The stability of a motorcycle during turning transients is related to upper extremity operating strategy

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Summary

Motorcycle fatalities are higher than those for other mobility, especially in emerging countries. Rider operation of a motorcycle is crucial in reducing accidents, but few reports have analyzed the relationships between rider operations and vehicle stability. We aimed to clarify the relationship between vehicle stability and rider operation in curves, where single fatal motorcycle accidents are frequent, and analyzed the transitional period from straight lines to turns. As a result, experts exhibited a smaller variance of the angular acceleration in the turning direction. Moreover, steer torque work and the magnitude of the roll moment applied by the rider to the vehicle through the steering were related to turning stability. Focusing on the operation of the upper extremities during turns is important for safer motorcycling.

Introduction

Honda aims to achieve zero fatalities from traffic accidents involving Honda automobiles and motorcycles worldwide by 2050. Motorcyclist fatalities are higher than for other mobility[1)], and the current challenge is to reduce these fatalities in emerging countries. Although how well a rider operates a motorcycle is the last resort in reducing accidents, few reports analyzed the relationships between rider operations and vehicle stability[2),3)]. Identifying the operations of those involved in safety will contribute to reducing the number of traffic fatalities.

Fifty-seven percent of single motorcycle fatalities occur on curves[4)]. Therefore, we believe that clarifying the relationship between rider operation and the vehicle's stability in curves will provide knowledge that will help to reduce accidents. Based on the above, we aimed to clarify the relationship between the motorcycle's behavior during turning and rider operation.

Methods

We analyzed the transition from a straight line to a turn for 13 male riders (novice: 2, intermediate: 8, expert: 3). Riders made a 25-meter radius turn from a straight line at 40 km/h, and then went straight again. The subjects kept 1/3 of the inside line of the lane during the turn. We installed 6-axis force sensors (Leptrino Inc.), a throttle position sensor (iC Haus LLC.), a steer angle rotary encoder (MTL Inc.), and GNSS (OXTS Inc.) on a 125-cc small scooter, Wave125i (Honda Motor Co., Ltd.) and measured the riding. Data were collected at 100 Hz and low-pass filtered at 6 Hz.

The variance of angular acceleration in the turning direction (yaw angular acceleration) was calculated as an indicator of turning stability. We also calculated the absolute sum of the positive and negative works of the torque applied by the rider around the steer axis (steer work) and the average moment around the longitudinal axis of the vehicle body given by the rider through the steering (roll moment). To account for variations in vehicle speed among riders and differences in body mass, the variance of the yaw angular acceleration was normalized to the mean speed, and the steer work and the roll moment were normalized to the vehicle mass and each rider's weight. Spearman's correlation coefficients were calculated between the variables at a 5% significance level.

Results and Discussion

The variance of the angular acceleration was 56.4±43.5 deg^2/sec^3m for all subjects, while for three experts, it was 22.7±7.8 deg^2/sec^3m, indicating a lower tendency (Fig. 1).

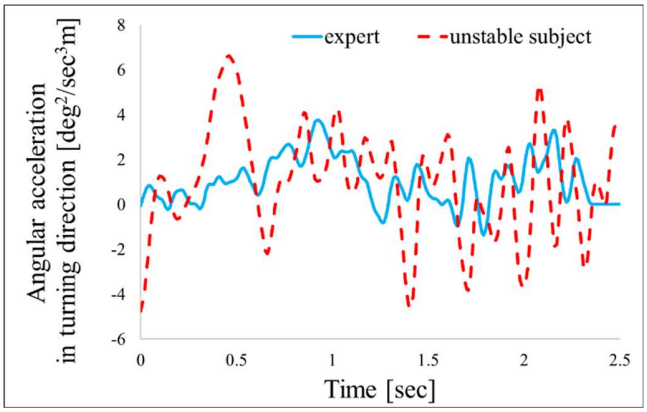

Figure 1: Waveform difference in the yaw angular acceleration between the expert and the subject with the most unstable yaw angular acceleration.

The variance of the yaw angular acceleration showed a significant positive correlation with both the steer work ($r_s = 0.67$, $p = 0.01$) and the roll moment ($r_s = 0.68$, $p = 0.01$). These results suggest that the upper extremity's active operation can make the motorcycle turn unstable and/or that the variation in yaw angular acceleration increased by some other operation, such as delay in the start of the turn, may be corrected by the upper extremity.

Conclusions

To ride a motorcycle safely, we need to pay attention to the use of the upper limbs during the turning transition period.

References

[1] M.I.N. Ma'arof et al. (2015), *Procedia Manuf.* **3**: 2581–2588.
[2] Huertas-Leyva P et al. (2019), *Transp. Res. F: Traffic Psychol. Behav.*, **60**: 93-107.
[3] Frank TA et al. (2020). *SAE Technical Paper*: 2020-01-1000.
[4] Wang Z et al. (2021). *Journal of traffic and transportation engineering (Eng. Ed.)*, **8(2)**, 225-236.