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Development of a Method for Evaluating Muscle Burden During Driving Operations

-Steering Emergency Avoidance Maneuver-

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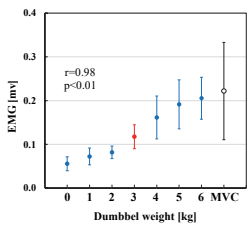
In recent years, the proportion of traffic accidents involving elderly drivers has increased. This study, a muscle burden assessment method using dumbbells to stably evaluate driver muscle burden during emergency avoidance maneuvers via steering was developed. The muscles evaluated were the right and left deltoideus anterior (DAR, DAL) and the right and left biceps brachii (BBR, BBL). Electrodes were attached to the muscles being evaluated to measure electromyography (EMG). Conventional manual muscle testing methods, involves the examiner applying force while the subject resists it and measuring the EMG. Based on this method, a dumbbell strength test was developed to estimate maximum muscle strength from low-load assessments (Figure 1(a)). Before the experiment, height, weight, BMI, grip strength, body fat percentage, arm muscle mass, and muscle mass percentage were measured using a body composition monitor. This experiment was conducted with the approval of the Ethics Review Committee for Medical Research Involving Human Subjects of the Suwa University of Science.

The results of the developed dumbbell strength test are shown in Figure 1(b). A correlation was observed between dumbbell weight and EMG value, and the maximum muscle strength (E_{MVC}) lies along this line. In addition, E_{MVC} showed a particularly strong correlation with the EMG of the 3 kg dumbbell (E_3). However, individual differences in EMG response were not considered, so an estimation formula including body-type metrics was developed. Analysis showed a strong correlation between E_{MVC}/E_3 and BMI. E_{MVC} was estimated using a formula that multiplies E_3 by BMI, and the coefficients were determined for each muscle using the least squares method. Favorable results were obtained, with a mean error of 10% and a standard deviation within 20%. To verify whether the estimation formula derived is applicable to elderly adults, a similar study was conducted with elderly subjects. As a result, the errors between the MVC test and the estimated values were within acceptable limits. These results confirmed the estimation formula is applicable regardless of age.

An emergency avoidance course by steering maneuvers was set and experiments with elderly subjects were conducted. Seating posture was evaluated under three conditions: forward leaning posture, standard posture, and backward leaning posture. Furthermore, %MVC, which is the ratio of maximum muscle force by dividing the EMG values recorded during the steering emergency avoidance maneuver by the E_{MVC} derived from the estimation formula was calculated. The results are shown in Figure 2 and 3. Compared to the young subjects , both groups exhibited the highest steering torque and the fastest steering angular velocity in the standard posture. Furthermore, for both groups, the %MVC in each posture was lowest in the standard posture. Therefore, the standard posture was optimal regardless of age.

(a) Dumbbell strength test (DAL)



(b) EMG Correlation (DAL)

Fig.1 Dumbbell strength test

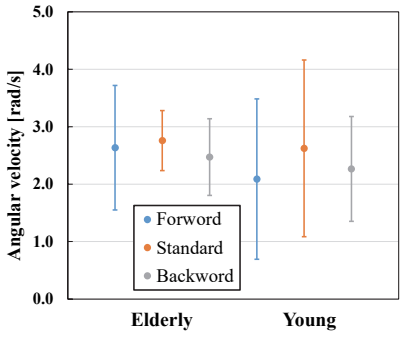


Fig.2 Steering angular velocity for steering emergency avoidance

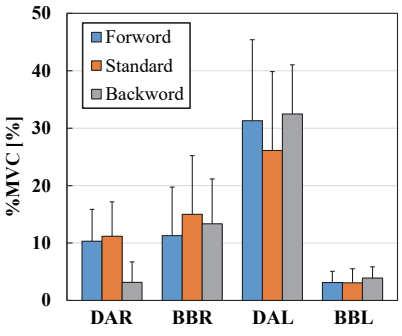


Fig.3 %MVC for elderly subjects