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Diurnal Variations in Autonomic Nerve Function for Actual On-Road Truck Driving

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***Abstract*—To prevent occupational driving accidents, we previously proposed a method of detecting worsening physiological states, such as fatigue, by measuring autonomic nerve function (ANF) before drivers start their shifts. Although increasing measurement times (e.g., while a driver is working) will improve the applicability to various worsening physiological states, little is known about how often we should measure ANFs for occupational driving due to their temporal variations within a day. We investigated how ANF indicators show diurnal variations compared to the baseline ANFs before drivers started their shifts.**

I. INTRODUCTION

Occupational driving accidents affected by drivers' worsening physiological states, such as fatigue, have been increasing. To prevent such accidents, we previously proposed a method for detecting worsening physiological states before drivers start their shifts using autonomic nerve functions (ANFs) [1]. To expand this method's coverage for various worsening physiological states when drivers are on shift, increasing measurement times will be effective since ANFs vary depending on the situation (e.g., resting vs. driving) and time [2]. However, increasing measurement times (e.g., during work) is costly, and we have to balance the cost and benefits of increasing measurement times. Regarding actual occupational driving, compared to simulated driving, little is known about how ANFs differ at various times, thus; we cannot consider the above balance. For this study, we investigated how ANFs show diurnal variations in on-road truck driving compared to the reference ANFs before drivers started their shifts.

II. METHODS

During three months, twenty male truck drivers (49.0 ± 8.2 years old) monitored their ANFs based on their electrocardiogram-based R-R intervals (myBeat WHS-1, UNION TOOL Co.). All procedures were in accordance with the Declaration of Helsinki, and the data were obtained in accordance with the standards of the internal review board on Research and Development Group, Hitachi, Ltd., following receipt of written informed consent. In pre-, mid-, and post-shifts, the low frequency (LF) (0.04–0.15 Hz), high frequency (HF) (0.15–0.40 Hz), LF+HF (Total Power, TP) and LF/HF, which is the indicator of sympatho-vagal balance, were calculated as ANFs based on the power spectral density.

To evaluate the diurnal variations in the drivers' physiological states, we conducted a correlation analysis of the ANFs measured during different periods. As a reference, pre-shift ANFs (resting with eyes closed) were selected. To evaluate the temporal variations in the ANFs when resting, the post-shift ANFs (resting with eyes closed) were compared. To compare the ANFs between resting and driving states, the average ANFs 30 min after starting their shifts were calculated. To quantify the differences in ANFs during driving shifts, 3-hour-averaged ANFs for five mid-shift periods (i.e., before 8:00, 8:00–11:00, 11:00–14:00, 14:00–17:00, and after 17:00) were used as the representative ANFs. We evaluated the Pearson's correlation coefficients between the ANFs of baseline pre-shift and other periods.

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III. RESULTS & DISCUSSION

During resting of the post-shift, the ANFs showed significant correlations with those in pre-shift (Fig. 1). However, the correlation between the ANFs during pre- and mid-shifts decreased over time, especially 3-hr after pre-shift. The ANFs during the period close to pre-shift showed the same level of correlations, indicating that measuring at least every 3 hrs mid-shift will expand coverage. However, LF/HF did not show significant correlations in most periods. This is probably because the degree of sympathetic nervous activity is significantly affected by the driving environment, which can cause differences in the ANFs during mid-shift and resting.

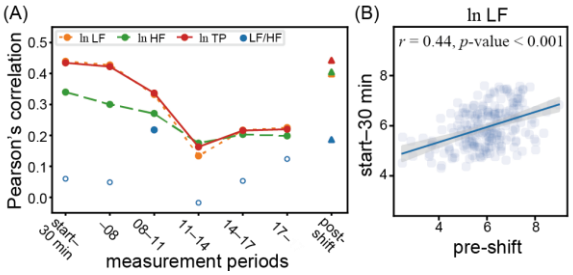

Fig 1. (A) Diurnal variations of Pearson's correlation coefficients in ANFs. Triangles and circles signify measurement during resting and driving, respectively. Empty symbols denote insignificant correlation. (B) Correlation analysis of ln LF (pre-shift vs. 30 min after starting shifts) shows strongest correlation (r=0.44) of seven periods.

IV. CONCLUSION

We showed the ANFs during driving deviated from those in pre-shift over time, especially in the afternoon, supporting the importance of ANF monitoring not only before but during shifts at least every 3 hrs. For future work, we will expand worsening detection using mid-shift ANF monitoring.

REFERENCES

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