Comparison of Time-Related Changes between Body Weight and Subsequent Effects of Supervised Cardiac Rehabilitation in Patients with Acute Myocardial Infarction

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ABSTRACT

Objective: We studied what factors can be used to predict the subsequent effects on anaerobic threshold (AT) post supervised cardiac rehabilitation program in patients who had suffered an acute myocardial infarction (AMI). **Materials and Methods:** Nety-four patients were asked to continue home-based exercise training after eight weeks of supervised exercise training. Exercise tests were performed at three stages including pre-training, post-training and sixth month post training. **Results:** There were two different time-related AT changes. In the incremental group (n=39), the AT value increased lineally from1.08±0.19 watt/kg at the post-training stage to1.23±0.32 watts/kg at sixth month after training ($p<0.05$). In the decrescent group (n=55), the AT value was an inverted V curve with a peak of 1.16±0.18 watts/kg at the post-training stage. Body mass index (BMI) for the incremental group decreased from 23.7±2.2 kg/m^2 to 23.3±2.7 kg/m^2, while BMI increased from 23.6±2.7 kg/m^2 to 23.8±2.7 kg/m^2. The percentage of patient compliance with an ongoing continuous home-based exercise training was higher in the incremental group than in the decrescent group (85% Vs 65%, $p<0.05$). **Conclusion:** Body weight alternations were converse to the subsequent AT value after supervised cardiac rehabilitation and were partially associated with continuous home-based exercise training. (***Tzu Chi Med J*** 2001; **13**:203-209)

Key words: body mass index, anaerobic threshold, acute myocardial infarction, supervised cardiac rehabilitation, home-based exercise training

INTRODUCTION

Previous studies have reported that patients who suffered from an acute myocardial infarction (AMI) and participated in a supervised cardiac rehabilitation program demonstrated improvement in exercise capacity and a decreased likelihood of further cardiac events [1-5]. Long-term supervised cardiac rehabilitation, however, is unrealistic because of increased costs. Patients usually decrease their exercise capacity after the completion of supervised cardiac rehabilitation. This study was designed to find out whether certain important factors including body weight changes, the severity of coronary artery disease (CAD) prior to this program, the timing of percutaneous transluminal angioplasty (PTCA), and the prevalence of risk factors for CAD can be used to predict the subsequent effects after the completion of supervised cardiac rehabilitation program.

MATERIALS AND METHODS

Study population

This study included 104 men who were admitted to

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our hospital because of AMI from February 1996 to March 1998. The criteria for the diagnosis of AMI included ischemic chest pain, relevant electrocardiographic (ECG) findings, and elevated serum cardiac enzymes. Patients received coronary angiography to evaluate coronary lesions on the seventh day after AMI and those who agreed to participate in this supervised cardiac rehabilitation program were enrolled in this study. Patients who had undergone coronary artery bypass surgery (CABG) were excluded from this study. Patients with heart failure (left ventricular ejection fraction < 40%), peripheral vascular disease, stroke, and chronic obstructive pulmonary disease were also excluded.

Protocol

This program was performed under regular medication and no medication was changed throughout the program. The exercise was stopped whenever exercise-induced ischemic symptoms and/or signs appeared, or patients were unable to continue the exercise due to reported fatigue. ECG was monitored and blood pressure was measured every three minutes throughout the exercise. PTCA was performed if myocardial ischemia was documented, while patients were asked to continue exercise training on the third day post PTCA.

Supervised cardiac rehabilitation program

This supervised exercise training program consisted of two phases. Phase I was conducted at the acute stage of AMI during hospitalization, and involved low-intensity exercise such as stretching and/or walking under ischemic monitoring. Phase II was performed on an outpatient basis and began 20th day after AMI and continued for eight weeks at a frequency of three times per week. The procedure was comprised of three parts. The first part, the warm-up, consisted of stretch and aerobic exercise for 15 minutes. The second part, the principal exercise training component, lasted for 20 minutes using an ergometer with the exercise intensity as specified by the target heart rate at the anaerobic threshold (AT) point which was individually determined. The final part, the cooling-down component, consisted of stretch exercises for another 10 minutes.

To enhance the benefits of this supervised cardiac rehabilitation, life-style modification such as risk factor control was given to all patients in the first 4 weeks.

Following phase II, all patients were asked to continue the home-based exercise training by themselves with the exercise formula prescribed according to the results of phase II.

Exercise tests

Exercise tests were done utilizing a breath-by-breath gas exchange analyzer (Minato AE-280S, Tokyo, Japan) which was connected to a ramp programmed cycleergometer (Combi 232C, Tokyo, Japan). Patients were tested at three stages including pre-training, post-training and sixth month after completion of training. The intensity of exercise testing started at 25 watts and increased by 1 watt every six seconds. The AT value of a patient was determined using a V-slope method [6]. Patients breathed through a mouthpiece connected to a turbine flowmeter for continuous measurement of CO_2 output and O_2 uptake during exercise. The computerized regression analysis of the slope of these data was used to detect when the beginning of the CO_2 output increase departed from a linear relationship with O_2 uptake, defined as the AT point.

A questionnaire was used inquiring about smoking habits, the compliance with the home-based exercise training including frequency per week and duration of each exercise, whether the patient had resumed work, and whether chest pain reappeared during exercise at sixth month post the completion of training.

Coronary stenosis was defined as a coronary obstruction larger than 50% of the vessel lumen as assessed from coronary angiograms. Left ventricular ejection fraction (LVEF) was calculated from left ventriculograms.

Statistical analysis

Data were collected and analyzed with a Statistical Package for the Social Sciences (SPSS for Windows 8.0, SPSS Inc., Chicago, IL., USA). A paired Student's t-test was used to analyze the differences of AT and body mass index (BMI) of patients at various stages in this program. The continuous variables corresponding to the different groups were analyzed by Student's t-test and categorical variables were analyzed by chi-square test. A p value of less than 0.05 was considered statistically significant.

RESULTS

There were 104 men (mean age 58.8±8.8 years) enrolled in this study. Ten patients did not undergo repeat exercise test and clinical assessment follow-up at sixth month after completion of this program including 7 patients who underwent emergency CABG because acute coronary syndrome occurred during PTCA and 3 who did not comply with this program. The remaining 94 patients who had AT values which increased at the post-training stage were followed up until six months after completion of training.

Eight weeks of phase II exercise training, significantly, increased the mean AT value from 0.94±0.19 watts/kg to 1.11±0.19 watts/kg ($p<0.05$).

Two different time-related AT value curves for these 94 patients are shown in the Fig. 1. There were 39 patients whose AT changes increased linearly from the pre-training stage to the sixth month after completion of training (the incremental group), and 55 patients whose AT changes presented as an inverted V curve with the peak at the post-training stage (the decrescent group). The decrescent group had a larger AT than that of the incremental group at the post-training stage (1.16±0.18 Vs 1.07±0.19 watts/kg, $p<0.05$) and a smaller AT than that of the incremental group at the sixth month after completion of training (1.00±0.17 watts/kg Vs 1.18±0.32 watts/kg, $p<0.05$), although there was no significant difference in AT value at the pre-training stage between the decrescent and incremental groups (0.93±0.18 watts/kg Vs 0.90±0.18 watts/kg, respectively). In contrast to these time-related AT value curves, the time-related BMI curve revealed that the BMI for the incremental group decreased from 23.7±2.2 kg/m^2 at the post-training stage to 23.3±2.7 kg/m^2 at the sixth month after completion of training ($p<0.05$) and the mean BMI decreased by 0.4±1.2 kg/m^2. In the decrescent group, the mean AT increased from 23.6±2.7 kg/m^2 to 23.8±2.7 kg/m^2 ($p<0.05$) and the mean BMI increased by 0.3±0.9 kg/m^2.

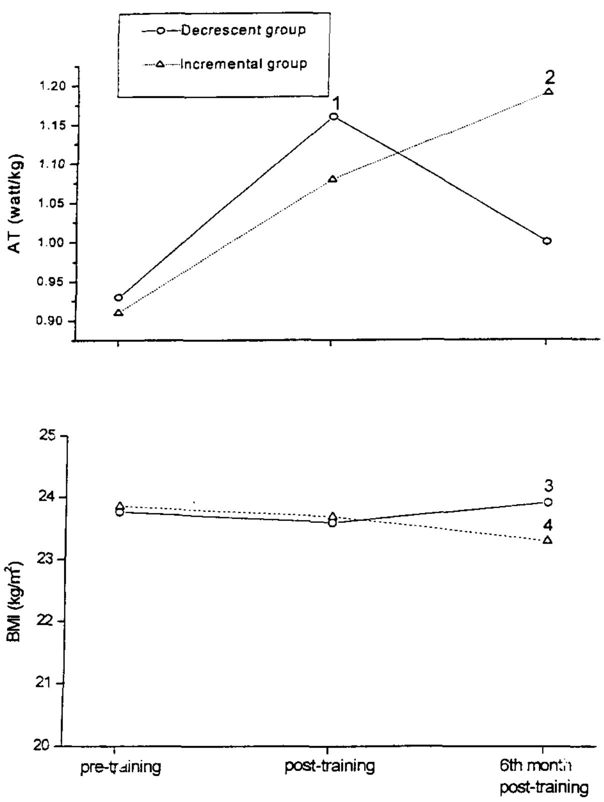

Fig. 1. Mean of the anaerobic threshold (AT) and body mass index (BMI) at three stages, pre-training, post-training and sixth month after the completion of training. The triangle indicate incremental group and circle indicate decrescent group.
1 : Significant difference ($p<0.05$) between the decrescent and incremental groups at the post-training stage.
2 : Significant difference ($p<0.05$) between the incremental and decrescent groups at sixth month after completion of training.
3 : Significant difference ($p<0.05$) between the sixth month post-training and post-training stages for the decrescent group.
4 : Significant difference ($p<0.05$) between the sixth month post-training and post-training stages for the incremental group.

The Table 1 depicts baseline clinical data for both groups. The decrescent group had a larger prevalence of cigarette smoking and family history of CAD than the incremental group (87% Vs 66%, $p<0.05$; 33% Vs 15%, $p<0.05$; respectively). All patients gave up smoking at the end of phase II, and the questionnaire revealed that none of the patients smoked at the sixth month after completion of training. There were no significant differences in the baseline mean age, BMI, LVEF, the prevalence of hypertension, diabetes mellitus, and hyperlipidemia between these two groups.

The mean number of stenotic coronary arteriores in the decrescent group was 1.54±0.69, whereas there were only 1.15±0.43 in the incremental group ($p<0.001$). The number of patients with one, two, or three stenotic coronary arteries was 34, 4 and 1 for the incremental group, and 31, 8 and 6 for the decrescent group. These results indicate that the severity of coronary stenosis was higher in the decrescent group than in the incremental group ($\chi^2=10.191$, $p=0.006$).

A total of 70 patients in this study had documented exercise-induced myocardial ischemia and they received PTCA treatment. The decrescent group had a higher percentage of patients who accepted PTCA than the incremental group (84% Vs 62%, $p<0.05$). These 70 patients included 22 during phase I and 48 during phase II of this supervised cardiac rehabilitation program. In the incremental group, 24 of 39 patients (62%) underwent PTCA, 12 (31%) during phase I and 12 (31%) during phase II. In the decrescent group, 46 of 55 patients (84%) received PTCA, 10 (18%) during phase I and 36 (66%) during phase II. These results indicate the percentage of patients who received PTCA in phase II was larger in the decrescent group than in the incremental group ($\chi^2=11.285$, $p=0.004$).

Table 1. A Comparison of Baseline Clinical Data for Incremental and Decrescent Groups

	Incremental group (n=39)	Decrescent group (n=55)
Mean age (years)	58.80±9.00	59.00±9.10
Hypertension(%)	62.00	55.00
Diabetes mellitus(%)	33.00	27.00
Hyperlipidemia(%)	38.00	36.00
BMI (Kg/m^2)	23.80±2.60	23.70±2.80
Smoking(%)	67.00	87.00*
Family history(%)	15.00	33.00*
Coronary stenosis(number)	1.15± 0.43	1.54±0.69**
LVEF(%)	50.60±10.10	52.10±8.30
PTCA therapy(%)	62.00	84.00*
During phase I	31.00	18.00
During phase II	31.00	66.00*

* : p< 0.050 Vs incremental group; ** : p<0.001 Vs incremental group;
LVEF: left ventricular ejection fraction; PTCA: percutaneous transluminal coronary angioplasty

The percentage of patient compliance with ongoing continuous home-based exercise training and patient resumed work was slightly higher in the incremental group than in the decrescent group (85% Vs 65%, p<0.05; 82% Vs 78%, respectively).

DISCUSSION

A supervised cardiac rehabilitation program not only increases a patient's exercise capacity and reduces the influence of risk factors for further cardiac events but also improves the quality of life and promotes the long term survival of AMI patients [1,2,4,5,7]. Moreover, the program described herein is performed under medically-supervised exercise conditions, and is a safe and effective program for cardiac rehabilitation. This type of comprehensive rehabilitation program has been demonstrated to exert a positive effect upon physical condition, appropriate life-habit changes and the cardiac health of AMI patients [8]. Thus, a supervised cardiac rehabilitation program should be considered an integral part of comprehensive cardiac care [9,10].

The AT value is an extraordinary point of change in physical response during exercise [6]. This threshold is considered a critical point for the increase of blood lactic acid production. It signifies an increasing reliance upon anaerobic metabolism, that is, oxygen transport during exercise becomes insufficient to meet demand. It has been suggested that the AT represents the minimal intensity level necessary for electing exercise-training adaptation in clinical treatment [11]. Published data reveal that the AT in healthy people and patients is a highly reproducible, accurately measurable and securely achievable parameter for non-invasive evaluation of an individual's cardiopulmonary exercise capacity [12]. From these results, it appears appropriate to use the AT as a surrogate for exercise capacity in this study.

This study revealed that eight weeks of exercise training improved the AT value for all AMI patients compared to that at pre-training stage. Two different time-related AT value curves, as seen in the incremental and decrescent groups, were observed after six months of a home-based exercise training.

The prevalence of cigarette-smoking was greater in the decrescent group than in the incremental group at admission, but all patients gave up smoking during supervised cardiac rehabilitation program. No patient had started smoking again during the six-month period after training. The prevalence of family history of CAD was greater in the decrescent group than in the incremental group. This study documented that the increase in the AT value was larger in the decrescent group than in the incremental group at the post-training stage, while patients in the decrescent group had more severe coronary stenosis than those in the incremental group. These results suggest that cigarette-smoking and a family history of CAD may be associated with the severity of CAD but not a factor that may cause this difference in the time-related AT change between these two groups [13-15].

Severe coronary stenosis may affect the AT value through ischemic cardiomyopathy and / or exercise-induced myocardial ischemia. Francis reported that regardless of the severity of CAD, the therapeutic effects of supervised cardiac rehabilitation are more desirable than those of non-supervised cardiac rehabilitation [16]. In this study, there was no difference in cardiac function between these two groups, although patients in the decrescent group reflected more severe coronary stenosis than those in the incremental group. All exercise-induced myocardial ischemia-related coronary stenosis were treated with PTCA during program. Thus, the severity of CAD prior to the supervised cardiac rehabilitation program did not directly influence this time-related AT change.

The PTCA procedure was first introduced in 1977 by Gruentzig as a non-surgical method for the treatment of coronary stenosis [17]. It has been widely used to reduce or eliminate the myocardial ischemic symptoms experienced by patients with CAD [18]. Successful PTCA therapy improves myocardial perfusion rapidly, resulting in an increase in exercise capacity of patients with CAD [19,20]. In this study, the number of patients who accepted PTCA while in phase II was larger in the decrescent group than in the incremental group, and patients who accepted PTCA therapy returned to this program safely from the third day after PTCA. These results suggest that the increase in the AT value at the post-training stage in the decrescent group, which was larger than that in the incremental group may be due to the effects of PTCA.

Restenosis has been reported to occur in the PTCA site with a rate of about 30% within six months [21]. In this study, none of the patients suffered from cardiac events and/or exertional chest pain during the six-month period after completion of training and at the exercise tests. The restenosis of PTCA site did not seem to relate this difference in a time-relate AT value change at the sixth month post the completion of training. However, we did not perform follow-up CAG to evaluate coronary restenosis at the sixth month after the completion of training.

BMI decreased and the AT value increased in the incremental group at the sixth month after the completion of training, while the BMI increased and AT value deceased in the decrescent group. These results revealed that time-related BMI curve was converse to the AT value curve in each group. Although many factors may influence this time-related change, our questionnaire revealed that the percentage of patients who complied with the requests of the continuous home-based exercise training and resumed working was larger in the incremental group than in the decrescent group. Thus, continuous home-based exercise training was partially, at least, associated with these results.

Finally, this study documented that an eight week exercise training of supervised cardiac rehabilitation program improved the AT value of AMI patients. In addition, time-related body weight changes was converse to that of subsequent AT value in our patients, and these time-related changes were partially related to compliance with an ongoing continuous home-based exercise training. To improve their compliance, home-based exercise training reinforced by scheduled home visits and/or telephone contacts may be useful [22].

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急性心肌梗塞病人接受心臟復健運動療法後其療效的持續性與體重變化的比較

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摘要

目的：接受過心臟復健運動療法的急性心肌梗塞病人，在臨床上常有運動耐受力比治療中降低之情形。本研究的目的在探討心臟復健運動療法後療效持續性的影響因素。**材料與方法**：94名急性心肌梗塞之病人於接受過心臟復健運動療法後，鼓勵其繼續居家自我運動訓練。有氧運動值(AT)於心臟復健療法前、後和6個月後分別測試之。**結果**：依AT值的經時變化可分為(1)增加組(incremental group，n=39)的AT值從心臟復健運動療法前的1.08 ± 0.19 watt/kg增加至6個月後的1.23 ± 0.32 watt/kg，(2)降低組(decrescent group，n=55)的AT值變化呈倒V字型，其最高點為心臟復健運動療法後的1.16 ± 0.18 watt/Kg。增加組的平均體重減少了0.4 ± 1.2 kg/m²，而降低組的平均體重增加了0.3 ± 0.9 kg/m²。另外，增加組較降低組有較多的病人繼續居家運動療法(85% Vs 65%，$p<0.05$)。冠狀動脈硬化的嚴重度，冠狀動脈氣球擴張術的施行時間和冠心病危險因子對AT值的經時變化並無明顯影響。**結論**：心臟復健運動療法後其療效的持續性與體重的變化成反比關係，而這些變化的關係可能與病人的持續居家自我運動訓練有關。(**慈濟醫學** 2001; **13**:203-209)

關鍵語：身體質量指數，有氧運動值，急性心肌梗塞，監視型心臟復健運動療法，居家運動訓練

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