Heart Rate Variability during Two-Leg to One-Leg Standing Shift in the Elderly

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Abstract. The purpose of this study was to investigate healthy elderly persons by a frequency analysis of heart rate variability during shift from two-leg standing to one-leg standing. The high frequency value was lower in the elderly persons in comparison with young adults, but there were no significant differences in heart rate and the low frequency / high frequency ratio of both groups. The low frequency / high frequency ratio of low values of the high frequency group was significantly higher than that of high values of the high frequency group. From these results, we consider that when the elderly experience decreases in parasympathetic nerve function, they compensate by activating sympathetic nerve function.

Key words: Heart rate variability, Old adults, Standing

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INTRODUCTION

Heart rate (HR) gets adjusted by the autonomic nervous system. To investigate the autonomic nervous system, which is made up of sympathetic and parasympathetic nerves, HR variability spectrum analysis was developed1). The high frequency (HF) range component, which is distributed from 0.15 to 0.4 Hz, reflects the parasympathetic nerve function, and the ratio of low frequency (LF) over HF (LF/HF ratio) reflects the sympathetic nerve function; LF ranges from 0.05 to 0.15 Hz. It has been reported that the HF component is not decreased by propranolol, a sympathetic nerve blocking agent, and the component is absent by atropine, which is a muscarine receptor blocking agent. The HF component, thus reflects heart labyrinth nerve activity2, 3), and autonomic nerve activity can be understood through frequency analysis of HR variability. It is known that autonomic nervous function lowers with age4, 5).

Prevention of falls by old people has become important for activities of daily living, for which maintenance of motor control ability is necessary. Regarding falls, studies of anticipatory postural adjustments have been carried out. The purpose of this study was to clarify the autonomic nervous system during anticipatory postural adjustments. To see what happens in autonomic nerve activity, we examined elderly persons during a shift from two-leg standing to one-leg standing.

METHODS

HR variability was continuously recorded by the
Thorax bipolar induction method during the shift from two-leg standing to one-leg standing in 17 healthy elderly persons (mean age 71.6 ± 4.0 (SD), height 156.3 ± 7.2, weight 54.9 ± 8.0, body mass index (BMI) 22.4 ± 3.2) and 8 healthy young adults (mean age 22.6 ± 4.4, height 172.6 ± 5.5, weight 61.4 ± 9.2, BMI 20.6 ± 2.8). Frequency analysis of recorded data was performed, and the HF values and the LF/HF ratios were calculated. In this measurement and analysis, MemCalc/Tarawa (GMS companies) was used. The subjects were instructed to raise their right legs on hearing a sound cue, and maintain this position for a short period before setting their legs down. The HR variability from 10 seconds before the sound cue to 10 seconds after it was used for analysis. The calculation of change of HR, HF, LF/HF ratio, y, for the interval from, say, 8 sec to 6 sec before action was as follows:

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y(\%) = \frac{(\text{value at 6 sec before action}) - (\text{value at 8 sec before action})}{\text{value at 8 sec before action}} \times 100
\]

Because there was a significant difference between the elderly and young adult groups in HF, the elderly group was divided into two groups according to the HF values, and the LF/HF value was compared to see if a relationship between HF value and the LF/HF ratio existed.

Statistical analyses were done using SPSS 12.0 for Windows (SPSS Inc.). The difference between interval times was done in multiple comparison, and differences between the two groups was examined by Mann-Whitney U test. Statistical significance was chosen as \(p<0.05\).

RESULTS

There were significant differences in HF in the elderly group in comparison with the young group at all measured times. However, there were no significant differences in HR and LF/HF ratio between the two groups at each point of time (Table 1). The change in HR was represented by a rapid rise after the end of action in the elderly group, which could hardly be recognized in the young group. As for the change in parasympathetic nerve activity of the elderly, it kept declining until just before action, whereupon it took an upward trend. In the young adults, a change in parasympathetic never activity could hardly be recognized. Both groups showed a negative gradient in the change in sympathetic nerve activity through a given pre-action interval. In the elderly group, a positive gradient was maintained after action, and in the young adults, the negative gradient continued.

Regarding the LF/HF ratio in the elderly, it was 2.4 ± 0.8 in the low HF value group, and 4.8 ± 2.3 in the high HF value group. There was a significant difference between the low and high HF groups in the LF/HF ratio, but there was no significance difference in HR.

DISCUSSION

In this study, the HR was measured in relation to anticipatory postural adjustments. The values of HF in the elderly were lower than in young adults, consistent with the findings of previous studies. In the elderly, the amplitude of HF (parasympathetic nerve activity) at rest lowers, and the reaction in standing and in motion is poor4, 5). HR does not reach high enough levels of about 130 beats/minute in the elderly solely due to a decrease in parasympathetic nerve activity at moderate exercise to achieve a higher HR. The elderly also need activation of the sympathetic nerve6), whereas young people show a rise in HR due to a decrease in parasympathetic nerve activity in proportion to peripheral oxygen demand. Because a heart load over 130 beats/minute could not be induced in the elderly subjects of the present study, there was no clarification as to how specifically the sympathetic and parasympathetic nervous systems played their respective roles in HR regulation. The former is responsible for rises in HR and the latter for decreases in HR. The parasympathetic nerve activity in the elderly was significantly lower than that in the young adults, and also the elderly showed decline in it until just before action, whereas the gradient of parasympathetic nerve activity was kept at a nearly fixed level in the young adults. These facts indicate that a lowering of parasympathetic nerve function did take place in the elderly group. In addition, the LF/HF ratio in the low HF value group was significantly higher than in the high HF value group. Thus, we consider that the sympathetic nerve activity was activated in
compensation in people whose parasympathetic nerve function was lowered.

Anticipatory adjustments by autonomic nerve activity are made through hyperactivity of the sympathetic nerve and role played by the central command. When activity of the sympathetic nerve was observed in this study, there was no significant difference between the elderly and the young adult groups, and the activity was low. A negative gradient in the change of the sympathetic nerve activity until just before action in both groups was shown. The type of action used in the present study therefore gave rise to little or no hyperactivity of the sympathetic nerve in anticipation of motion.

Previously, Matsukawa et al. reported that sympathetic regulation played an important role in anticipatory circulatory regulation. The blood vessels of skeletal muscles receive sympathetic innervation, and the sympathetic nerve contains adrenergic fiber, cholinergic fiber and nitric oxide actuating fiber. It is conceivable, therefore, that the vasodilator action of the sympathetic nervous system might be at work.

Decety et al. reported that during mental simulation, both heart and ventilatory rate increased immediately after mental exercise was begun, and this increase was proportional to the amount of the simulation exercise. Wuyam et al. demonstrated that in a group of highly trained competitive sportsmen, imagination of treadmill exercise produces a treadmill speed-related increase in ventilation which amounts to approximately one-fifth of that observed during actual performance of the same exercise. In these reports, it is possible that HR was raised prior to action by merely imagining training of a motion. However, since the present study opted for an extremely low load, elevation in HR failed to result when an action was imagined. We would like to verify the effect of image training such as muscle force at a much higher load in future.

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**REFERENCES**


