A (very brief) review of literature discussing motorcycle-helmet induced hypoxia

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Motorcycle helmets can cause riders to inhale increased levels of carbon dioxide and reduced levels of oxygen. This paper presents a brief review of literature examining this phenomenon, and makes some suggestions as to the choice and use of helmets.

Literature review

Research into hypoxia induced by protective gear has been conducted in the fields of diving, aviation, space, motorcycle and scooter riding, and industrial use of welding helmets and respirators. More relevant research into oxygen and carbon dioxide levels in motorcycle helmets has and is currently being conducted by EMPA, the Swiss Federal Laboratories for Materials Testing and Research.

Research has found that full-face motorcycle helmets may deteriorate cognitive performance and cause increased levels of carbon dioxide at low riding velocities. As far back as 1981 it was found that "*the CO2 concentration inside full-face motorcycle helmets is too high in many true traffic situations*." (Aldman *et al*., 1981)

Research by Brühwiler *et al*. (2005) found that "*both the CO_2 and O_2 concentrations deviate from the atmospheric ideal for the wearer of an integral helmet, especially at standstill…"* Subsequent research by Bogerd *et al.* (2010) concluded that "*Carbon dioxide levels can reach at least 2% which rapidly drops with the presence of airflow around the helmet. Although only occurring at stand-still these elevated carbon dioxide levels are relevant since they have been shown to negatively affect cognitive performance*."

There is acknowledgement amongst the researchers that a number of factors can affect the cognitive performance and consciousness of riders. These include the limited amount of dead space in a helmet, decreased oxygen concentration due to CO_2 build-up, the effects of CO_2 itself, reduced flow of fresh air due to closed visors and slow speeds, temperature, and the impairment of ventilation due to clothing. Although performance of helmets has increased, some researchers see the CO_2 performance of helmets as unchanging over the last 25 years (Bogerd *et al*., 2010). Recent studies found concentrations peaking around 2% in the microclimate around the upper lip during normal use of a helmet. The situation changes when at a standstill, with CO_2 exhalations peaking at 6% and average CO_2 at 5% (Bogerd *et al*., 2010; Brühwiler *et al*. 2005). The research did not disclose whether this included the effects of clothing blocking ventilation around the neck line.

It may be expected that riders will notice symptoms like drowsiness or nausea, but research again suggests that riders may not necessarily display obvious symptoms or be in a state to notice them. Brühwiler *et al*. (2005) noted "*In cooler weather, the drive to lift the visor when stopped can be reduced, suggesting that natural feedback mechanisms will not automatically eliminate the problem, and therefore that future work on the cognitive aspects of exposures at these levels is warranted."*

Carbon dioxide may also impair one's ability to observe symptoms. According to the University of York, CO_2 has an anaesthetic effect at concentrations over 14%, depleted oxygen due to increase in CO_2 causes hypoxia and fainting, and concentrations of 1.5% of CO_2 should not be for more than 10 minutes. The concentrations of 5% reported by other researchers would induce symptoms of intoxication, physical exhaustion, headaches, visual disturbance, confusion and even loss of concentration after a few minutes.

The validity of this research should be considered. Although the laboratory work appears thorough and the experimental scenarios plausible, the studies only demonstrate that motorcycle helmet hypoxia is possible under theoretical conditions. No literature was found to research the presence or prevalence of this phenomenon on the road. In itself this absence of confirmatory evidence is not conclusive. The search was brief. There is not an abundance of literature on this topic anyway, so road traffic investigators may not be aware of the phenomenon or look for it. The phenomenon requires several conditions to be present at the same time. And researching hypoxia as a causal factor in road traffic accidents would be challenging; hypoxia can be difficult to diagnose post-event, and road traffic accidents can be difficult to analyse.

Suggestions

There is sufficient evidence to show that real motorcycle riders are potentially at risk, and should at least be aware of the phenomenon so they may take precautions. The following suggestions may be made in the choice and use of helmets:

- Helmets are certified to not cause rider safety issues under normal circumstances, but all full-faced helmets that were tested were able to cause a build-up of CO_2 and reduced oxygen pressure.
- Helmets that limit airflow may be used for years in all conditions with no ill effects, simply because the unique combination of factors had never been encountered. Conditions that increase the risk of hypoxia and reduced cognition include the 'fit' of the helmet, hair and clothing, limited airflow over the motorcycle, moisture levels, ambient temperatures, slow speed and closed visors.
- Awareness of the phenomenon is important. Hypoxia is not a subject of warnings on most riding gear, is not a priority in road safety education, and is not a popular topic on discussion forums. Riders should be encouraged to pay attention to airflow and leave the visor even partially up as a default position.
- Awareness of the symptoms is important. Hypoxia does not affect all victims in the same way or to the same degree. The effect of CO_2 build-up and oxygen deprivation can work together to reduce cognition and loss of consciousness, so warnings may be brief and ignored. At the very least, riders should raise their visor and increase airflow as often as possible and at the first sign of discomfort.
- More research is required, and accident investigators should consider hypoxia as a possibility. Hypoxia may not always lead to a serious incident, so it is plausible that a significant number of riders have been affected but displayed little more than drowsiness or reduced cognition. Even if the outcome was serious, cause is likely to be attributed elsewhere such as to falling asleep, medication, alcohol or underlying medical conditions.

Conclusions

In conclusion, research presents sufficient evidence to show that hypoxia may be induced whilst wearing motorcycle helmets under particular conditions. Full-faced helmets are particularly at risk. Motorcycle riders should be aware of the phenomenon and take action to improve the airflow and the quality of air they are consuming.

References

Aldman, B., Balldin, U., Gustafsson, H., Nygren, A., Sporrong, A. and Astrand, I. (1981) "Carbon Dioxide Retention Inside Motor-Cycle Helmets", *VIth International IRCOBI Conference on Biomechanics of Impacts*, 8-10 Sept, France

Aldman, B., Gustafsson, H., Nygren, A., and Astrand, I. (1982) "Motorcycle Helmets: Ventilation", *Journal of Traffic Medicine*, Vol. 10, Issue 2

Bogerd, C.P., Strässle, K. and Brühwiler, P.A. (2009) "The Effects Of Wearing A Full-Face Motorcycle Helmet On Cognitive Performance In A Warm Environment", *13th International Conference on Environmental Ergonomics*, Boston, USA

Bogerd, C.P., Carley, M., Crundall, D., Otte, D., Shahar, A., Shinar, D., Webb, D. and Brühwiler P.A. (2010) "COST Action 357—Accident Prevention Options with Motorcycle Helmets", *EMPA*, St. Gallen, Switzerland

Brühwiler, P.A., Stämpfli, R., Huber, R. and Camenzind, M. (2005) "CO_2 and O_2 concentrations in integral motorcycle helmets", *Applied Ergonomics*, Vol. 36 No. 5, pp. 625-33

Iho, L., Jonasson, H., Petersson, J., Stridh, G. and Ljung, C. (1980) "Measurement of aerodynamically generated noise and concentrations of carbon dioxide and oxygen in protective helmets for motorcycle riders", *Report SP-RAPP 1980:31*, Statens Provningsanstalt, Sweden

University of York, "Effects and Symptoms of Oxygen Depletion / Carbon Dioxide Enrichment", available online at http://www.york.ac.uk/biology/web/safety/saf_dryice/Effects.htm