Effectes of Weekly Interval Training at Different Intensity on Dynamic Cardiorespiratory Responses

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Abstract: There is strong evidence that exercise intensity mediates central and peripheral cardiovascular and respiratory adaptations to exercise and improvements in maximum aerobic capacity (VO2max). However, the effects of different exercise intensity on once-a-week interval training are uncertain for dynamic cardio-respiratory responses to exercise. The subjects were 16 male college student athletes. The interval training load was determined for each individual using a maximal exercise test, and was performed weekly for 8 weeks in 2 groups of 95% or 80% intensity (TG95%, TG80%). The training consisted of three bouts of exercises to volitional fatigue at TG95% or TG80%, maximum work rate. Regardless different of training intensity, increased VO2max and maximal exercise performance in both training groups were observed after training program (P <0.01). TG95% induced cardiac adaptation in enhancing heart rate during maximal exercise. The present results indicate that high intensity interval training markedly induces training intensity-dependent specific cardiorespiratory response at the onset of exercise through changes in autonomic neural regulation.

Keywords: Longitudinal study; Exercise training; Biological adaptation; Heart rate.

1. Introduction

Recent studies have shown that interval exercise training with high intensity and short duration can improve exercise performance and maximal oxygen uptake (VO2max) as well as endurance training with moderate-to-low-intensity and long duration. This mechanism is considered to be adaptive change due to improvement of maximal oxygen transport capacity by cardiovascular system and/or improvement of oxygen utilization capacity in active muscle. In addition, functional changes in autonomic neural regulation of the circulatory system during exercise may also be an important mechanism. For example, it is known that the mechanism by which heart rate (HR) increases at the start of exercise varies depending on exercise intensity, and that HR changes during moderate-to-low-intensity exercise are greatly affected by vagal withdrawal, whereas those during high-intensity exercise are primarily due to increased sympathetic nerve activity. In fact, the VO2 kinetics at the onset of exercise are known to be faster in endurance athletes. Hickson et al. [1] reported that the acceleration of VO2 at the start of exercise occurs with intense endurance training. Thus, the dynamics of cardiovascular and respiratory responses during exercise may vary greatly depending on the intensity of exercise training. Previously we reported that weekly interval training at 80% intensity resulted in similar improvements in VO2max and cardiac morphologic changes to those reported previously [2]. However, it has not been determined whether more intense interval exercise training will have the similar effect on VO2max or alter the dynamics of the cardiorespiratory response during maximal exercise. The present study investigated the effects of weekly interval training at different intensities on dynamic cardiorespiratory response during exercise and maximal exercise performance.

2. Materials and Methods

Subjects: Sixteen male college athletes were divided into two groups: a 95% intensity training group [TG95%] (Age; 20.7 ± 1 yr, range 19 – 24 yr, height; 172.1 ± 4.1 cm, Weight; 90 ± 15.6 kg) and a 80% intensity training group [TG80%] (Age; 20 ± 1 yr, range 19 – 22 yr, height; 170 ± 3 cm, Weight; 64 ± 7 kg). Sixteen subject were recruited into the study having provided written informed consent and following ethical approval by the Human Subjects Committee of Morinomiya University of Medical Science (No.2018014). pulmonary disorders, and were not head injured and using any prescribed medication. Participants were familiar with performing maximal cycle ergometer exercise and the laboratory procedures for obtaining cardiorespiratory data.

Experimental procedures and protocols: Incremental exercise test. Each subject performed maximal cycle exercise for the measurement of VO2max. We determined the level of exercise stimulus for interval training through a maximal exercise test. The maximal cardiorespiratory variables were assessed with an incremental protocol on a computer-controlled bicycle ergometer (232CXL, Combi Co., Tokyo). The work rate was set at 20 W initially and increased by 1 W every 3 second (i.e. 20 W per minute) until the subject could no longer maintain the pedaling frequency of 60 rpm despite strong verbal encouragement.

Exercise training program. Interval training was conducted at once per week for 2 months. The
exercise training program involved bicycle ergometer exercise. Each training consisted of three bouts of exercises to volitional fatigue at 95% or 80% maximum work rate. Recovery period between training bouts was also fixed at 2min of active recovery at 0 watt and 1min of rest.

**Experimental measurements:**
HR was monitored using a three-lead electrocardiograph. The subject breathed through a face mask with a flow meter. Respiratory and metabolic data during the experiments were recorded by an automatic breath-by-breath respiratory gas analyzing system (ARCO2000-MET, Arcosystem, Chiba, Japan).

**Data analysis:** Resting values of cardiorespiratory variables averaged over 3min before starting exercise. Maximum mean values of respiratory variables and heart rate were calculated for 10 seconds at maximum level during exercise programs.

**Statistical analysis:** All data are presented as mean ± SD. Depending on the purpose of the comparison, one- or two-way repeated measure analysis of variance (ANOVA) was conducted on each response variable using individual subject mean data. Significance was accepted at p < 0.05.

3. Results
Figure 1 shows the changes in HR, VO₂ and V̇E over time in TG95% and TG80% during maximal incremental test before and after the intervention program in the interval training. After training, maximal exercise performance time was significantly improve in TG95% (⊿89%) and TG80% (⊿33%). The HRmax after training was significantly higher only in TG95% than before training. VO₂max and V̇Emax were significantly increased by TG95% (VO₂max; ⊿9%, V̇Emax; ⊿19%) and TG80% (VO₂max; ⊿6%, V̇Emax; ⊿19%) respectively, in both training groups than before training. ANOVA revealed a significant main effect for those variables. We found that only the HR response in TG95% after training maintained a high value even at the same intensity compared with before training, but not TG80% (Figure 1). In addition, HR at rest also showed a significant increase. ANOVA revealed the significant interaction effects of training and intensity for HR at rest and during exercise.

4. Discussion
In this study, we demonstrated that weekly interval training at different intensities improved both VO₂max (TG95%; ⊿9%, TG80%; ⊿6%) and maximal exercise performance time. This is consistent with previous studies that compared the effects of intensity differences in high-intensity interval training [3]. In addition, this is the first study to show that weekly training has similar cardiorespiratory effects as reported in previous training studies [2].

We also found that acceleration of heart rate response to exercise and increase in maximum heart rate occurred only in the TG95%. These results imply training-induced functional changes in the autonomic neural regulation of the circulatory system during exercise. Furthermore, this may be one of the mechanisms explaining the differences in training effects in maximal exercise performance time observed among training intensities (TG95%; ⊿89%, TG80%; ⊿33%).

![Figure 1](image)

Figure 1. Time courses of heart rate (HR), oxygen uptake (VO₂) and minute ventilation (V̇E) at rest and during maximal incremental test before and after the intervention program in the interval training. Vertical bars indicate ±SD.

5. Conclusion
Our results indicate that high-intensity interval training markedly induces training intensity-dependent specific cardiorespiratory response at the onset of exercise through changes in autonomic neural regulation.

**Reference**