Comparing Riders' Experiences in Real Life Crashes with and without Airbag Jackets

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15th International Motorcycle Conference, Dec. 2024, Cologne, Germany

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1. Introduction

The number of motorcyclists injured in Austria is rising. In 2023, it reached the pre-coronavirus pandemic level again and, at 4,179, was the second-highest figure since 2000. They accounted for 9.4% of all road traffic injuries and 26% of fatalities, which is much more than the European average (16%). Whilst fatality statistics are much more volatile than injuries, the 50% increase in fatalities from 2022 to 2023 is alarming. Between 2019 and 2023, around 17% of motorcyclists injured were female, as were around 3.5% of those killed. Among those actually driving the vehicles, women accounted for 12% of those injured and 2.5% of those killed. Severe motorbike crashes are therefore predominantly a male phenomenon.

1.1. Unprotected road users?

Moped and motorbike riders have been categorised as ‘vulnerable road users’ at European level for around two decades. However, riders should and must not take this designation too seriously. It is neither necessary nor advisable, as will be explained below. On a symbolic level, the term stems from the fact that personal protective equipment (PPE) is the only possible protection. In the hierarchy of occupational safety, on the other hand, PPE is at the lowest level. Priority number 1 would be to avoid hazardous environments and processes. If this is not possible, technical protective measures must be taken. Any remaining hazards must be kept at bay with organisational measures. And only what cannot be addressed via all these measures must be dealt with through PPE. Of course, there is also more than just PPE for motorised two-wheelers. ‘Vision Zero’, i.e. zero system-related fatalities, is the goal. A ‘Safe System Approach’ is the state of the art, i.e. the requirement to design everything in the transport system with safety as the prime directive. ‘Sustainable safety’ is the school of thought that firstly requires a safe system from the traffic space design, but then also requires road users to use it correctly and in accordance with regulations. However, if a large number of users exhibit errant behaviour, the responsibility is transferred back to the system provider, who must then improve the system. ‘Forgiving infrastructure’ is an important keyword in this context and is referred to in the following text.

1.2. Motivation

The starting point for this paper was a project of a motorbike club in Upper Austria. The active work and deep conviction of the chairman led to around 250 people purchasing an airbag waistcoat. The few who had already had an accident with such an airbag waistcoat on their body were asked about their riding habits and the accident. As a comparison, roughly the same number of people were surveyed who had had accidents without an airbag waistcoat, as well as those with an airbag waistcoat but who were accident-free.

There have also been significant changes to other motorbike protective clothing in recent years. For some time, there were only standards for clothing for *professional* motorcyclists. The demand for high-quality protective clothing could therefore not be met in a meaningful way.

Around 2020, a whole series of standards were published on what protective clothing for motorcyclists should be able to do and how it should be tested. This includes airbags. Compliance with these standards is mandatory via the so-called EU PPE Regulation[1], which stipulates that

[1] REGULATION (EU) 2016/425 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 2016 on personal protective equipment and repealing Council Directive 89/686/EEC. OJ L 81, 31.3.2016, p. 51-98.

personal protective equipment must fulfil minimum technical requirements. The standards to be applied are determined in accordance with the procedure laid down in the regulation and published in the Official Journal of the EU. The European Commission also occasionally publishes a summary of the notified standards (around 200) [2].

Motorbike helmets have a special status; the regulations of the European Economic Commission (ECE) apply to them. ECE Regulation No. 22[3] was also recently updated.

1.3. Injuries

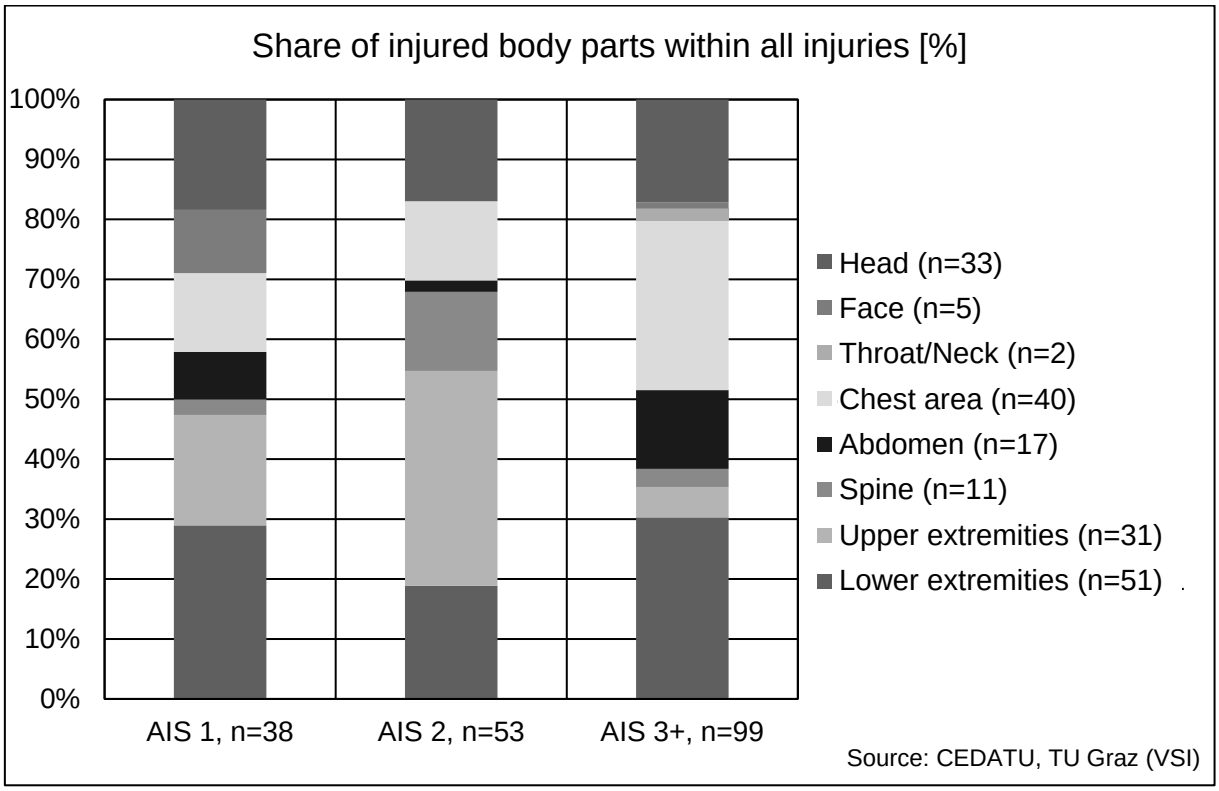

Figure 1 Injuries by severity and affected body part. Source: CEDATU, TU Graz

The first question to ask when considering protective clothing is the type of injury and the parts of the body that are injured. This information can be used to assess the potential of protective wear. In 2017, the KFV analysed the 'CEDATU' (accident database of Graz University of Technology), which is fed by data from court cases. It contains extremely detailed descriptions of road accidents. 'AIS' is the Abbreviated Injury Scale, a scale that describes the severity of injuries in seven levels: uninjured (0), minor (1), serious (2) and further from 3 (severe) to 6 (unsurvivable).[4] 101 accidents involving 113 motorbike users were analysed from the CEDATU. Two of them had no injuries,

[2] https://ec.europa.eu/docsroom/documents/57175
[3] UN Regulation No. 22: "Uniform provisions concerning the approval of protective helmets and their visors for drivers and passengers of motorcycles and mopeds". https://unece.org/sites/default/files/2021-09/R022r4am3e_0.pdf
[4] https://de.wikipedia.org/wiki/Abbreviated_Injury_Scale

while 190 injuries were documented among the 111 injured persons. Figure 1 shows their distribution according to injury severity and affected body part.

On average, each injured person suffered 1.7 injuries. Overall, the legs are the most frequently injured body part, whereas the arms also play a major role, and the chest area stands out in terms of serious to fatal injuries.

The 'Injury Database' (IDB) provides an even broader basis for the analysis. The data is collected during interviews with injured persons during follow-up treatment in Austrian hospitals. Between 2019 and 2023, 1116 injured motorbike users were interviewed. The most common injury pattern (16%) was a polytrauma, i.e. several injured body parts. This was followed by the shoulder, ankle and lower leg at around 8% each. The knee, collarbone and wrist were next with around 6% each.

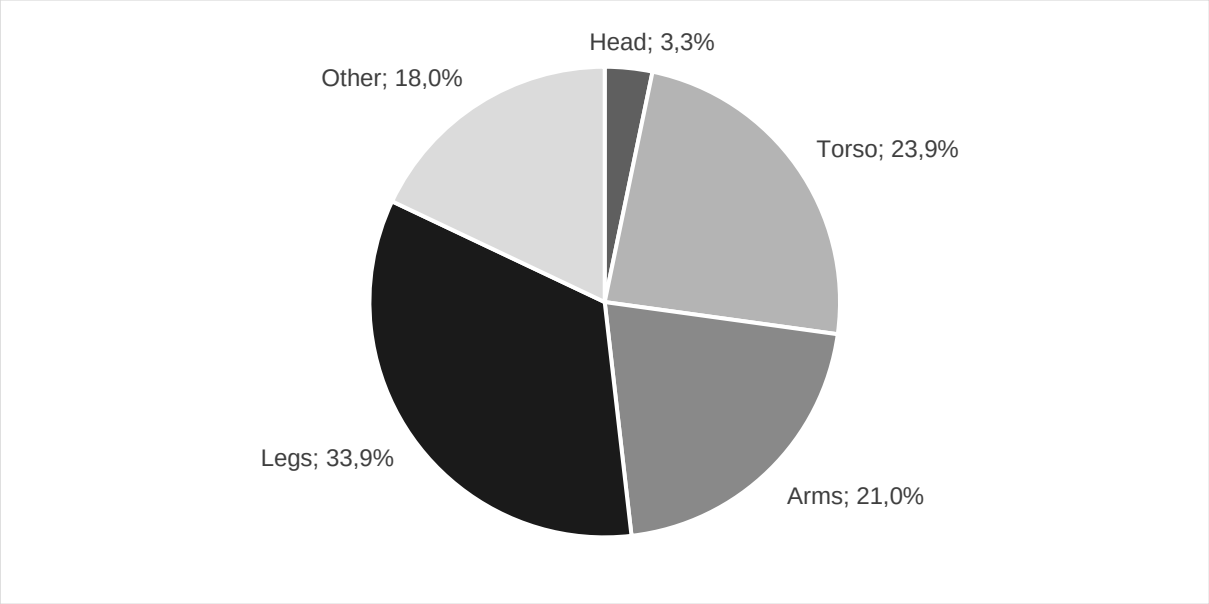

Figure 2 Injuries by affected body region. Source: IDB Austria 2023, KFV

As a rule, there are no cases with serious injuries in the IDB because those involved cannot remember what happened, which means that relevant information is largely missing. Naturally, there are also no cases with fatal injuries. There are also no cases with injuries that are not treated in hospital or do not require follow-up care. Nevertheless, the two analyses show remarkable parallels. Polytrauma occurs in only 2% of all IDB datasets (around 15,000 interviews per year in 15 hospitals), compared to 16% of motorbike users. The legs are the most frequently injured region among motorbike users, followed by the arms. The upper body plays a greater role in serious injuries. It is noteworthy that the head is equally affected in all injury severities - although the head is generally associated with more severe injuries. The considerable difference between IDB and CEDATU is most likely due to the difference in survey methods. People with head injuries are probably rarely seen in hospital for follow-up treatment, whereas such severe cases are likely to end up in court more often than average and thus find their way into the CEDATU.

As for the arms, injuries to the hand and wrist dominate. The same applies to the legs. On the upper body, the shoulder, collarbone and ribs are particularly frequently affected. Whether airbags

can prevent shoulder injuries depends on the product and the interaction with other protective clothing. A broken collarbone is a typical fall-related injury, as are wrist and elbow injuries.

1.4. PPE usage rates

KFV collects data of usage rates of PPE by riders on a regular basis. 14,000 vehicles are observed every year. Locations are representatively spread all over the country. The observation campaign runs for the whole summer on sunny days.

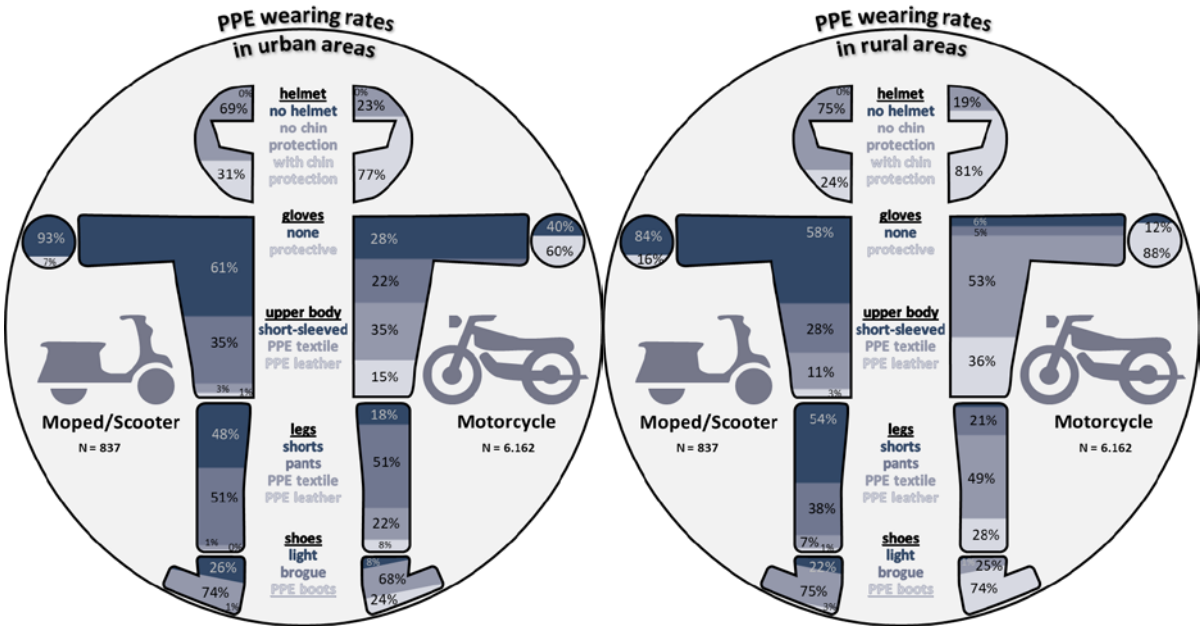

Figure 3: Usage rates of personal protective equipment by body region, vehicle type and location. Source: KFV

Figure 3 shows that a vast majority of moped and scooter riders did not wear any protective equipment, except for the helmet, which is mandatory. Motorcycle riders are dressed much better (in terms of safety). But they also seem reluctant to wear PPE in urban areas.

This kind of analysis is done since 2015. A continuous trend cannot be observed for any of the body regions during this period.

1.5. Risk compensation

This phenomenon was first discussed by Peltzman in regard to safety regulations for cars[5]. The idea can be summed up by the proverb: 'When an elephant gets too comfortable, he goes dancing on the ice.' In concrete terms, it could be that airbag users feel safer and are therefore inclined to drive more riskily. In this way, a preventive effect could be offset or even reversed. The literature study in the run-up to this study showed remarkably diverse results for the occurrence of risk compensation in motorbike safety measures. Taking the example of helmet use: Grimm[6] found

[5] Sam Peltzman: The Effects of Automobile Safety Regulation. In: Journal of Political Economy. Band 83, Nr. 4, August 1975, S. 677–726
[6] Grimm M, Treibich C. Why do some motorbike riders wear a helmet and others don't? Evidence from Delhi, India. Transp Res Part A Policy Pract. 2016; 88: 318–336.

higher driving speeds among helmet wearers, whereas Obst[7] and Ouellet[8] found no compensatory effects at all. To date, there are no known studies on this subject relating to airbag jackets.

2. Airbag jackets

2.1. Products

Airbag jackets are primarily made available for motorcycling and, to a lesser extent, for (horse-) riding, skiing and cycling. They usually vary in their airbag volume (usually between 5 and 20 litres), their deployment speed after the first impact (between 20 and 200 milliseconds), the time required for inflation, the gas composition, the positioning and the pressure of the gas container (which is often kept secret by the company). The ability to replace the gas cartridges yourself after use and the areas covered by the jacket also depend on the model. However, they are most frequently differentiated by their release mechanisms: [9]

- Mechanical deployment: The airbag system is attached to the motorbike with a ripcord; in the event of an accident in which the rider is thrown from the vehicle, the airbag deploys.
- Electronic deployment (usually in newer generations): Sensors on the motorbike or in the jacket itself continuously measure acceleration, rotation and proximity. Algorithms recognise relevant emergencies and trigger the inflation[10].

The manufacturers promise optimum protection just a few milliseconds after activation. Some tests (such as those conducted by the ÖAMTC[11] and the ADAC[12]) show promising results at low speeds, but also indicate that effectiveness decreases with increasing speed. In this test, a dummy on a motorbike was driven at 50 km/h at a right angle between the front wheel and the door against the side of a car. Only systems with electronic activation were used in this test. However, this and comparable tests were critiqued because the simulated collision (motorbike hitting a car at 30 to 40 km/h at the height of the front wheel) did not represent the dangers of more relevant accident sequences (head-on collision of two vehicles in motion or motorcyclists sliding on the road) and was often only carried out with prototypes.

2.2. Scientific studies

A comprehensive scientific study would at least be expected to verify a model by varying different input parameters, i.e. testing different accident constellations at different speeds. Such tests are very time-consuming and expensive, so computer simulation tends to be used instead. This technology is highly advanced and reliable. To obtain meaningful results, the test conditions should reflect the real accident situation as much as possible. Section A.3 has already highlighted the fact that this is challenging. The tests carried out by magazines and associations, which are aimed more at consumers, are also interesting, but lack scientific breadth. They should be considered as additional sources.

[7] Obst, M., Rzepczyk, S., Głowiński, S., & Żaba, C. (2023). Motorbike protective helmets, construction, testing and its influence on the type and severity of injuries of motorbike accident casualties: a literature review. Vibrations in Physical Systems, 34(1).
[8] Ouellet J.V. (2011). Helmet use and risk compensation in motorcycle accidents. Traffic Inj. Prev. 12, 71–81.
[9] Serre, T., Masson, C., Llari, M., Canu, B., Py, M., & Perrin, C. (2019, September). Airbag jacket for motorcyclists: evaluation of real effectiveness. In IRCOBI 2019, International Conference on the Biomechanics of Injury (pp. pp533-547) – S. 3
[10] Aranda Marco, R. (2022). Biomechanical effectiveness assessment of motorcyclist airbags in realistic impact scenarios using human body models (Doctoral dissertation, lmu). – S. 26
[11] https://www.youtube.com/watch?v=3GEs41zd3zI
[12] https://www.adac.de/rund-ums-fahrzeug/zweirad/motorrad-roller/motorrad-fahren/motorrad-airbag-westen/

A study in France[13] attempted to achieve representativeness by analysing 27 real cases of drivers wearing airbag jackets. The results of this study are very similar to the work presented here. The injuries were mostly minor, and the users were satisfied with the effectiveness of the airbags. The authors consider airbags to be predominantly effective up to collision speeds of 30 to 40 kilometres per hour. Aranda[14] also came to the conclusion that the effect of airbags is to be expected above all at rather low collision speeds. Nevertheless, many experts believe that airbag jackets have great potential for widespread use, as less serious injuries such as grazes can be completely prevented in the vast majority of cases, and serious injuries can be reduced or even avoided. Capitani[15] used numerical simulation and attributed an unspecified potential for injury prevention to airbag jackets. [16]. As early as 2006, Bellati ventured a cautiously positive assessment of the potential of airbag jackets in certain accident constellations.

A very interesting contribution was made by Gitelman and Hakkert, who applied Serre's model[13] to Israeli accident data. They arrived at benefit-cost ratios of between 1.0 and 4.5, according to which motorbike protective clothing with airbags would certainly be efficient. However, they judge the evidence for the effect to be too weak for airbags to be advertised on a large scale or even made mandatory.

The German Research Institute “Unfallforschung der Versicherer“ (UDV) investigated the potential of airbags based on fatal real-life crashes. They developed 3 test scenarios and used finite element models to calculate the injury outcome at different impacts speeds. Airbags were found to be effective for the typical impact to the road surface. Little effectiveness was found for pole impacts (diameters 75 and 250 mm) at 50 and 60 kph for the airbags available on the market at that time. UDV found some potential for improved airbags in these scenarios, however, they estimated the vertex of the protective potential of airbags at 70 kph.

3. Survey

3.1. Survey design

The motorcyclists' association has around 500 members. Most of the 250 airbags were purchased by members of this association. A total of 34 interviews were conducted: People with and without airbags, and with and without accidents, although it did not seem appropriate to interview people without airbags and without accidents. The first 50 or so questions were about the person, riding habits and attitudes. A further 50 questions dealt with the accident, whereby questions and answers were taken from the question programme of the official system in Austria[17] (UDM, accident data management) on the one hand, and from the codebook of the ‘Initiative for the Global Harmonisation of (in-depth) Accident Data’ (iGLAD) on the other[18] - especially the more detailed questions. At the end of the survey, three more questions were asked about protective clothing.

[13] Serre, T., Masson, C., Llari, M., Canu, B., Py, M., & Perrin, C. (2019, September). Airbag jacket for motorcyclists: evaluation of real effectiveness. In IRCOBI 2019, International Conference on the Biomechanics of Injury (pp. pp533-547) – S. 3
[14] Aranda Marco, R. (2022). Biomechanical effectiveness assessment of motorcyclist airbags in realistic impact scenarios using human body models (Doctoral dissertation, lmu). – S. 26
[15] Bellati, A., Cossalter, V., Lot, R., & Ambrogi, A. (2006, October). Preliminary investigation on the dynamics of motorcycle fall behaviour: influence of a simple airbag jacket system on rider safety. In Proceeding of 6th International Motorcycle Conference, IFZ Institute for Motorcycle Safety, Cologne (pp. 9-10). – S. 1
[16] Capitani, R., Pellari, S. S., & Lavezzi, R. (2010). Design and numerical evaluation on an airbag-jacket for motorcyclists. – S. 1
[17] https://www.statistik.at/fileadmin/shared/QM/Standarddokumentationen/RW/std_r_strassenverkehrsunfaelle.pdf
[18] http://www.iglad.net/

The interviews were conducted, documented and analysed by the author of this article by telephone in August and September 2024.

3.2. Sample

There were 25 airbag users among the respondents, 11 of whom had already had an accident with the airbag jacket on, 14 of whom had not. 9 respondents stated that they did not wear an airbag, 5 of whom had already had one accident, three of whom had even had several accidents and one of whom stated that he had not had an accident. This person's data set was removed. This left 33 interviews to be analysed. As previously indicated, the interviewees were recruited from the active members of a motorbike club in Upper Austria. Representativeness for all Austrian motorcyclists cannot be assumed due to the size of the sample alone; highly selected variables also exist in the origin, the affinity to club life and how much that influences their behaviour.

3.3. Results

Due to the size of the sample, no attempt was made to find significant differences between the groups. Furthermore, many of the statements were too similar. For example, using the school grading system, almost all interviewees gave themselves a B for their riding ability, which - according to the comments made when answering this question - was to be understood as a ‘modest A’. Most of the interviewees described themselves as ‘rather experienced’, whereby one clearly had the impression that they would have preferred to answer ‘experienced’ but did not want to appear arrogant. Social desirability is therefore a considerable dimension in the responses.

The youngest respondent was 34, the oldest 75, the average age was 60, airbag wearers were on average about a year younger. 27 respondents were male, 6 female, including 5 airbag wearers. Among the interviewees, there were, from an educational perspective, 25 with apprenticeship training, 3 high school graduates and 5 university graduates, with no significant differences in terms of the airbag wearer rate. There were 26 people in cohabiting relationships in the sample; there was no difference in the airbag wearer rate compared to people with a different marital status. 27 of the 33 respondents lived in Upper Austria, including all airbag deniers. Airbag wearers have an average of 1.96 children, airbag deniers only 1.16.

With regard to the frequency of motorbike use, no differences could be found between airbag wearers and airbag deniers. Most respondents stated that they ride several times a week or several times a month. Around a quarter are (also) functional riders, i.e. people who use their motorbike for essential journeys. The proportions of accident riders and airbag wearers among the functional riders are negligible. Airbag wearers and people who have already had accidents predominated among riders who like to ride fast and in a sporty manner on the road. The vast majority of respondents stated that they often or almost always ride for fun. It is therefore not striking that all accident riders and airbag wearers belong to this subgroup. When it comes to the frequency of riding in a group, the middle characteristics ‘often’ and ‘sometimes’ dominate. The same applies to long-distance journeys, although the interviews gave the impression that the threshold for what counts as a ‘long-distance journey’ was set rather low. There were no long-distance travellers among the interviewees. The annual mileage reported by the airbag wearers was remarkably higher (9,400 km) than for the airbag deniers (3,900 km), and slightly lower for the riders who had had accidents (7,700 km) than for the accident-free drivers (10,200 km). The interviewees predominantly stated that they usually travelled in a group, while those who were airbag-averse tended to drive alone.

The sample was sensitive to weather conditions. Only 4 of the 33 interviewees stated that they rode all year round. This was also the subgroup that stated that they also rode in rain, and in very high or very low temperatures. Regarding rain, most of them said that they would probably finish trips in the rain, but do not set off in the rain.

3.4. Accidents

Only 3 of the 25 drivers involved in accidents collided with another road user. For 16 of them, the primary impact was on the road surface, whereas for 6 riders it was an impact with objects on the side of the road. Almost all of them were separated from the vehicle during the collision, causing the airbag to deploy. 9 remained uninjured, 10 suffered minor injuries and 8 serious injuries. Nevertheless, in almost three quarters of the accidents, neither the police nor the emergency services were called. Regarding this, a quick crosscheck was done comparing the IDB and Austrian police-recorded crashes. This comparison[19] suggests that slight less (motorcycles) or more (mopeds) of hospital-treated injuries are not reported to police and hence, do not appear in official crash statistics. The “Dynamics of motorcycle crashes” survey by Hardy et al[20] included 1,578 included about 1/3 of property-damage-only crashes, studies like these appear to be a more reliable source for the definition of a “typical” motorcycle crash in general, but in particular for analysing the potential of protective equipment.

Only one of the accident riders was wearing everyday clothing at the time of the accident, whereas all the others were wearing full motorbike clothing, mainly textile-based. Almost all accidents happened in daylight and good weather. 17 of the accidents happened on bends, 10 on straight roads.

Only one of the accident victims had to be treated in an intensive care unit; in most cases the injuries were bruises and abrasions. For eight persons, the injuries were considered “severe”. Eight ribs were broken in one person not wearing an airbag. Two arms broke, one person wearing an airbag broke both ulna and radius and she also sustained contusions and abrasions on her hands and legs; one person not wearing airbag, who also dislocated and broke a shoulder. One person without airbag sustained a rotational fracture of a lower leg. One person without airbag fell onto her recently operated shoulder, an oedema of the medulla was caused. One person without an airbag broke his clavicula and a finger. Two of the interviewees sustained multiple severe injuries; one of which wearing and airbag and one who did not. The injury pattern was quite similar, multiple fractures of legs and arms, and a cervical vertebra. The person without airbag in addition sustained a fracture of the collarbone and multiple rib fractures. The crashes of these two persons were the only two in the sample which involved a collision speed of 100 km/h or more.

It was difficult to analyse the causes of the accidents because neither the classification according to the Austrian accident data management system nor that according to iGLAD could adequately reflect the actual causes. All collisions with other road users were described in a broader sense as priority / give way violations committed by the other party. The rest were self-inflicted, with the majority of interviewees describing the cause as ‘rider error’. Slippery spots were often not recognised as such or not recognised in time; in these cases - although not entirely correct - inappropriate speed was recorded as the cause of the accident. In a few cases, unexpected but not incorrect behaviour on the part of other road users - in some cases also from their own

[19] Austria, 2021-2023: Mopeds: 3,100 injuries in police reports, 7,800 according to IDB extrapolation. Motorcycles: 3,900 police, 7,100 IDB.
[20] Hardy, E., Margaritis, D., Ouellet, J., & Winkelbauer, M. (2020). The Dynamics Of Motorcycle Crashes: A Global Survey of 1578 Motorcyclists. See proceedings of the 2020 ifz conference for a summary of the results!

motorbike group - triggered the respective riding error. In two cases, it was clearly determined that the cause was that the rider was unable to achieve the necessary lean angle with the given cornering radius and selected speed.

3.5. Risk compensation

When asked whether their riding style had changed as a result of the airbag, 18 people answered categorically with ‘not at all’, 5 others - mostly rather hesitantly - with ‘a little’. It is known that socially desirable answers are often given to such questions, often because the respondents perceive themselves to be better behaved than they actually are. Therefore, the (‘projective’) question is asked as to how they believe other motorcyclists are. This question was answered by 12 people with ‘a little’, three respondents said that airbag wearers ride completely differently. Of the 15 answers on how their own riding style might change, around a third cautiously indicated a greater willingness to take risks - this was the case for 17 of the 18 answers to the projective question. The percentage of all injuries that were perceived to be preventable by airbags ranged between 20 and 95%, with an average of 58%. This is more than could actually be prevented due to the body regions injured. The respondents therefore overestimated the safety potential. Airbag wearers who had a fall predominantly escaped without injuries to the upper body and unanimously attributed this to the airbag.

3.6. Protective clothing

As the above data shows, the respondents wore protective clothing more often in the accidents than observations on motorbike routes indicate. In this context, it should be mentioned that the motorbike club also organises events several times a year with manufacturers and dealers of protective clothing, which are almost always associated with the opportunity to purchase at a discount. The frequently asked issue of how to choose motorbike clothing was raised. A total of 20 of the 31 responses mentioned ‘safety’ as a criterion, of which safety was mentioned eleven times as the first criterion. 7 of the respondents understood the question differently and mentioned information channels, most frequently advice in specialist shops, magazines and tests, as well as personal recommendations and clear brand preferences. In terms of motives, wearing comfort, weather resistance and visual appeal were mentioned in descending order of frequency.

4. Standards

Austrian Standards has made available 20 standards that free of charge for this article on the subject of motorbike safety, all of them standards at European level. Six of these deal with ‘restraint systems’, more commonly known as ‘guard rails.’ The issue here is that fallen motorcyclists can slip under the guard rails and come into contact with the uprights, which can cause extremely serious injuries. The standard deals with so-called ‘under rails,’ i.e. a kind of deflector for fallen motorcyclists. The problem that remains unresolved to this day is that motorcyclists can also fall over the guardrail and come into contact with the uprights.

The EN 17092 series of standards deals with clothing of various safety classes, the four-part EN 1621 series with protectors (including inflatable ones), and three others with shoes, gloves and eye protection, as well as one with impact protection for off-road motorbikes.

4.1. Significance

There is only a legal obligation for motorcyclists to wear personal protective equipment in the form of helmets. The helmet requirement was introduced in Austria as Art IV of the 4th amendment to the Motor Vehicle Act (KFG, Kraftfahrgesetz) on 1 January 1977. However, until the introduction of penal provisions for motorbikes on 1 January 1985 and for mopeds on 1 January 1986 (Federal Law Gazette No. 253/1984), riding without a helmet was only a partial offence in the event of an accident. An offence was initially punishable with a fine of 100 Austrian Schillings (7 Euros). With the 26th KFG amendment (Federal Law Gazette I No. 117/2005), the provisions were incorporated into § 106 KFG about passenger transport without any further substantial changes. From a technical point of view, there has recently been a change. The 69th amendment to the KDV 1967 (the bylaw to the motor vehicle act published in Federal Law Gazette II No. 91/2024) stipulates that from 1 January 2025, only helmets that comply with the latest (sixth) version of ECE Regulation R22 may be offered for sale. This also applies to the sale of second-hand goods on sales platforms. We strongly advise against buying second-hand motorbike helmets anyway. Accident damage may be present but not even recognisable to experts.

The footnote to Federal Law Gazette No. 548/1988 states: ‘Since the Austrian notification concerning the application of Regulation No. 22 was received by the Secretary-General of the United Nations on 29 May 1987, this regulation entered into force for Austria on 28 July 1987 in accordance with Art. 1 para. 8 of the aforementioned Convention.’ The technical regulations of the European Economic Commission (ECE) of the UN have therefore applied in Austria since this date.

There is no obligation to use other protective equipment. However, since autumn 2015, anyone who does not wear protective clothing when riding a motorbike must expect a reduction in the pain-and-suffering allowance. In 2Ob119/15m, the Supreme Court stated analogously that the use of protective clothing is expected, and the negative consequences of non-use are known to such an extent that a motorcyclist must accept partial responsibility for the consequences of non-use. For the injuries that would have been prevented by protective clothing, the pain-and-suffering compensation should thus be reduced by 25%. The reduction in pain-and-suffering compensation for a speeding cyclist without a helmet was based on similar considerations a year earlier (2 Ob 99/14v). The Higher Regional Court of Vienna ruled in 15 R 38/17v that even 35 degrees C outside temperature should not stand in the way of the application of the principle of ‘motorbike protective clothing contributory negligence’. It has not yet been decided whether this should also be applied in inner-city traffic, as both cases have a significant component of the use of the motorbike outside urban area.

In order to assess which injuries could have been avoided through the use of protective clothing, it is essential to know the performance of protective clothing.

4.2. Types of outerwear

In the standards of the EN 17092 series for three safety levels (AAA, AA and A in parts 2 to 4 of the standard), requirements are specified for all types of outerwear, i.e. jackets, trousers, combinations and one-piece suits. Part 5 (Class B) deals with jackets without protectors and Part 6 (Class C) with protectors without jackets (these are garments whose primary purpose is to hold the protectors in place). To determine the abrasion resistance, the body regions (1 to 3) are categorised according to how much stress they are subjected to in the event of a fall, and

requirements are defined in each case. Test procedures and criteria are also defined for seams, impermeability, tear resistance of the material, fasteners, pockets and wearing comfort.

4.3. Protectors

With regard to protectors, EN 17092 only specifies in Part 1 where they should be - again depending on the safety class. Shoulder and elbow protectors for jackets and knee and hip protectors for trousers are mandatory for all safety classes, while lumbar, chest and back protectors are optional in some cases. The most important thing for the user is the mandatory labelling. However, there are also extensive regulations in the standard regarding the content of the user manual, including what the respective item of clothing is to be used for, what can and cannot be expected in terms of safety, as well as cleaning and other practical aspects.

The technical regulations for the protectors themselves are set out in the EN 1621 series of standards. Essentially, they deal with minimum sizes and impact absorption. Of particular importance here is the labelling, which allows consumers to recognise which area the protector is for, how well it absorbs impact (performance class), which area is covered (type A or B) and whether the special tests for particularly high and particularly low temperatures have been passed.

4.4. Airbags

The technical regulations for ‘inflatable protectors’ can be found in Part 4 of EN 1621. The system follows the other standards. The innocuity, body parts that must be protected, retention capacity, shock absorption properties, wearing comfort and mandatory contents of the instructions for use are specified. As is logical for airbags, the speed of inflation and deployment is also specified.

4.5. Other elements of protective clothing

The standard for motorbike footwear specifies test methods and quality levels for four criteria: height of the upper part of the shoe, impact abrasion resistance, drop cut resistance and lateral stiffness. There are also requirements for the lining, sole, comfort and chemical resistance.

There are similar requirements for motorbike gloves in EN 13594, here in the same order as in the standard: innocuity, hard inserts, ergonomics, size and cuff length, adjustment system, tear resistance, seam strength, cut resistance, impact abrasion resistance and impact absorption. Of course, it is specified how each of these properties is to be tested and assessed, what the conformity label should look like and what must be included as a minimum in the operating instructions.

For eyewear, optical properties are also added to the mechanical properties. The regulations cover fit, ventilation, the minimum size of the field of vision, resistance to and permeability of ultraviolet and infrared radiation, fogging protection, contents of the operating instructions and labelling.

4.6. Survey

Half of the respondents stated that they knew that there are standards for determining the safety of motorbike clothing. Without exception, all respondents would find it clearer if there was a standardised label that showed the safety of an item of clothing at a glance. During the interviews, it was clear that very few people had precise knowledge of the current mandatory labelling.

As the above comments clearly show, it is not made easy for consumers. The labelling of protective clothing is far from self-explanatory; garments and protectors must be assessed separately. If you don't take a close look at the labelling and don't have a suitably knowledgeable advisor, the buying experience can be a shot-in-the-dark, so to speak. It is urgently advisable to send a clear and easily understandable message. This could be done with labels such as those that must be attached to refrigerators with regard to energy efficiency - with a colour-coded representation - or a star rating, as is common in vehicle safety.

5. Summary and conclusions

A number of studies have been carried out on the effectiveness of airbag jackets in preventing injuries while riding motorbikes. However, these studies do not yet have sufficient breadth to justify large-scale campaigns in favour of their purchase or even an obligation to use them. The respondents in this study generally overestimated the preventive effect of airbags, on average with the avoidance of 58% of injuries, with around 55% of motorbike injuries occurring on the legs and arms alone. It depends on the individual product in combination with other protective equipment whether protective effects can be expected also for legs, arms, shoulder and pelvis. Scientific evidence indicates that airbag jacket are effective predominantly at low impact speed, e.g. an impact to the road surface. Severe injuries as occurring at high impact speed (> 50 kph) are less likely to be affected, above 70 kph, no effect can be expected in collisions with rigid objects.

The survey shows that the idea that airbag use could lead to more pronounced risk behaviour is not unfounded. However, this finding is mainly based on projective questions and would at best have to be verified by means of a ‘field operational test’ (FOT), i.e. a before-and-after investigation under observation of the driving dynamics.

The survey on accidents revealed that in a large proportion of accidents neither the emergency services nor the police were notified despite injuries having occurred. For accident researchers, this indicates a high number of unreported cases, which was previously known for bicycle accidents but not for motorbike accidents. This fact needs to be investigated in more detail, especially as it limits the validity of research based on accidents involving personal injury. The interviewees could be right suggesting that airbags avoid 58% of all injuries, because statistics (55% injuries of extremities) do neither include upper body injuries that were not reported to the police or even did not occur due to the protective effect of an airbag. Surveys among riders might be a more reliable source to investigate the impact of protective equipment. I would probably be more relevant asking what injury a rider would have sustained without an airbag instead of arguing, what injuries could be prevented by airbags.

Concerning the relation between injury severity and airbag wearing, the sample is too small to allow for precise conclusions. There is some indication that airbag wearing mitigates upper body injuries. The data also supports the hypothesis that airbags do not (fully) prevent severe injuries of the upper body in high-speed crashes.

It was also found that respondents most frequently cited *driver error* as the cause of the accident, which could not be correctly documented either in the official accident statistics or in scientifically orientated databases.

European standards allow for an accurate assessment of motorbike protective clothing. There are technical regulations for the clothing itself, the protectors, airbags, goggles, shoes and gloves. Half of the respondents stated that they were aware of this. The standards also regulate the conformity label to be applied, but the respondents were hardly familiar with these, while safety was considered by the majority to be the most important criterion when making purchasing decisions. It is therefore necessary to simplify the assessment of the protective effect for the consumer. The ratings of the individual components should be combined into a prominent and easy-to-understand overall rating, for example in the style of a star rating at Euro-NCAP or the European labels for lamps, refrigerators or car tyres.

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