A Study on Reducing Effect of Driver Fatigue Increasing by using Seat with Increased Support Part of Back Support Mechanism

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Abstract. In this study, in order to reduce the driver fatigue for a long time driving, in addition to the conventional lumbar support, we examined the reduction effect of driver fatigue by increased the back support part using the pelvis support. As a result of the driving experiment by using the driving simulator, we evaluated the driver fatigue based on the biological information (pulse wave muscle fatigue curves and blood lactate level) and Subjective evaluation, clarifying the difference in the driver fatigue.

1. Introduction

The accumulation of the driver fatigue at the time of the long-time driving leads to the mistake the operation and the judgment. So it seems one of the big factors of the traffic accident. Main causes of driver fatigue during long-time driving include problems such as driving with a state of being seated for a long time, poor circulation due to adhesion of muscles of the buttocks, and lowering of posture holding power. Various researches are being conducted to solve this problem. For example, there are studies that verify the reducing effect of driving fatigue increase rate by operating various mechanisms built in a seat [1,2]. As a previous study in this laboratory, it has focused on the lumbar support (lumbar) built in the driver's seat in order to realize reduction increase rate of fatigue with a long time evaluation [3, 4]. It has been shown that reducing the fatigue increase of the driver can be realized by operating it periodically during operation. Furthermore, we are conducting research on a method to improve fatigue increase reduction effect more than this method. It is investigating the Pelvis support mechanism (pelvis), considering that further fatigue reducing effect can be realized by increasing the number of supporting parts of the back support mechanism.

In this paper, we will further investigate the operation method which periodically uses lumbar and pelvis (lumbar/pelvis) which realizes further improvement of fatigue reducing effect than the reduction effect shown in reference [5], aiming to verify the reducing effect of driving fatigue during long-time driving, to analyze what type of body movement occurs in the driver by using Lumbar and Pelvis which have not been verified so far. Based on a long-time driving experiment using a driving simulator (DS), objective muscle fatigue evaluation based on finger plethysmogram and blood lactate level increase amount as biological information and subjective evaluation result based on questionnaire. We
report on the results of evaluating the fatigue reduction effect of driver by temporal support position change using Lumbar/Pelvis.

2. Experiment to verify fatigue during long-time driving

2.1 Specifications of sheets used for experiments

In this study, and a lumbar supporting the lumbar region and a pelvis supported to support the pelvis are built in. Figure.1 show the internal parts configuration of the backrest of this seat. It consists of skeletal parts on the back of the seat, a drive motor, a lumbar / pelvis screw unit, and a panel pushed out by it. The lumbar / pelvis is fixed in the vertical position, and only the overhang amount can be arbitrarily changed. Lumbar · pelvis is a unitary unit, this support cannot extend both at the same time, choose either one to use. Figure.2 show the lumbar is about 150 mm above the planned Hip Point (SRP), and the Pelvis is about 90 mm above the SRP, and the maximum overhang amount is 30 mm for both mechanisms.

2.2 Structure of experimental equipment

In order to evaluate the reducing effect of fatigue increasing during long-time driving using lumbar / pelvis built in driver's seat, measurement of fatigue during long-time driving is carried out using DS. Figure.3 show the composition of DS. In this DS, one large monitor, steering, accelerator and brake are installed in the cockpit part. In addition, it consists of automobile seat, seat belt and one measuring
instrument with Lumbar · Pelvis built in the back of the seat. For finger plethysmogram of biological information used for objective fatigue evaluation, BACS detector manufactured by CCI is used. The device is placed on the elbow rest on the left side of the seat. This device measures the finger plethysmogram using the light absorption characteristics of hemoglobin in the blood. The sampling time is 5 msec. In addition, lactate-pro 2 ™ LT-1730 manufactured by ARKRAY Co., Ltd. was used for measurement of blood lactate level.

2.3 Experimental conditions

Since biological information, are susceptible to daily life, subjects should have their daily life rhythms from the day before the experiment the same and the experiment start time is also as far as possible. It was the same time. Also, because finger plethysmogram is affected by the surrounding environment such as temperature and humidity, air conditioning management is carried out so that the same conditions are obtained. The subject is a single male in his twenties. One experimental time was 90 minutes. Even when using support equipment, we did not operate lumbar or pelvis in all patterns for 15 minutes after the start of the experiment based on our previous research results, and the use of lumbar and pelvis was made after 15 minutes from the start of the experiment. In this paper, in addition to using only the conventional lumbar, the purpose is to verify the effect of using Lumbar · Pelvis. The experimental patterns are as follows. (1) Do not use support equipment. (2) Run only the lumbar bar every 15 minutes. (3) Do not use anything for 7 minutes 30 seconds during the time period (15 minutes) not using the lumbar of the above (2), and make it operate to use Pelvis for the remaining 7 minutes and 30 seconds.

2.4 Driving fatigue evaluation method

In this study, we evaluate seating fatigue evaluation of driver of long-time driving from both aspects of objective evaluation and subjective evaluation. As objective evaluation, to measure two biological information about finger plethysmogram and blood lactate level and analyze their values to evaluate driving fatigue. Therefore, in this study, using the fatigue evaluation method based on the finger plethysmogram analysis proposed by Fujita et al. [6], pulse wave muscle fatigue curve to be used for fatigue evaluation is derived. Because finger plethysmogram is affected by body motion, always place the left hand on the armrest and measure it, steering with only the right hand. During the experiment, the actual driving situation is assumed, and body movements such as sitting and driver's posture change are allotted to the subject within a range not affecting the measurement of the finger plethysmogram. For measurement of blood lactate level, Yamada et al. [7] measure the lactate level and make the difference between the lactate level before and after the driving be the blood lactate level increase value. This method was also used in this paper to evaluate this as the muscle fatigue increase value of the driver during long-time driving. Blood sampling was done with sufficient attention to infectious diseases and careful use of medical instruments. (Accepted experiments at Mie University School of Engineering Ethics Committee.) As a subjective fatigue assessment, we also conduct a questionnaire survey at five locations: neck, hip, buttocks, back, and arm. Evaluate the degree of fatigue of each part on a self-evaluated basis every 5 minutes, assuming the initial value of fatigue level at the start of the experiment to be 1, and +1 if it is felt that the current degree of fatigue has increased compared to 5 minutes ago, otherwise We use a method to evaluate it as no change. This evaluation is carried out every 5 minutes at an experimental time of 90 minutes, and fatigue evaluation is performed as subjective evaluation for each part and each experimental pattern.
3. Experimental result

3.1 Objective fatigue evaluation result by pulse wave muscle fatigue curve

Figure 4 shows the average pulse wave muscle fatigue curve three times for each experimental pattern. The vertical axis shows the degree of fatigue of the body, and the horizontal axis shows time [min]. In the figure, the red line is the pattern 1, the blue line is the pattern 2, and the green line is the pattern 3. Regarding the result of pattern 2, it was confirmed that by increasing the lumbar support at 15 minute intervals, the increase in seating fatigue of the driver can be reduced as verified by our authors. The result of Pattern 3 with pelvis proposed this time is slightly lower fatigue value than Pattern 2.

3.2 Objective fatigue evaluation result by blood lactic level increase amount

Table 1 shows the results of four times experimental patterns of blood lactate level increase amount before and after a long-time driving experiment. The unit of values in the table is mmol / l. In addition, Figure 5 shows the results of a significant test by multiple comparison performed on the blood lactate level increase amount between experimental patterns shown in Table 1. For the multiple comparison, Bonferroni’s method was used. The vertical axis shows blood lactate level increase amount, and the horizontal axis shows each experimental pattern. The red bar chart shows the pattern 1, Blue bar chart pattern 2. The green bar graph shows the pattern 3. Each shows the average value of blood lactate level increase amount. The black vertical bars in the bar graph indicate the standard deviations. * Mark indicates the level of significance, * indicates a significant difference of 5% level, ** indicates that a significant difference of 1% level was obtained. From this result, a significant difference of 1% level was obtained for pattern 2 and pattern 3 as compared with pattern 1. The method of alternately operating the Lumbar - Pelvis which we studied this time resulted in the effect of reducing the fatigue increase almost equal to that of the conventional method.

3.3 Subjective Fatigue Evaluation Results and Discussion

In the final fatigue value of each part obtained by the questionnaire, in order to check whether there was a significant difference in fatigue value between experimental patterns, multiple comparison was performed and the significant difference between experimental patterns was evaluated. Figure 6 shows the average value and standard deviation of the final fatigue values of each part of each experimental pattern used for analysis of variance and multiple comparisons. The vertical axis shows the fatigue value, and the horizontal axis shows each part used in the subjective evaluation. The red bar graph shows the average value of the final values of the pulse wave muscle fatigue curve of the pattern 1, the blue bar graph shows the pattern 2, and the green bar graph shows the average value of the pattern 3. The black vertical bars in the bar graph indicate the standard deviations. * Mark indicates the
significance level **, indicating that a significant difference of 1% level was obtained.

As a result, a significant difference was confirmed at the 1% level by both methods of pattern 2 and pattern 3 compared with pattern 1 at the waist and back. It can be confirmed that the evaluation is almost the same for the parts where the support system does not function, such as the neck and arm.

4. Posture change verification by support of back support mechanism

4.1 Experimental method of attitude change measurement

Based on these results, information on what type of posture change is occurring when the driver is operating Lumbar / Pelvis is needed. Therefore, using the seat of the same specification as the driving seat used for the driving test this time, we measure how the driver changes the posture when using Lumbar and Pelvis. In this experiment, measuring markers were attached to the six point of the hip point (HP), B70, B100, B130, B160, B190, B220, B250, B280, B310, B340 on the side of the body of the subject sitting on the seat. With respect to each of the lumbar and the pelvis, the overhang amount was changed to 10 [mm], 20 [mm], 30 [mm], and the coordinates of each part to which the marker was attached was measured using a three-dimensional measuring device FARO.

4.2 Measurement experiment result of attitude change

Figure 7 shows the result of measuring the amount of displacement from the initial position of each part to be measured of the subject when the lumbar bar and the Pelvis protrude. (a) shows the measurement result when the lumbar is operated, and Fig. 7 (b) shows the measurement result when the Pelvis is operated. Both graphs show the coordinate values of each measurement point. Each line shows the overhang amount, green is 10 [mm], yellow is 20 [mm], red is 30 [mm].

Looking at the result of the lumbar in Fig. 7 (a), HP has hardly changed by extruding the back side using a lumbar bar, but the vicinity of B150 which is the measurement point in the vicinity where the lumbar is overhanging moves larger than others (up to 11 [mm]), it can be confirmed that pushing the backbone which is the original purpose of the lumbar so as to be in the form of an inverted S shape and urging the driver to change the posture.

Looking at the results of pelvis shown in Fig. 7 (b), in the case of pelvis, by increasing the overhang amount, the shape near B90 is extruded. It can be confirmed that the posture change is not encouraged when the extension length of pelvis used this time is 13 [mm]. By using pelvis at the maximum overhanging amount of 30 [mm], it can be confirmed that the anterior lordosis from the pelvis to the lower part of the lumbar vertebrae (maximum 7 [mm]).

From the results in the previous section and the results of this attitude measurement, it is highly likely that most of the fatigue reduction effect by the lumbar / pelvis switching proposed this time was the effect of lumbar posture change. Therefore, the fatigue evaluation result was the same degree of fatigue.
reduction effect as lumbar. Moreover, from this, it is thought that a posture changes effective for reducing effect of fatigue can be encouraged by re-examining the mechanism and raising the support position of the pelvis upward.

5. Conclusion

In this paper, we have not only used lumbar which authors have proposed reducing effect of driving fatigue increase for a long-time driving, but also used the prevention to increase the support part for realizing further reduction of fatigue. Therefore, verifying whether reducing effect of driving fatigue increase for a long-time driving of the driver is improved by alternately using lumbar / pelvis periodically, and by measuring the posture change using the marker, it aimed to analyse what type of body movement is occurring by using pelvis. As a result, it was confirmed that reducing effect of driving fatigue increasing can be realized as compared with when the support system is not driven, but it was only about the same effect as compared with the conventional method of operating the lumbar only. From the weighing result of attitude change, Lumbar urged the trunk to change, and urged posture change, but in Pelvis it was not really confirmed that change in posture which changes body trunk to push forward body forward. As a result, the fatigue alleviating effect due to the lumbar / pelvis switching is mostly due to the posture change of the lumbar. The contribution of reducing effect of driving fatigue is low, so the switching of the back position at this added support position It was not effective. As a future subject, we will explore the change of posture which can change to the trunk of the same level as the lumbar, then measure and investigate the muscular use site in each posture using electric potential measurement, planning to verify reducing effect of driving fatigue for a long-time driving.

References


