

COMPARISON OF HIGH INTENSITY INTERVAL TO MODERATE INTENSITY CONTINUOUS AEROBIC EXERCISE ON VENTILATORY MARKERS IN CORONARY HEART DISEASE PATIENTS: A RANDOMIZED CONTROLLED STUDY

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ABSTRACT

Objectives: This study aim was to compare the impacts of high intensity interval (HII) to moderate intensity continuous exercise (MIC) on ventilatory markers in patients with coronary heart disease (CHD).

Design: Twenty eight patients with mild to moderate CHD aged 50-60 years were selected for this study. They randomized to two groups, each group comprised of 14 patients, group I received a program of high intensity interval exercise (HII 3 times/week for 12 weeks) and group II received a program of moderate intensity continuous aerobic exercise (MIC 3 times/week for 12 weeks). The ventilatory marker changes (O_2P , slope of VE/VCO_2 and OUES) have been measured at the beginning and the end of the study.

Result: After 12 weeks of enrollment, HII group showed statistically significant improvement in O_2P but no significant changes in MIC group (21% with $p < 0.05$ versus 1% with $p > 0.05$). No significant differences appeared in VE/VCO_2 and OUES (pre- and post- program) in the two groups $p > 0.05$.

Conclusions: It was concluded that HII had greater improvements than MIC on ventilatory markers in patients with CHD in a short term (up to twelve weeks).

KEY WORDS: Coronary Heart Disease, High Intensity Interval Exercise, Moderate Intensity Continuous Exercise, Ventilatory Markers.

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Access this Article online

Quick Response code



DOI: 10.16965/ijpr.2017.126

International Journal of Physiotherapy and Research

ISSN 2321- 1822

www.ijmhr.org/ijpr.html

Received: 21-02-2017

Accepted: 03-04-2017

Peer Review: 22-02-2017

Published (O): 20-05-2017

Revised: None

Published (P): 11-06-2017

INTRODUCTION

Coronary heart disease is the commonest type of cardiovascular disease. It included a number

of diseases; myocardial infarction, angina (stable or unstable), ischemic heart disease and sudden arrest [1].

Cardiopulmonary exercise test has been more implemented in clinical assessment as it is a non-invasive method and able to recognize unknown lack of exercise endurance, these decisions were supported with respect to therapeutic interventions and helping prediction appreciate [2].

Maximal oxygen consumption (peak VO_2) is commonly the highest useable in the clinical and studies assessment as it is the ventilator expired gas variable which obtained during exercise testing. Although the normal recognized value of peak VO_2 , other cardiopulmonary exercise test variables like oxygen pulse (O_2P), oxygen uptake efficiency slope (OUES) and the slope of ventilation and carbon dioxide production ratio (VE/VCO_2 slope) were revealed as important values in studies and researches. The slope of VE/VCO_2 and OUES were appearing as a more predictive value than peak VO_2 in patients with cardiac disease, while a level of O_2P was regarded as a sign of myocardial ischemic [2]. Ventilatory changes during exercise training were identified as a clinical marker of cardiac disease, such as improvement of cardiovascular function in cardiac patients [3].

Some studies concentrated on the impacts of exercise on ventilatory markers and heart function involved slope of VE/VCO_2 , OUES and O_2P . Generally, exercise has been revealed to enhance ventilatory marker in patients with heart failure, the outcomes of these studies are slightly blended when coronary heart disease patients are assigned [4].

It was appeared that the program of HII enhanced aerobic tolerance more than the program of MIC, and so recommended that it would be more beneficial in cardiac patients [2,5].

It has shown that recent studies have evaluated the impacts of different intensities of aerobic training, performed by patients with coronary heart disease [6,7]. Also, a recent review has explained that HII program was more effective than continuous exercise program in patients with CHD [8].

The current study illustrated that different intensities of aerobic exercise could be able to enhance O_2P peak in patients with CHD [6]. In addition, models of aerobic exercise should be

assessed in patients with CHD and its effects in clinical record parameters.

Earlier studies have investigated the impacts of exercise on clinical record of VE/VCO_2 slope, OUES and O_2P [9]. Also, HII versus MIC on ventilatory markers are still indigent defined in patients with coronary heart disease (CHD). The hypothesis was that both HII and MIC would enhance the ventilatory markers in patients with CHD. Also, hypothesis were that no differences between HII and MIC.

Objectives: This study aim was to compare the impacts of high intensity interval exercise (HII) to moderate intensity continuous exercise (MIC) on ventilatory markers in patients with CHD.

MATERIALS AND METHODS

Subjects: Between April 2016 to July 2016, twenty eight patients with CHD were randomly selected for this study. These patients were diagnosed with mild to moderate CHD according to the American Heart Association standard criteria [10], aged 50-60 years, their ejection fraction (EF) greater than 50%. Acute myocardial infarction or revascularisation (<90 days), pacemakers, heart failure, musculoskeletal limitations and changes in medication are excluded from this study. The participant patients were selected from the cardiac rehabilitation unit, Cairo University Hospitals. The twenty eight patients were randomly classified into two groups; each group consisted of fourteen patients. The group I received (HII 3 times weekly / 12 weeks) and Group II received (MIC 3 times weekly / 12 weeks). This study was approved by the ethical committee of Physical Therapy Department, Cairo University Hospitals.

Study design: This study was a randomized controlled study. After selection of the patients an informed consent was taken from all patients that participated in the study, before starting the study all patients were informed about the aims, benefits and procedure of the study. Patients were assessed for ventilatory markers (peak VO_2 , slope of VE/VCO_2 , OUES and O_2P) before starting the study and at the end of 12 weeks by the same investigator who was blinded concerning the group to which each patient was appointed. Patients have been randomly assigned into two groups: HII and MIC.

Evaluation: Before and after the exercise intervention, cardiopulmonary exercise test (CPT) was applied. To determine each patient's threshold of tolerance the increments of work rate were subjected within 8–12 min, as beforehand explained [10]. Borg score was applied to evaluate the discerned effort. Ventilatory markers and HR were recorded every 20s.

To measure The O_2P , VO_2 was divided by HR and also recorded every 20s within CPT. the O_2P curve slopes were compared before and after the exercise program. Also, slope of VE/VCO_2 and OUES were recorded at the start and after 12 weeks of the program at the end of the study.

Treatment: Every CHD patient was consented to perform treadmill aerobic exercise, 3 times / week for 12 weeks. The group I received (HII 3 times/week) for twelve weeks, according to the following parameters; 5 minutes warm up, followed by 30 minutes of high intensity interval exercise with intensity lower (60% maxHR) and higher (90% maxHR) workloads were interchanged within 2min. Group II received (MIC 3 times/week) for twelve weeks, according to following parameters; 5 minutes warm up, followed by 30 minutes of continuous aerobic exercise with constant intensity at 70 to 75% of peak HR and 5 minutes cool down. The ECG measures were recorded by cardiologist every week to check exercise protocols. Also, these measures were obtained at the beginning and the end of the intervention.

Statistical Analysis: Descriptive statistics were applied with mean \pm SD. Baseline and clinical characteristics between the two groups were compared by unpaired *t*-test. It was investigated the changes of ventilatory markers at the end of the intervention using unpaired *t*-test between the groups and paired *t*-test within group, data analysis was applied by SPSS version 17.0 with statistical significance at *p*-value \leq 0.05.

RESULTS

Twenty eight patients (19 males & 9 females) with mild to moderate CHD were included in this study. Patients were randomized to HII (group I) and MIC (group II). At the start of the study, there was no statistically significant difference between the two groups in their ages, BMI, EF, medical diagnosis and treatment with

p-valued \leq 0.05. The baseline characteristics of all participating patients in the both groups are mentioned in table 1. These data clarified that the two groups had similar characteristics.

Table 1: Baseline characteristics between group I and group II.

| Items | Group I | Group II | p-value |
|--|-----------------|-----------------|---------|
| Baseline characteristics | | | |
| Male (%) | 71.4 | 64.3 | 0.8779 |
| Age (yrs) | 57.3 \pm 4.4 | 56.9 \pm 4.7 | 0.818 |
| Weight (Kg) | 80.7 \pm 5.7 | 79.2 \pm 7.6 | 0.5598 |
| Height (cm) | 170 \pm 2.3 | 171 \pm 3.6 | 0.3891 |
| Body mass index (Kg/m ²) | 27.68 \pm 3.3 | 27.08 \pm 3.6 | 0.6496 |
| Ejection fraction (%) | 63.7 \pm 12.3 | 62.5 \pm 10.6 | 0.5244 |
| Medical Diagnosis (%) | | | |
| Myocardial infarction | 57.1 | 64.3 | 0.5946 |
| Ischemic heart disease | 50 | 50 | 0.9998 |
| Medical Treatment (%) | | | |
| Coronary angioplasty | 85.7 | 78.6 | 0.3115 |
| Myocardial revascularization | 71.4 | 64.3 | 0.5664 |
| Significance at (<i>p</i> \leq 0.05) | | | |

The results of this study showed that the peak VO_2 and peak O_2P improved were statistically significant improved in group I (HII) *p*<0.05, while remaining stable in group II (MIC) *p*>0.05. But in ventilatory threshold, There was no statistically significant difference between the two groups in VO_2 and VE pre- and post- program. Also, there was no statistically significant improvement in slope of VE/VCO_2 and OUES in both groups. The percentage of change in O_2P for group (I) was 21%, whereas, in group (II) was 1%. Compared with recipients of (MIC) group II, recipients of (HII) group I had the significant improvement in O_2P (*p*<0.05). These results clarified that the HII was more effective in patients with coronary heart disease as mentioned in table 2.

Table 2: Ventilatory outcomes of CPT at ventilatory and peak threshold between group I & II.

| Items | Group I | | Group II | | p-value |
|---|----------------|------------------|----------------|----------------|---------|
| | Pre- | Post- | Pre- | Post- | |
| Cardiopulmonary Exercise Test (CPT) | | | | | |
| Ventilation (L/min) | 46 \pm 11 | 54 \pm 14 | 45 \pm 12 | 49 \pm 13 | 0.3365 |
| VO_{2peak} (mL Kg ⁻¹ min ⁻¹) | 21.2 \pm 6 | 25.6 \pm 5.4* | 21.5 \pm 6 | 21.7 \pm 4.4 | 0.0461* |
| Oxygen pulse (mL/beat) | 12.3 \pm 3.3 | 14.9 \pm 2.02* | 12.2 \pm 3 | 12.3 \pm 2.4 | 0.0459* |
| VE/VCO_2 slope | 28.1 \pm 5.6 | 27.3 \pm 4.3 | 27.8 \pm 5.2 | 26.9 \pm 3.5 | 0.7893 |
| OUES | 1.8 \pm 0.7 | 1.9 \pm 0.5 | 1.8 \pm 0.4 | 1.9 \pm 0.8 | 0.9878 |
| Respiratory exchange ratio | 1.03 \pm 0.2 | 1.02 \pm 0.2 | 1.04 \pm 0.1 | 1.06 \pm 0.1 | 0.5092 |
| Heart Rate (bpm) | 121 \pm 17 | 122 \pm 29 | 123 \pm 15 | 124 \pm 22 | 0.8387 |
| SBP (mmHg) | 178 \pm 32 | 172 \pm 29 | 175 \pm 39 | 155 \pm 41 | 0.2165 |
| DBP (mmHg) | 78 \pm 8 | 71 \pm 7 | 77 \pm 7 | 70 \pm 18 | 0.8479 |
| Perceived exertion | 18 \pm 1.6 | 19 \pm 2.1 | 17 \pm 2.9 | 18 \pm 1.4 | 0.1502 |
| Ventilatory threshold | | | | | |
| Ventilation (L/min) | 21.1 \pm 5.6 | 24.4 \pm 5.8 | 22.4 \pm 4.6 | 21.3 \pm 5.5 | 0.1587 |
| VO_{2peak} (mL Kg ⁻¹ min ⁻¹) | 13.3 \pm 2.9 | 14.6 \pm 2.5 | 13.6 \pm 2.6 | 13.1 \pm 2.8 | 0.1469 |
| Oxygen pulse (mL/beat) | 11.3 \pm 2.3 | 12.1 \pm 2.9 | 11.1 \pm 2.4 | 10.7 \pm 2.7 | 0.1977 |
| *Significance at <i>P</i> \leq 0.05 | | | | | |

This study assessed the impacts of (HII) and (MIC) on ventilatory markers in patients with mild to moderate CHD. Compared HII group to MIC group, significant results were obtained in VO_2 peak and O_2P in HII group.

The main findings of this study were that cardiopulmonary functions (peak VO_2 and O_2P) in patients with CHD were significantly greater improved in the HII group when compared to MIC group. Also, slope of O_2P exercise related differences were noticed in the HII group showed to be greater in high intensity versus lower intensity exercise (above 70% of cardiopulmonary exercise test duration).

In agreement with this study results, a randomized controlled study done by Anderson, 2016 [11] approved similar results when comparing the effect of HII to MIC on HF patients that the high intensity exercise may be an a great agent for enhancing aerobic capacity and both HII and MIC had improved quality of life in patients with HF.

Similar results were obtained by Gustavo et al. 2015 [12] approved that HII was better impact than MIC to enhance O_2P in patients with CHD. But the two groups HII and MIC had a similar effect to improve the slope of VE/VCO_2 and OUES.

Also, Taylor et al. 2004 [13] concluded in their review that moderate intensity aerobic exercise may be wasn't enough to improve the VO_2 peak in CHD patients actually acquires less than 1MET have been established. Taylor study is consistent with the present study results, explained that HII was effective, but MIC wasn't efficient to increase the aerobic fitness in CHD patients.

In contrast to this study results, Conraads et al. 2015 [14] approved that HII and MIC resulted in influential and alike improvement in VO_2 peak. But their study duration mean of aerobic exercise in MI group was 47 minutes when compare nearly 30 minutes in the present study, and number of patients were eighty nine versus 28 in this study. These causes could be resulted in shortage of improvement in VO_2 peak, which noticed in this study for MI group.

O_2P response is identified with myocardial ischemia in CHD patients [15] and greater responses is allied with a high prognosis in HF

patients [16].

O_2P peak changes which caused by the HII exercise program were only noticed in intensity above 70% of maximal CPT. This result explained that the satisfying time of diastolic and ejection time of systolic lowered progressively when increased exercise intensity [17]. This diminishing of O_2P may result in a flattening of stroke volume [18], considering it as specifically recorded in patients with impairment in ventricular function [19].

On the other hand, the present study evoked that diastolic stuffing and emptying of the ventricles are enhanced in endurance exercised patients, resulting in advanced improving of stroke volume during training [20,21]. Briefly, stroke volume improvements within the exercise training would be related to improved diastolic stuffing and ventricular emptying.

Hence, it is possible to theorize that the HII was only capable of improving diastolic stuffing and ventricular clearing at intensities of exercise reaching maximal HR, feasibly more than ventilatory entrance. The results of this study vouch for more evaluations analyzing the impacts of HII and MIC on O_2P at sub maximal workloads, and likewise analyzing its physiological mechanisms in different stages of CHD.

In disagreement with current study results, the previous studies had provided enhancements of ventilatory efficiency after HII exercise program, results abide blended and disputable, with many researches showing particular marker enhancements, but no improvement in other variables [3,22]. No differences were found after training in slope of VE/VCO_2 and OUES in the present study. This result was unsuited with previous research in patients with HF [23,24].

Several interpretations explained the non significant change in slope of VE/VCO_2 and OUES in the present study results. Firstly, in the present study all patients with heart failure were excluded. Also, all of the patients in the study were stable at intervention time with ejection fraction means of nearly 63%. VE/VCO_2 slope and OUES means at the beginning of the study were approximately (27.5 and 1.8) for all patients, which were under the common measures for high risk (typically more than 34 for slope of

VE/VCO₂ and less than 1.4 for OUES) and less than measures taken by researches providing an enhancements of the variables in consequences of exercise training [24-26].

So, it is probable to believe that the patients in this study had low rank to demonstrate efficient ventilatory gains than subjects with a severe level comprised in earlier studies.

Finally, the results of this study provided that HII had greater improvements in VO₂peak and O₂P than the MIC. But there were no differences between the both groups in their effects on VE/VCO₂ slope and OUES.

Limitations:

The present study investigations included a small sample. This sample included patients with only mild or moderate CHD. Also, EF with approximately 63% may cause the inclined effects of exercise on ventilatory variables. In the present study more ventilatory variables of ventricular function, lung perfusion and arterial blood gases were needed to determine the underlying mechanisms of the impact of exercise on stroke volume and ventilatory competence which were not obtained in this study.

CONCLUSION

It was concluded that HII had greater improvements in VO₂peak and O₂P than the MIC. But there were no differences between the both groups in their effects on VE/VCO₂ slope and OUES in patients with CHD in a short term (up to twelve weeks).

ACKNOWLEDGEMENT

The authors thank all patients who participated in this study.

Conflicts of interest: None

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How to cite this article:

Walid Kamal M. Abd Elbasset, Shereen H. Elsayed, Tamer I. Abo Elyazed. COMPARISON OF HIGH INTENSITY INTERVAL TO MODERATE INTENSITY CONTINUOUS AEROBIC EXERCISE ON VENTILATORY MARKERS IN CORONARY HEART DISEASE PATIENTS: A RANDOMIZED CONTROLLED STUDY. *Int J Physiother Res* 2017;5(3):2013-2018. DOI: 10.16965/ijpr.2017.126