Influence of cool-down exercise on autonomic control of heart rate during recovery from dynamic exercise

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Abstract—The recovery of post-exercise heart rate (HR) is enhanced by a procedure of cooling down; however, the mechanism of this facilitated reduction is unknown. To determine whether more cardiac vagal reactivation is associated with a decrease in HR following cool-down exercise, we examined high-frequency R–R interval variability (HF, 0.15–0.40 Hz), an index of cardiac vagal tone, in six young healthy male subjects with a comparison between sitting rest after 6 minutes of cool-down cycling at 20% peak oxygen uptake (V̇O₂peak) and sitting complete rest, following 5 min of upright cycle exercise at 70% V̇O₂peak. During the last minute of exercise, there was no difference in HR between the two exercise tests before performing or not performing cool-down exercise (mean ± SE, 148.7 ± 6.9 versus 149.7 ± 7.0 beats/min, respectively, by a Wilcoxon signed-ranks test). After exercise, a similar initial rapid decrease in HR and subsequent decline was observed during the first 6 min of recovery, regardless of cool-down exercise. However, the resting HR average following cool-down exercise was significantly lower than the corresponding HR without cool-down exercise (92.1 ± 3.0 versus 100.8 ± 3.6 beats/min, P < 0.05). The corresponding HF amplitude was slightly, but significantly greater with than without cool-down exercise (10.6 ± 2.2 versus 9.0 ± 1.9, P < 0.05). Thus the increase in HF amplitude corresponded to a decrease in resting HR following cool-down exercise, as compared to complete rest without cool-down exercise. Therefore, we conclude that after moderate exercise, the decrease in resting HR following cool-down exercise is associated with an increase in cardiac vagal tone.

Key words: Spectral analysis; R–R interval variability; vagal tone; cycle exercise; active recovery.

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1. INTRODUCTION

It has been found that, following exercise, heart rate (HR) decreases rapidly during an early phase of recovery and then during the subsequent phase decreases gradually to a stable level, which remains elevated above the resting or pre-exercise baseline level for a relatively extended period [1−3]. The elevation of the post-exercise HR in a quiet rest without cool-down exercise is sustained far beyond the time required for the restoration of respiratory gas exchange [2, 3]. Our recent studies [3, 4] have demonstrated that a protocol of cool-down exercise during recovery is effective in decreasing the time for the recuperation of HR to pre-exercise resting levels compared with a protocol without cool-down exercise. To date, cool-down exercise during recovery from exercise has been shown to play important roles in facilitating venous return and in preventing the pooling of venous blood in the post-exercise legs in an upright position [3, 5]. In the previous study [3], we speculated on the physiological significance of the recovery of HR during and after cool-down exercise, e.g. antiarrhythmic effect, restorative effect and protection from cardiac catastrophe. Although Dimsdale et al. [6] have suggested that cool-down exercise with a gradually decreasing work load is important to reduce the risk of cardiac events, there has been little evidence regarding the salutary effects of cool-down exercise on cardiac functions such as chronotropic action.

Human studies on autonomic control of HR during recovery from exercise have been made in short-term and long-term periods using the technique of spectrum analysis of HR variability [1, 7−10]. The exponential character of post-exercise cardiodeceleration was accompanied by an increase in the high-frequency (HF) amplitude of HR variability and by a decrease in the low-frequency amplitude. These results suggested that an initial rapid decrease and a subsequent slow decrease in HR following exercise are mediated by a prompt reactivation of the parasympathetic nervous system and a gradual withdrawal of the sympathetic nervous system. However, it has not been well understood whether the recovery of post-exercise HR enhanced by additional exercise of cooling down is associated with change in cardiac autonomic nerve activity, especially in cardiac vagal tone.

We sought to determine the role of an increase in cardiac vagal tone in the consequent decrease in resting HR following cool-down exercise during recovery from exercise. Changes in beat-to-beat HR fluctuation were examined in the two different recovery conditions: inactive recovery (during which the subject performed quiescent rest following exercise) and partially active recovery [during which the subject performed exercise and then continued cool-down exercise (light-intensity cycling) followed by quiet rest]. We examined HF R–R interval variability, an index of cardiac vagal tone [11], during the resting period of recovery following cool-down exercise. We hypothesized that cool-down exercise would enhance post-exercise cardiac vagal activation and thus this vagal mechanism would account for a lower mean resting HR level for partially active recovery compared with inactive recovery.