Tenth International Conference on Managing Fatigue: Abstract for Review

Motorcycling performance during an extended ride on a dynamic simulator: sleepiness and riding duration effects

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Problem to be addressed

Road safety statistics report a significant decrease of traffic accidents. Nonetheless, powered two-wheelers (PTW) are still highly represented in fatal accidents. PTWs only represent a small proportion of circulating vehicles in most countries (3-15%) but they are involved in nearly 20% of fatal accidents worldwide. In France, most of these accidents occur during the day but the risk of being killed is 1.5-fold higher at night, while sleep deprived.

The aim of this study was to further investigate the effects of time-of-day and sleep deprivation on simulated motorcycling performance during extended riding sessions (60min), and to identify associated electrophysiological, biological markers of sleepiness.

Methods used

Sixteen healthy male participants (24-36 years old; height: 178.1±1.4 cm; weight: 74.2±4.1 kg; intermediate chronotype) with high motorcycling experience (motorcycling license hold since 8.5±0.9 years) volunteered to participate in 4 simulated motorcycling sessions at 07:00h, 11:00h, 15:00h and 19:00h after a normal night of sleep and after a total sleep deprivation, in a counterbalanced order.

The 60min motorcycling session was realized on a dynamic simulator with a 3 screens video display (Figure 1). The course was divided into different areas: (i) in the city (8min) the participants needed to avoid 6 hazardous situations (red traffic lights, pedestrian crossing, exit of parking place, cut off while overtaking, right-of-way violation) which can each, intervene at 3 different places (drawn by lot); (ii) on a country road (2min), with other vehicles in the opposite direction only; (iii) on a monotonous highway (40min), during which the participants had to maintain their position in the right lane of the road while other vehicles were crossed in the opposite direction only.

Various indicators (number of inappropriate line crossings (ILC), variation of lateral position, number of falls, variation of speed, driving errors, violations of speed limits) were retained for motorcycling performance evaluation, while the participants were continuously monitored for electro-encephalogram (EEG), electro-oculogram (EOG), electrocardiogram (EKG) and electromyogram (EMG) analysis.

Figure 1: dynamic simulator with a 3-screens video display and synchronized electrophysiological monitoring.

Each riding session was preceded and succeeded by a brief version of the psychomotor vigilance task (PVT-B, 3min), the Karolinska sleepiness scale (KSS), saliva samplings to measure cortisol and testosterone concentrations, glycaemia measurements.

A statistical analysis of variance (ANOVA) with repeated measures was conducted. All differences were considered as significant for a p-value < 0.05.

Results

Throughout the day, the mean speed increased while the number of ILC and the variability of speed decreased (-11% between 07:00h and 19:00h). These observations were in line with a reduction in glycaemia, testosterone and cortisol levels observed from morning to late afternoon measurements.

After the night of sleep deprivation, regardless of the time of the day, the subjective level of sleepiness increased (5.3±0.5 points vs 2.7±0.3 points). The number of ILC

(Figure 2), the variability of the lateral position and the variability of speed (×2), and also the number of falls increased (×14), particularly on the highway.

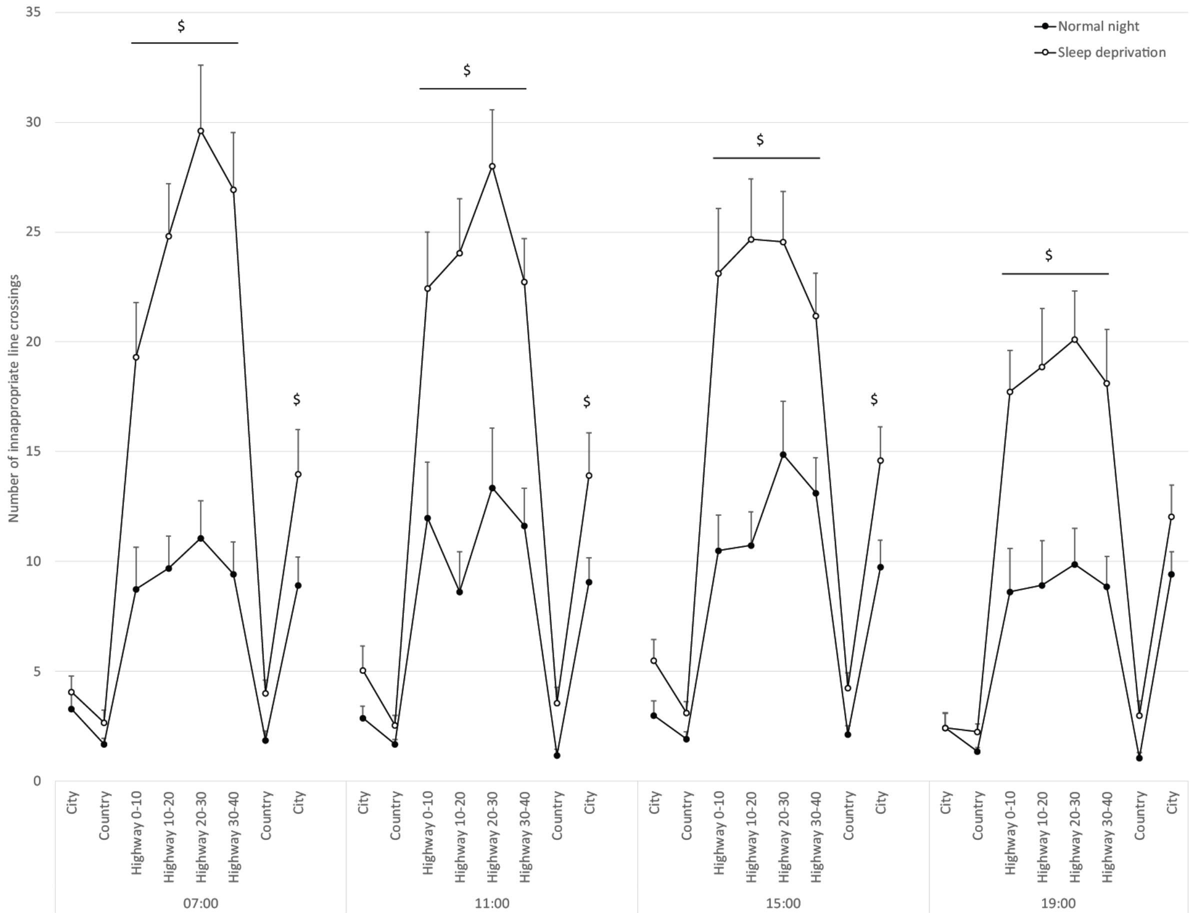

Figure 2: number of inappropriate line crossings observed while riding at 07:00h, 11:00h, 15:00h and 19:00h, throughout the different areas (city, country, highway 0-10min, highway 10-20min, highway 20-30min, highway30-40min, country, city) after the normal night and sleep deprivation. $: significant difference between normal night of sleep and sleep deprivation (p<0.05).

This evolution of motorcycling performance may be linked to the ratio ((α+θ)/β) observed from the synchronized EEG recordings. More precisely, this ratio increased at 11:00h and 15:00h after the night of sleep deprivation, and was also higher in the city in comparison with highway riding (Figure 3).

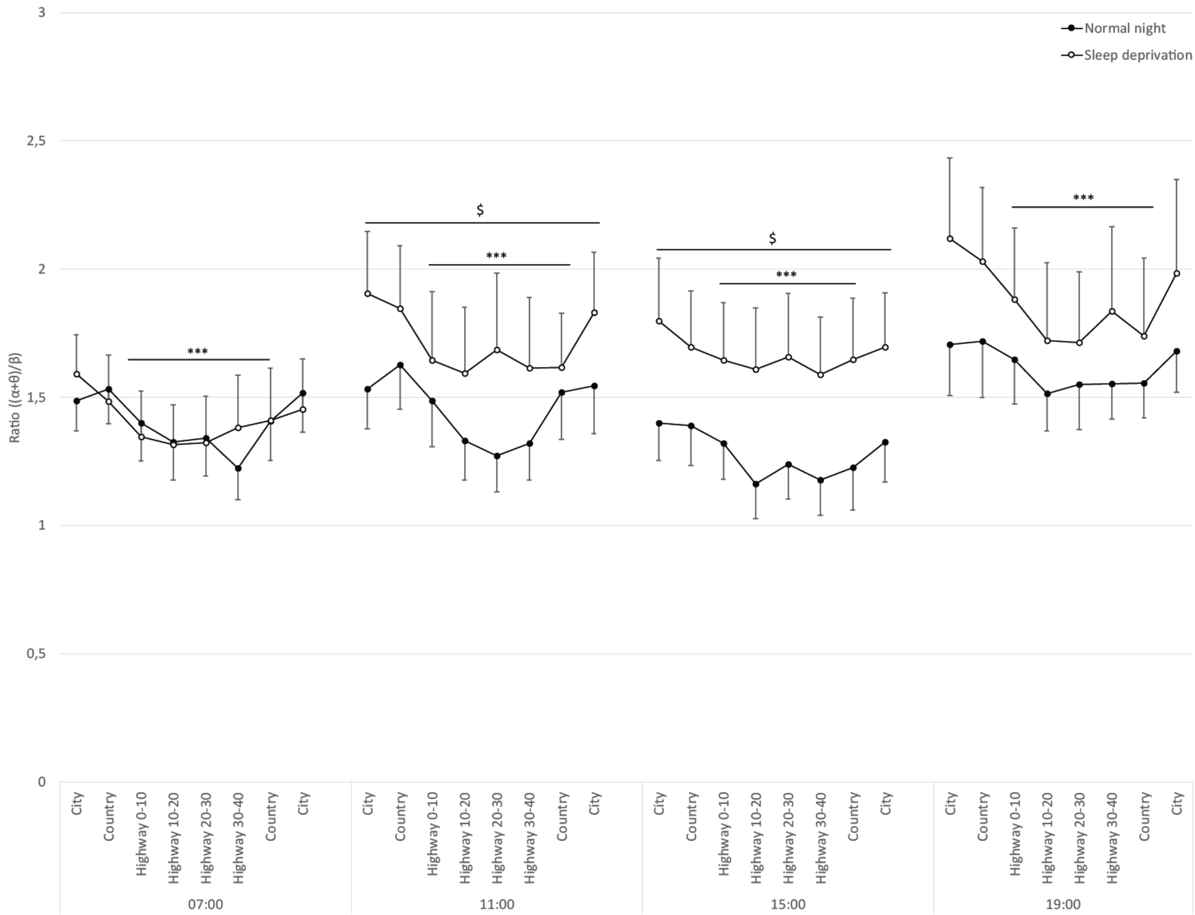

Figure 3: ratio ((α+θ)/β) measured from synchronized EEG signals while riding at 07:00h, 11:00h, 15:00h and 19:00h, throughout the different areas (city, country, highway 0-10min, highway 10-20min, highway 20-30min, highway30-40min, country, city) after the normal night and sleep deprivation. ***: significant difference between the areas concerned and city riding (p<0.001); $: significant difference between normal night of sleep and sleep deprivation (p<0.05).

Regardless of time-of-day and sleep condition, an influence of riding duration (50min) was observed on the number of errors while riding in the city. The number of collisions with pedestrians or other vehicles, the non-respect of traffic lights and turning without flashing (×1.5), as well as violations of speed limits (×3.6) increased between going and returning.

The number of lapses in the PVT-B (reaction times>355ms) measured after the normal night was not significantly different before and after riding (1.5±0.5 *vs* 1.6±0.5), but was less important than after the night of sleep deprivation. After sleep deprivation, the participants had more lapses before than after riding (4.1±1.0 *vs* 2.9±0.9).

Discussion

Motorcycling in the city and on country roads seems to be only weakly impacted by sleepiness in comparison with highway riding. Hazardous situations, frequent changes of speed and direction in the city, requiring a high level of attention, may have had a stimulant effect. Nevertheless, even in the city, the number of riding errors such as the non-respect of traffic lights or collisions with pedestrians and other vehicles increased when the participants rode back (after 50min). Moreover, it has also to be noticed that violations of speed limits were significantly increased after leaving the highway. PTW riders should be aware that after riding on the highway for a long time, they become used to ride at higher speeds, which can increase accident severity. Different biological mechanisms related to glycaemia, testosterone and cortisol levels may be implied as their evolution is in line with riding performance throughout the day.

The effects of the lack of sleep seem to be particularly important while riding on the highway. The monotony induced by riding at a constant speed, without crossing or overtaking any other vehicle may reinforce the effects of the lack of sleep, which may result in fatal accidents. This assumption is supported by the observation of an increased ratio $((\alpha+\theta)/\beta)$ calculated from the synchronized EEG signals. From a practical point of view, the number of lapses in the PVT-B and the KSS scores might be useful to inform PTW riders of their impaired level of neurobehavioral functioning.

Summary

This study indicates for the first time the effects of sleepiness, induced by time-of-day and sleep deprivation, on motorcycling performance during extended riding sessions on a dynamic simulator. Our results show that PTW riders reduce the number of ILC but evolve at higher speed in the late afternoon. Moreover, it seems that riding duration increases the risk of accident as PTW riders made more errors when they rode back in the city (after 50min). Motorcycling performance is strongly impaired while sleep deprived, more particularly on the highway. PTW riders are no longer able to maintain their speed and trajectory, which may result in loss of control or even fatal accidents.

Prevention campaigns specifically addressed to PTW riders may be pursued and encouraged. Further analysis need to be performed to look for possible correlations between electrophysiological, biological measurements to be able to predict the evolution of motorcycling performance.