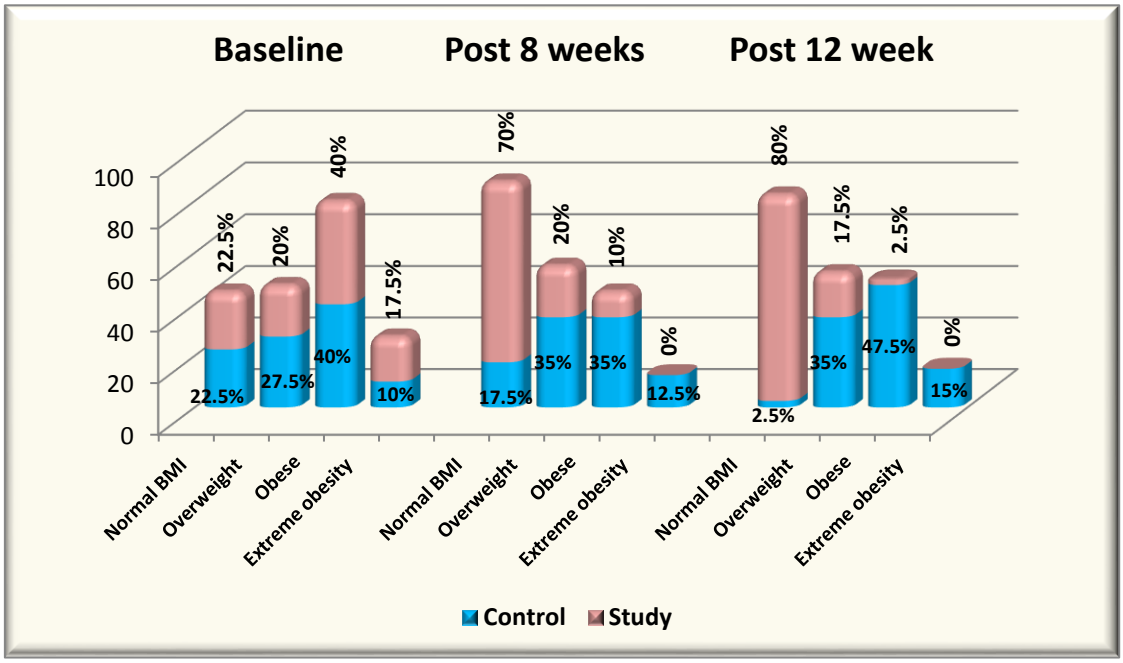

Figure 2: Comparison between both Study and Control Groups in relation to Body Mass Index (BMI) post 12- week of Aerobic Exercises (n = 80)

Table 2. Comparison between the two groups Regarding the Anthropometric Measurement at Baseline, post 8-week and 12-week of Aerobic Exercises (n = 80)

Variables	Study group n=40	Control group n=40	F^1	P-value
Waist Circumference				
Base line	96.9±11.2	96.3±11.9	**0.058**	**0.810**
8 weeks	89.2±7.87	96.8±12.1	**7.3**	**0.02***
12 weeks	84.2±6.76	96.7±12.7	**30.1**	**0.000****
F^2 (P value)	27.4 **(0.000**)**			
Hip circumference				
Base line	118.8±13.9	119.±13.9	**0.962**	**0.330**
8 weeks	115.6±19.8	119.±13.9	**8.10**	**0.01***
12 weeks	102.3±20.5	120.±15.8	**9.01**	**0.004****
F^2 (P value)	**30.7 (0.001**)**			
Waist-to-hip ratio				
Base line	1.6±0.2	1.03±0.23	**49.1**	**0.30**
8 weeks	0.762±0.99	1.1±0.21	**52.2**	**0.01***
12 weeks	0.656±0.94	1.09±0.22	**127.1**	**0.000****
F^2 (P value)	**7.57 (0.001**)**			

NS= not significant * p = ≤.05 (statistical significance) ** p = ≤.01 (highly statistical significance).

F^1: One Way Annova F^2: Repeated Measures Annova

Table 3. Comparison Between the Study and Control Groups Regarding the Clinical manifestation of IR at Baseline and Post 12-Week of Aerobic Exercises (n = 80)

Variables	Study group n=40		Control group n=40		Chi	P value
	no (%)	no (%)	no (%)	no (%)		
	Yes	NO	Yes	NO		
A waistline over forty inches in male and thirty-five inches in female						
Base line	20 (50)	20 (50)	24 (60)	16 (40)	10.45	0.001**
12 weeks	22 (55)	18 (45)	32 (80)	8 (20)		
Skin patches –dark, velvety skin named acanthosis Nigerians on the neck, groin as well as armpits						
Base line	29 (72.5)	11 (27.5)	32 (80)	8 (20)	3.20	0.047*
12 weeks	30 (70)	10 (30)	36 (90)	4 (10)		

NS= not significant * p = ≤.05 (statistical significance) ** p = ≤.01 (highly statistical significance).

Table 4. Comparison Between the two Groups in relation to the Laboratory Investigations Indices for IR at Baseline, 8-week and Post 12-Week of Aerobic Exercises (n=80)

Variables	Study group n=40	Control group n=40	F^1	P
Fasting Blood Sugar (mg/dl)				
Base line	128.8±28.7	136.5±27.1	1.52	0.220
8 weeks	95.3±4.8	128.3±24.4	7.09	0.05*
12 weeks	86.1±6.3	137.8±27.9	13.1	0.001**
F^2 (P value)	179.2 (0.001**)			
Insulin (mIU/L)				
Base line	8.1±1.9	8.6.±1.7	1.30	0.257
8 weeks	5.5±1.4	9.2.±1.4	126.2	0.02*
12 weeks	3.6±0.7	9.5.±1.1	868.1	0.001**
F^2 (P value)	22.3 (0.000**)			
HOMA-IR				
Base line	1.977±0.52	1.96±0.52	0.022	0.882
8 weeks	1.050±0.354	2.3±0.56	141.8	0.01*
12 weeks	0.813±0.26	2.4±0.46	361.1	0.001**
F^2 (P value)	10.4 (0.001**)			
Insulin: Glucose Ratio				
Base line	25.8±5.6	24.1±4.3	2.47	0.121
8 weeks	24.4±4.2	24.3±4.5	2.99	0.088
12 weeks	23.5±3.8	24.4±4.4	8.11	0.006**
F^2 (P value)	3..88 (0.05*)			
Hemoglobin A1c Test				
Base line	6.5±1.06	6.9± 1.3	2.81	0.098
8 weeks	6.5±1.06	6.9± 1.3	2.81	0.098
12 weeks	5.5±.053	6.9± 1.3	43.1	0.001**
F^2 (P value)	36.1 (0.000**)			

F^1: One Way Annova **F^2: Repeated Measures Annova**

NS= not significant * p = ≤.05 (statistical significance) ** p = ≤.01 (highly statistical significance).

Table 5. Comparison Between the Study and Control Groups Regarding the Lipid Profile Indices for IR at Baseline, 8-week and Post 12-Week of Aerobic Exercises (n=80)

Variables	Study group n=40	Control group n=40	F^1	P
Total cholesterol, mmol/L				
Base line	223±20.3	232±31.9	2.19	0.142
8 weeks	191.3±158.5	248±28.8	5.02	0.028*
12 weeks	102.7±20.5	259±22.8	103.9	0.000**
F^2 (P value)	8.10 (0.001**)			
Triglycerides, mmol/L				
Base line	247.2±48.4	236.6±53.1	0.930	0.338
8 weeks	141.8±36.6	263±37.1	217.6	0.01*
12 weeks	194.7±46.9	241.3±44.8	20.5	0.000**
F^2 (P value)	14.5 (0.001**)			
HDL-C, mmol/L				
Base line	19.3±6.7	20.1±7.1	0.164	0.686
8 weeks	51.6±14.6	20.6±6.5	110.2	0.03*
12 weeks	52.5±15.1	19.8±6.4	157.7	0.001**
F^2 (P value)	38.1 (0.000**)			
LDL-C, mmol/L				
Base line	210.8±65.1	211.7±53.5	0.004	0.948
8 weeks	61.6±15.8	217.1±53.6	140.1	0.01*
12 weeks	39.8±15.5	217.6±63.1	299.6	0.001**
F^2 (P value)	33.3 (0.001**)			
LP-IR, Lipoprotein Insulin Resistance Index				
Base line	85.2±10.8	85.8±10.8	0.066	0.797
8 weeks	35.7±5.4	87.1±8.1	109.1	0.04*
12 weeks	7.72±4.6	89.2±9.6	229.7	0.001**
F^2 (P value)	57.4 (0.000**)			

F^1: One Way Annova F^2: Repeated Measures Annova

NS= not significant * p = ≤.05 (statistical significance) ** p = ≤.01 (highly statistical significance).

Table 6. Correlation Between Body Mass Index and Laboratory Investigations among The Study Groups (N=80)

Lab Investigations	Body Mass Index			
	Study group n=40		Control group n=40	
	r	p	r	P
Fasting Blood Sugar (mg/dl)	0.398	0.011*	0.067	0.680
Insulin (mIU/L)	0.309	0.050*	0.115	0.481
HOMA-IR	0.479	0.002**	0.034	0.833
Hemoglobin A1c Test	0.364	0.029*	0.177	0.275
Total cholesterol, mmol/L	0.357	0.024*	0.190	0.239
Triglycerides, mmol/L	0.347	0.028*	0.012	0.941
HDL-C, mmol/L	- 0.340	0.032*	0.035	0.831
LDL-C, mmol/L	0.292	0.046*	0.179	0.270
LP-IR, Lipoprotein Insulin Resistance Index	0.483	0.002**	0.031	0.850

NS= not significant * p = ≤.05 (statistical significance) ** p = ≤.01 (highly statistical significance).

Table 7. Correlation Between WC and Laboratory Investigations Indices for IR among the study Groups (N=80)

Lab Investigations	Waist Circumference			
	Study group n=40		Control group n=40	
	r	p	r	P
Fasting Blood Sugar (mg/dl)	0.961	0.009**	0.171	0.291
Insulin (mIU/L)	0.340	0.032*	0.065	0.688
HOMA-IR	0.135	0.345	0.049	0.763
A1c Test	0.163	0.315	0.240	0.135
Total cholesterol, mmol/L	0.301	0.05*	0.091	0.578
Triglycerides, mmol/L	0.719	0.032*	0.031	0.850
HDL-C, mmol/L	- 0.479	0.002**	0.021	0.900
-LDL-C, mmol/L	0.381	0.015*	0.147	0.367
LP-IR, Lipoprotein Insulin Resistance Index	0.483	0.002**	0.285	0.075

NS= not significant * p = ≤.05 (statistical significance) ** p = ≤.01 (highly statistical significance).

Discussion

According to the socio-demographic data current research results displayed that the mean age of the both groups (study and control) was virtually equal 53.5±9.1 and 54.7±9.6 respectively, this could be due to HF and IR tend to increase with age. This result was agreed with **McHorney et al. (2021),** who confirmed that the mean age of the study sample was (59.3±8), regarding to gender; it was found that more than half of the studied groups were male, the researchers interpreted this that male's bodies may require higher levels of insulin to regulate blood glucose levels. This may be due to a variety of factors, including differences in body composition, metabolism, and hormonal profiles so they more risk for occurrence of IR. This consistent with, **Al-Jarallah et al. (2020)** who reported that the majority (76.0%) of the study sample were male while females constituted 24.0% of it. As well as, **Julián et al. (2020)** described that 78.5% of the studied sample is male. In addition, **Gao et al. (2019)** who reported that the incidence of HF was higher in men, among the 5.1 million cases of HF, 52.9% were male while 47.1% were female.

In respect to BMI, the findings of the actually research demonstrated that nearly fifty percent of both groups were obese according to BMI measurement before the application of aerobic exercises training, and after 12 weeks, the majority of the study group became with normal BMI while, there wasn't improvement in the control group. The researchers' opinion was that, Egyptian people depend on carbohydrates like bread and rice in their eating while, exercise concepts are not manipulated for them, all of these leads to obesity. On the other hand, aerobic exercise can help to increase muscle mass, as well as overall muscles strength and mobility, which can improve IR. This can be particularly important for HF patients who may have reduced muscle mass due to their condition and low physical activities. These research findings were supported by **Parcha et al. (2022); Kumar et al. (2019),** who stated that aerobic exercise can have a positive effect on BMI of obese HF patients, as well as, aerobic exercise can help these patients lose weight and improve their cardiovascular health functions, which can lead to better outcomes.

Concerning the anthropometric measurements (WC, HC, as well as WHR) indices for IR, findings of the present study reflected that all anthropometric measurements decreased from baseline to 12-weeks of aerobic exercises in the study group while increasing in the control group. In the researchers' opinion, aerobic exercise has been shown to have beneficial effects on anthropometric measurements, which may contribute to improvements in IR. Insulin is a strong anabolic hormone that controls glucose, lipid homeostasis, and energy storage. As a result, the liver and skeletal muscles store glycogen and triglycerides, and fat is deposited in adipose tissue. However, IR prevents the anabolic metabolic benefits of insulin-sensitive tissues. In this respect, **Ren et al. (2016),** said that one of the most potent signs of insulin resistance is central fat. The three useful metrics for central obesity are WC, WHR, and WHR. According to studies, those with a higher WC have higher visceral fat as well as are more prone to chronic diseases brought on by IR than people with a low in the WC as well as the like BMI. Moreover, in the same line, the study conducted by **Ampuero et al. (2023),** who demonstrated that numerous articles have demonstrated the crucial independent impact of aerobic and concurrent physical activities on lipid profile, fitness, and lowering body fat mass. Furthermore, **Lee et al. (2017) and Shepherd et al. (2017),** added that how the evaluated different adiposity metrics related to one another. BMI, WC, total lean mass, total mass of fat, mass leg fat, mass arm fat, as well as mass trunk fat were the adiposity indicators included in our studies. **Finally, Abdelhamid (2017)** indicated that patients' BMI significantly increased while they stayed inactive without exercise training.

Regarding the laboratory investigations indices for IR, the research data revealed an improvement in the results of the laboratory investigations (FBG, HOMA-IR, insulin-glucose ratio, and HBA1C test) post twelve weeks of aerobic exercise training for the study group compared with the control group. According to the researchers' opinion were that; regular aerobic exercise is a key component of a healthy lifestyle and it is a primary low-cost, and safe prevention strategy for metabolic disorders and heart failure. These results were in context with, **Abdelhamid, (2017)** and **Ren et al. (2016)** who indicated that blood sugar, and HOMA-IR was significantly increased while the patients stayed inactive without exercise training, so they displayed that, aerobic exercise can lead to reductions in body fat, particularly visceral fat (fat stored around the organs in the abdomen), which was strongly associated with IR and metabolic disorders. Also, **Jerkins et al. (2023); Yang et al. (2022); Sticka et al. (2018)** noted that there was a drop in HbA1c seen after eight weeks of aerobic exercise training. In addition, **Collins et al. (2022)** showed that all exercise training groups significantly enhanced fasting insulin and HOMA-IR among traditional fasting makers of glycemic status. As well as, **Kumar et al. (2019)** reported that physical activity and aerobic exercise training provided a lot of benefits beyond glycemic control, involving lowering IR and improving the aerobic capacity, muscular strength, body composition, and

endothelial functioning. Moreover, **Hayes et al. (2020)** who reported that the study's key findings show that twelve weeks of aerobic exercise training had a positive effect on enhancement of fasting glucose, insulin, and HOMA1-IR.

Concerning blood lipid profile indices for IR the current research data revealed that there was a decrease in total cholesterol, triglycerides, LDL-C, and LP-IR, lipoprotein insulin resistance index while an increase in HDL-C, values post twelve weeks of aerobic exercise training in the study group when compared to the control group. In the researches' opinion, based on the review literature by **Sofra and Badami (2020)** clarified that dyslipidemia and visceral obesity are frequently present in patients with IR. Activation of lipoprotein lipase (LPL) by aerobic exercise can lead to a reduction in circulating levels of triglycerides and LDL-C, which are important risk factors for HF and IR. These findings were agreed with **Hsu et al. (2019)** who documented that aerobic exercises decrease LDL-C and Triglycerides (TG), concurrently with increasing HDL-C. Also, this was agreed with **Doewes et al. (2023**) who explained that aerobic exercise had a positive effect on TG, as well as cholesterol but raises HDL-C.

Regarding to the correlation between BMI, WC and laboratory investigations indices for IR, there was a positive statistically significant correlation (between low body weight, low WC and low laboratory investigations**)** but a negative statistically significant correlation with HDL-C among the study group participants. In the researchers' opinions higher BMI were generally associated with lower levels of HDL-C, which is considered to be protective against HF disease. This may be due to a number of factors, including impaired HDL metabolism, decreased physical activity, and genetic factors. These results were in line with **Ren et al. (2016)** who showed that IR and TG/HDL-C were related, and that the relationship persisted in the presence of, BMI WC, WHR, and WHR. This can lead to a reduction in circulating levels of triglycerides and LDL-C, and an increase in HDL-C. Furthermore, **Burger et al. (2023)** discussed that, although differences were bigger and more significant for HOMA-IR; WC and lipids were more significantly associated with HF than were HOMA-IR and lipids. The authors commented that, regular aerobic exercises training can lead to improvements in blood pressure, heart rate, and vascular function, all of which can contribute to a reduction in the risk of HF disease as well as IR.

Limitations of study:

- Patient's internal factors as fear from the injury, decreased of knowledge about importance of aerobic exercise, lack of self-discipline and motivation, or changing health status.
- Some external factors as (hurdles relating to weather, expense, friends/partner disinterest, and safety). So that the researchers performed a careful examination of the clinical history. To establish the probability of aerobic exercise-related cardiovascular disorders because of cardiovascular issues during exercise were risky, and when starting an aerobic exercise training program with patients who had HF and cardiac

comorbidities, two crucial clinical concerns were addressed in this instance: How could the researchers determine which exercise approach was the safest for the participated patients? and if they were a suitable candidate for a fitness program? also, the researchers examined the patients' motivation. Researchers and patients created reasonable objectives in order to stay motivated for continuing aerobic exercise training program.

- Cost of some laboratory investigations which didn't done in the hospital

Conclusion

Regular aerobic exercise training can help in reducing WC, BMI, and other anthropometric measurements and laboratory investigations. Overall, incorporating regular aerobic exercises training into the treatment plan for non-diabetic HF patients has the potential to provide numerous benefits for HF, with subsequently reducing IR.

Recommendations

- Educating the patient and family so they have a good understanding regarding the advantages of participating in an aerobic exercise training as essential strategy in controlling the risk of obesity and therefore, IR.
- Continuing education through hospitals and mass media about importance of aerobic exercise as an essential treatment for IR to improve ongoing surveillance and monitoring with relying on preventing the progression of IR and its consequences in heart failure patients.
- Replicated the study using a bigger sample from different geographic locations to gain universality of the results.

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