EVALUATION OF FATIGUE USING HEART RATE VARIABILITY AND MYOELECTRIC SIGNALS DURING SKIING

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Abstract - We studied the change in functional activities during skiing exercise for a whole day, in terms of the interactions between cardiovascular and neuromuscular activities with the progression of fatigue. To evaluate functional activities at each phase, we developed a radio controlled remote data acquisition system for measuring multichannel biosignals. Then we used the Wavelet analysis for analyzing the details in the heart rate variability (HRV).

Based on the previous results, we proposed a scatter graph between an autonomic nervous activity related index and a muscular fatigue related index. The scatter graph was effective as a tool for a snapshot evaluation of fatigue or degeneration of functional activities during long-term physical exercise.

I. INTRODUCTION

We have studied skiing exercise in terms of the adjustment of autonomic nervous activities in the HRV to fatiguing muscle activities, using a remote data acquisition system [1]. Since the time-scales of those changes range from several ten seconds to several hours, it needs to handle multivariable measured signals with different time-scales. We have introduced appropriate biosignal processing at each phase during fatiguing exercise. However, a practical approach has not been proposed for applying field experiments.

II. METHODS

We used a battery supported radio controlled remote data acquisition system to measure biosignals during skiing. Data acquisition process started after receiving the trigger signal and then the process moved into the waiting mode again. We analyzed each 2-min of HRV during skiing and ski lift riding in order to clarify the periodical time-varying behavior of the sympatho-vagal interactions using the Wavelet analysis. In the time-frequency representation, we traced several local frequency component peaks at limited frequency ranges.

We focused on the relationship between an autonomic nervous activity related index, LF/HF calculated from the results of HRV, and a muscular fatigue related index, the correlation coefficient of average rectified value and mean power frequency, $\gamma_{ARV\text{-}MPF}$. We chose $\gamma_{ARV\text{-}MPF}$ because negative value was frequently observed at muscular fatigue expected phase during cycle ergometer exercise. Note that $\gamma_{ARV\text{-}MPF}$ was estimated every non-overlapping consecutive interval of 10-sec and LF/HF was calculated from averaged LF and HF within the same interval. Hence we can evaluate changes in functional activities using the scatter graphs of meaningful parameters as a function of trial.

III. RESULTS and CONCLUSION

Five male subjects participated in our experiment on separate days after they were informed of the experimental procedures and risks associated with the muscle fatiguing efforts. **Figure 1** indicates the scatter graph of the relationship between LF/HF and $\gamma_{ARV\text{-}MPF}$. The figure includes the results at first, 7th (just before lunch), 8th (just after lunch), and 14th (final) trials. The time-courses demonstrated a few peak in LF/HF and steady decrease in $\gamma_{ARV\text{-}MPF}$. The scatter graphs showed a high value in LF/HF with positive $\gamma_{ARV\text{-}MPF}$ around lunch. The value of LF/HF was the same between first and 14th trials, but $\gamma_{ARV\text{-}MPF}$ at 14th trial showed negative whereas $\gamma_{ARV\text{-}MPF}$ at first trial scattered around zero. We confirmed this feature in the scatter graph for other subjects.

Those results will allow us to assess the functional activities during long-term physical exercise, in terms of the relationship between cardiovascular and muscular activities.

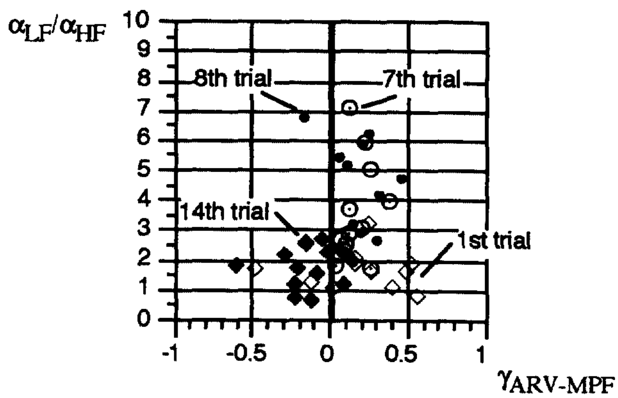

Fig. 1. Scatter graph between LF/HF and $\gamma_{ARV\text{-}MPF}$.

REFERENCE

[1] T. Kiryu, T. Abe, T. Gocho, Y. Ushiyama, and M. Okada, "Snapshot Evaluation of Fatigue during Skiing Exercise," in *Proc. 20th Annu. Int. Conf. IEEE/EMBS*, Hong Kong, China, pp. 2775-2778, 1998.