

Evaluation of Driver Seating Fatigue during Long-Duration Driving Using Motion and Static Driving Simulators

Kota Kurita ¹⁾ Yamato Masuda ¹⁾ Soichiro Hayakawa ¹⁾ Ryojun Ikeura ¹⁾

Shunichi Yoshida ¹⁾ Tetsuya Kitagawa ²⁾

*1) Mie University, Graduate School of Engineering
1577 Kurimamachiya-cho, Tsu, Mie 514-8507, Japan (E-mail: 425m115@m.mie-u.ac.jp)*

2) FORTEC Co., Ltd.

5-13-3 Esaka-cho, Suita, Osaka 564-0063, Japan

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Driver fatigue during long- duration driving is an important issue because it can contribute to traffic accidents. Previous studies have investigated driver seating fatigue during long- duration driving; however, our previous experiments have mainly been conducted using a static driving simulator. In such a static driving environment, vehicle motions caused by acceleration, deceleration, cornering, and road conditions are not sufficiently reproduced. Therefore, fatigue evaluation using only a static driving environment may not adequately represent the seating fatigue that occurs during actual driving. In this study, long- duration driving experiments were conducted using motion and static driving simulators to investigate the effects of seat motion on driver seating fatigue.

The experimental system consisted of a six-degree-of-freedom motion system, a steering wheel, a vehicle seat, a curved monitor, and a Windows PC. In the motion driving simulator (M-DS), the motion system operated in response to vehicle acceleration, deceleration, and cornering in Assetto Corsa. In the static driving simulator (S-DS), the motion system was deactivated, while the other experimental settings were kept the same. Two male participants in their twenties performed five 95-min driving trials under each condition. The order of the M-DS and S-DS trials was randomized to minimize order effects. The transmission was set to automatic, and the participants were instructed to maintain a consistent driving pace without driving at the limit. Driver seating fatigue was evaluated using whole-body muscle fatigue derived from fingertip photoplethysmography, mean buttock contact pressure measured using a pressure distribution sensor, and subjective fatigue ratings for five body regions: the neck, lumbar region, buttocks, back, and arms.

Figures 1 and 2 show the whole-body muscle fatigue evaluation results for Participants A and B, respectively. For both participants, the final value of the muscle fatigue index was significantly higher in the M-DS condition than in the S-DS condition ($p < 0.01$). The mean buttock seat pressure was also higher in the M-DS condition than in the S-DS condition during all three time intervals of 0–30, 30–60, and 60–95 min for both participants. The subjective fatigue ratings in the lumbar region and buttocks were also significantly higher in the M-DS condition for both participants. In contrast, Participant A showed significantly higher fatigue in the back region under the S-DS condition.

Under the present experimental conditions, differences between the M-DS and S-DS conditions were observed in multiple fatigue evaluation indices for both participants. In particular, higher whole-body muscle fatigue, mean buttock seat pressure, and subjective fatigue in the lumbar and buttock regions were observed under the M-DS condition in both participants. Further experiments with a larger number of participants are required to confirm the reproducibility of these results.

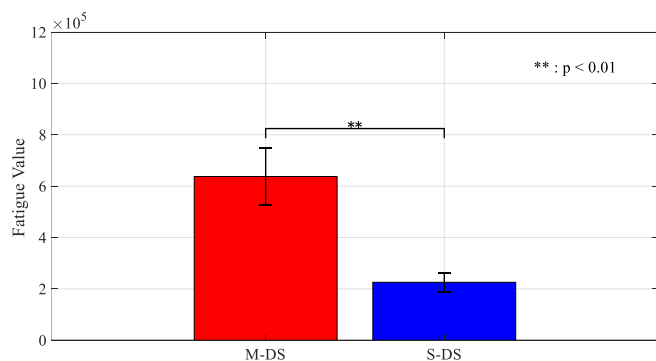


Fig.1 Whole-Body Muscle Fatigue Evaluation for Participant A

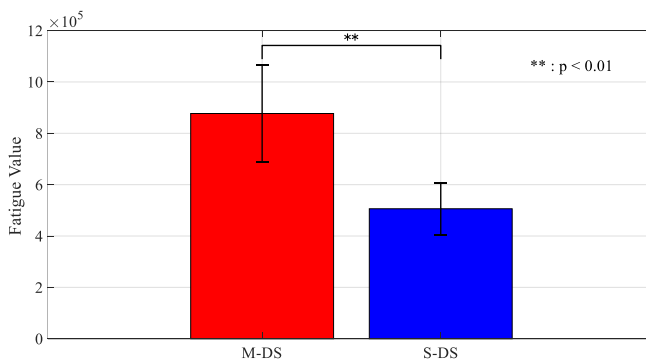


Fig.2 Whole-Body Muscle Fatigue Evaluation for Participant B