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The motorcyclist impact against a light vehicle: Epidemiological, accidentological and biomechanic analysis

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ABSTRACT

This paper summarizes the results obtained within the framework of the French PROMOTO Project (PROtection of the MOTOrcyclist). The aim of this project was to analyze the impact between a motorcycle and a light vehicle from an epidemiological, accidentological and biomechanical point of view. The results have made it possible to outline the most frequent accident configurations such as the "turn on the left" and the most common injuries sustained by motorized two-wheelers (head and trunk). The biomechanic analysis has enabled a better understanding of the kinematics involved in an impact between a motorized two-wheeler and a light vehicle in various accident configurations (chronology and speed impact). While it is well known that motorcyclists frequently receive life threatening injuries to the head, spine and torso, this paper has been able to observe specific injury mechanisms such as pelvis impacts against the vehicle fuel tank and hyper-extension of the neck due to head impact on passenger cars.

1. Introduction

Even if the number of accidents involving cars has declined substantially over the last few years, accidents involving motorized two-wheelers have, on the other hand, gone up sharply and represent a key issue in the field of road safety (Amoros et al., 2008; Guyot et al., 2008). Much thought and study has gone into an improved understanding of motorized two-wheeler accidentality such as the MAIDS Project – In-Depth Investigation of Motorcycle Accidents (MAIDS, 2010).

As an inherent part of these studies the aim of the French PROMOTO Project (2006–2009) was to improve the PROtection of MOTOrcyclists by focuses on the field of passive safety (PROMOTO, 2008). Despite the fact that today protection gear remains relatively basic (apart from wearing a helmet which is now compulsory) recent technical innovations have made it possible to develop promising new safety systems to protect the motorcyclist.

These systems range from inflatable devices (airbags) built into the motorbike (Kuroe et al., 2005) to airbags fitted into the clothing worn by the motorcyclist (Helite, 2010; Dainese, 2010; API, 2010). In the latter instance, the rider or the passenger is able to wear a jacket fitted with one or several inflatable bags which can inflate extremely quickly as soon as the power two wheelers (PTW) reaches a specified degree of acceleration.

To better appreciate the efficiency of such systems in terms of road accidentology it proved necessary to first study the behavior of a motorcyclist's body under impact when not equipped with any such device. This article thus puts forward an evaluation of the main biomechanic and accidentological results required to develop these passive safety systems.

One of the main objects of this work was therefore to single out the conditions in which motorcyclists accidents occurred and their consequences. It was particularly important to accurately assess the mechanisms related to the most frequent and serious injuries and then to develop the appropriate biomechanics. This article is divided into two main parts:

- The first part deals with the accidentological and epidemiological analysis: this work has demonstrated the most frequent accident configurations and the injuries most often sustained by PTW.
- The second part focuses on the biomechanic study: the aim of this part is to analyze the kinematics involved in an impact between

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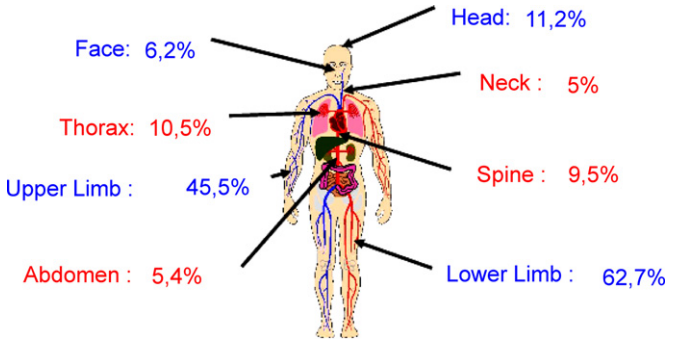

Fig. 1. Location of injuries (% of victims showing at least one injury in the area shown).

a PTW and a light vehicle (i.e. passenger car) in various accident configurations and identify the main causes leading to injury.

The other results obtained within the PROMOTO Project concerning the actual study of the airbag jacket are therefore not presented in this article. The importance of this paper lies in clarifying the data used to design these systems. The reader wishing for additional information on the development and assessment of the airbag jacket itself can consult previous publications (Thollon et al., 2008; Godio et al., 2008).

2. Epidemiological and accidentological analysis

2.1. Epidemiological analysis

The main objective of the epidemiological analysis was to evaluate the types of injuries sustained by PTW users in terms of their frequency and severity. An analysis of the injuries of 11,800 PTW riders wearing helmets was carried out using the data collected from the register of victims of road accidents in the Rhône area over the period 1996–2005 (Moskal et al., 2006). The advantage of this database is to collect exhaustively all the road injuries in the hospitals of the Rhône area. The inconvenient is to have poor information concerning the configuration of the accidents (involved vehicle, speed assessment, etc.). Charts showing the overall injuries sustained by PTW and particularly those on the thorax, spine and abdomen areas, were thus established (see Figs. 1 and 2).

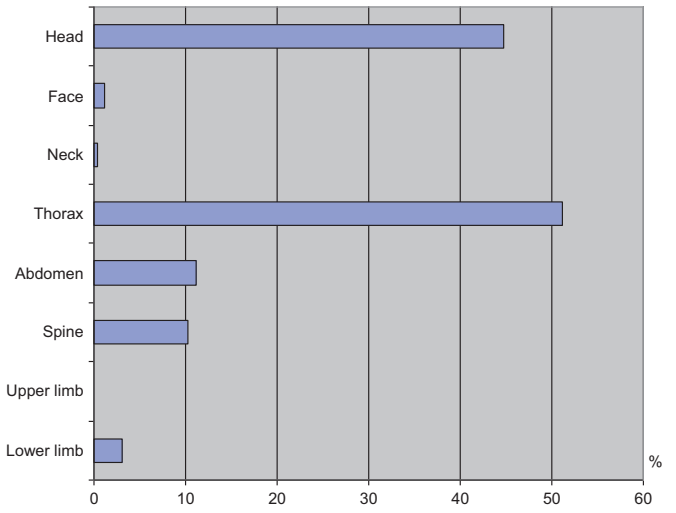

Fig. 2. Distribution of potentially fatal injuries (AIS maximum ≥ 4% victims with at least one injury in the shown area).

It can thus be seen that the lower limbs sustained the highest number of injuries while almost half the riders had injuries on their upper limbs. One in ten victims suffered at least one head injury. For victims wearing helmets the percentage of riders with thorax injury (10.5%) is approximately the same as for riders with head injury (Moskal et al., 2006, 2007). About 10% of riders suffered spine injury, mainly on the cervical spine, whereas 5% were affected by injuries to the abdomen. As far as most serious injuries are concerned the affected areas are distributed in a very different way: half the potentially fatal injuries (Abbreviated Injury Scale (AIS) ≥ 4) concern thorax (bilateral bruising of the lung being the most frequent) and 44% concern the head (brain injury is the most frequently observed). One in ten riders suffers severe injury to the abdomen and the spine. In nearly 90% of cases there is severe injury to the internal organs and the remaining 10% suffer from multiple fractures. The distribution of injuries affecting moped riders and motorbike riders shows that risk of injury to the thorax, the abdomen, the spine and the upper limbs are higher for motorbike riders than for moped riders. The differences in results between moped and motorbike rider accidents can be explained by factors such as speed, the collision energy during the crash and its location as it will be shown below.

2.2. Accidentological analysis

2.2.1. National data

In addition to the previous analysis which concerned data from the register of road accident victims in the Rhône area, a statistical analysis of national data covering physical injury caused by road accidents from 1996 to 2005 (police source) has provided a certain amount of information on the types of accidents, their configuration and the impact points. If this database concerns all the accident data collected by the police, however it does not contain exhaustively all the accidents.

It can be seen that 80% of body injury to the PTW involves accidents with another motorized vehicle. Collisions with a passenger car are the most frequent (64%). Collisions between PTW and a truck make up 1.7% of accidents but 6.5% of all fatal accidents. Accidents involving pedestrians or cyclists make up 6.4% of accidents and in these accidents the PTW wearing a helmet has no injuries in 63% of cases.

In half the collisions involving two vehicles the main impact point on the PTW is at the front. 50% of these “front impact PTW collisions” involve frontal collisions with another motorized vehicle. Two other accident configurations, collisions on the front of the PTW and the back or side of another motorized vehicle represent in turn 20% and 16% of these collisions. Multiple collisions make up 17% of the accidents.

2.2.2. Detailed accident data study

A second analysis has been made from an in-depth accident investigation (EDA) collected in Salon-de-Provence (France) from the beginning of the 1980s (Ferrandez et al., 1995). This database contains very detailed information on the accident cases but the sample is low. This task was aimed at assessing the typical characteristics of a motorbike accident, singling out the conditions, speed and orientation at the impact point of each vehicle involved, as well as assessing its consequences and making a special study of the injuries of the people involved.

The EDA database (1992–2007) contains 161 accidents involving at least one PTW. These 161 accidents involved 164 PTW divided, for administrative, reasons into the following categories: 65 mopeds, 19 light motorcycles (LMC), 78 motorcycles, 1 cross country motorbike and 1 pocket bike.

59% of accidents involve at least one light motorcycle or motorcycle (with the exclusion of mopeds), that is to say 97 accidents