



The risk of whiplash-induced medical impairment in rear-end impacts for males and females in driver seat compared to front passenger seat



Bertil Jonsson ^{a,*}, Claes Tingvall ^b, Maria Krafft ^c, Ulf Bjornstig ^a

^a Department of Surgical and Perioperative Sciences, Division of Surgery, Umea University, SE-901 85 Umea, Sweden

^b Swedish Road Administration, SE-781 87 Borlange, Sweden

^c Folksam Research, SE-106 60 Stockholm, Sweden

ARTICLE INFO

Article history:

Received 30 December 2012

Received in revised form 31 March 2013

Accepted 3 April 2013

Keywords:

Rear-end impact

Whiplash

Gender

Driver seat

Front passenger seat

ABSTRACT

The objective of this study was to study whiplash injury outcome in front-seat occupants in rear-end impacts using double paired comparison technique. The combination of gender, seated position, and outcome was analyzed. Folksam, a Swedish insurance company, has a database of whiplash injuries. A questionnaire was used to collect study data. The response rate was 81%. The inclusion criteria included medical impairment one year after the impact, as judged by medical specialists. The study included rear-end impacts between 1990 and 1999 that resulted in at least one permanent neck injury impairment; in total, 430 impacts with 860 occupants and 444 impairments. Of those suffering impairment, 302 were female and 142 male; 235 were seated in the driver's seat and 209 in the front passenger seat. Relative risk estimates for impairing whiplash injury, by gender and seated position:

1. Driver male (DM)/passenger female (PF) relative risk = 0.5 n = 218
2. Driver male (DM)/passenger male (PM) relative risk = 1.4 n = 57
3. Driver female (DF)/passenger female (PF) relative risk = 2.5 n = 102
4. Driver female (DF)/passenger male (PM) relative risk = 4.6 n = 67.

Females had a relative risk of medical impairment of 3.1 compared to men after adjustment for the average increased risk in the driver position. The driver position had a doubled relative risk compared to the front passenger position. As a conclusion it may be of value to take risk differences between male and female occupants and between driver and front passenger positions into account in future automotive car and seat construction.

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1. Introduction

Whiplash injuries caused by automotive collisions are a major health problem, because of the long-term consequences. Many researchers have found that females have higher whiplash injury risk than males [1–13]. This is also true in case of rear-end collisions, where females have a 60–140% increased risk compared to males [14,15]. Female drivers involved in rear-end impacts, have been found to have neck pain in 45% of

the cases, and for males the corresponding figure was 28% [3]. Females also have increased disability rates compared to males [9,16].

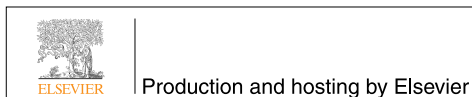
A study with data from the Volvo accident database found a significant injury risk difference between driver and front passenger position for both genders [17]; females and drivers were both more prone to sustaining whiplash injuries. Other Swedish researchers have showed that drivers had an increased risk ratio of 1.78, and front seat passengers an increased risk ratio of 1.4 in comparison to rear seat passengers [18]. An analysis of Folksam real-world rear-end impact reports that females in the driver position had a threefold increased risk of becoming disabled, compared to males in the driver position; male driver risk set to 1 [9]. They also found that females in the front passenger position had a 1.44 increased risk compared to male drivers; however, males showed only a minor difference between the driver position and the male front passenger position, the latter of which had a slightly lower risk of 0.91 (male driver risk set to 1.0 in both comparisons).

In order to control for impact severity, this study is restricted to rear-end impacts in which there were two occupants in the front seats, at least one of whom sustained a whiplash injury with resulting

* Corresponding author at: Vasteralnas 107, SE-894 91 Själevad, Sweden. Tel.: +46 70 250 47 54; fax: +46 660 89626.

E-mail address: bertil.jonsson@mail.se (B. Jonsson).

Peer review under responsibility of International Association of Traffic and Safety Sciences.



permanent medical impairment. The combination of gender, seated position, and injury outcome was analyzed.

2. Material and methods

Folksam, a Swedish insurance company, has a database of traffic injuries. For this study, which is a study with similar methodology as in an earlier Folksam study [9], we selected a larger and more specified data set. Included was all whiplash injuries WAD 1–4, reported to Folksam during 1990–1999, from rear impacts with both a driver and a front seat passenger in the struck car. Information about seating position, age, stature, weight, and gender was received from the company’s injury file and the questionnaire administered by Folksam to the impaired occupants. The same data was collected for the uninjured occupants by the same questionnaire. The questionnaire was sent out in 2002, and the response rate was 81%. This is thus a register study and by answering the questionnaire the respondents were giving informed consent to participate.

In the whole Swedish population between the ages of 16 and 84, males have a mean age of 46 and females a mean age of 47. Between 1996 and 1999, the mean stature in this age group was 179 cm for males and 165.4 cm for females, and mean weight was 80.2 kg for males and 65.6 kg for females [19]. These figures give a male BMI of 25 and female BMI of 24.

The inclusion criteria for the subjects were: ≥18 years for the driver, and ≥16 years or ≥150 cm stature or ≥50 kg in weight for the front seat passenger. The rear-end impact direction was between the directions of 5 o’clock and 7 o’clock on the struck car, distributed as follows: 5 o’clock, n = 12 (3%); 6 o’clock, n = 390 (90%); and 7 o’clock, n = 28 (7%). The data set used included vehicles with a driver and a front seat passenger on board, according to the principles of double paired comparison [21].

In Sweden, the criteria for determining the extent of permanent medical impairment are related to loss of physical function, pain, and mental dysfunction regardless of cause and without regard to the injured occupation, hobbies or other special circumstances, as described in a manual and evaluated by a physician, preferably a specialist in suitable specialty [20]. The final degree of impairment in percent is usually not settled until some years after the injury event, when the condition is regarded as stationary: a preliminary estimation is, however, determined about a year after the injury event. In this study, all cases had been given a preliminary determination of medical impairment, but a final decision on exact degree of impairment was not always settled. However, the final judgment of degree of impairment is usually the same as, or higher than, the degree determined in the preliminary estimation. Sequela of medical impairment in the neck is graded to maximum of 18%.

3. Theory/calculation

The calculations were built on matched pairs, with occupants in the same vehicle being classified according to seating position and gender. Ideally, if there was no increased risk for position and/or gender, the same number of drivers and front seat passengers would be injured. Thus, deviation from these ideal risks could be detected via the matched pairs.

In probability (p) terms, the matched pairs could be expressed as follows:

Driver to passenger: pD/pP	Male to female: pM/pF
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Four different occupant situations could be identified:

1. Driver male (DM)/passenger male (PM)
2. Driver female (DF)/passenger female (PF)
3. Driver male (DM)/passenger female (PF)
4. Driver female (DF)/passenger male (PM).

If the seating position in itself was a risk factor, with the same increased risk for both genders, then the first two combinations would generate the same ratios; while if gender was also a risk factor, the combinations with a male driver and female passenger and vice versa would generate a risk combination of gender and position. In the analysis, the influence of position was computed first, and the risk factor for position was then used to isolate the influence of gender.

4. Results

The study population represented 430 impacts with 860 occupants, 444 of whom were medically impaired; 143 males, 301 females, 235 drivers, and 209 passengers, whose characteristics are presented in Table 1.

The number of medically impaired males and females in different seating positions are presented in Table 2 and in Table 3 are the relative risk calculations presented.

The seating position ratios were 1.4 for male driver and male passenger, and 2.5 for female driver and female front passenger, indicating a nearly doubled risk for the driver compared to the front passenger. The average of 1.95 was then used to extract the influence of gender. The risk ratio varied between 4.6 (driver female/passenger male)/1.95 (female/male) = 2.35 for one combination and 1.95 (male/female)/0.5 (driver male/passenger female) = 3.8 for the other, and an average of 3.1 (2.35 + 3.8 = 6.15/2). That is, the risk for a female was more than threefold that for a male.

5. Discussion

The impaired occupants had almost identical mean stature, weight, and BMI to the Swedish population of the same age group (16–84 years), though mean ages differed; the mean age among the males of the study group was four years less than the mean age among the males of the whole population, while the gap for females was slightly larger, mean age being six years less for the study group than the whole population. Since the response rate was high, 81%, and as the male/female distribution did not differ between the study and the drop-out group our presented data for the study population can be regarded as representative for the whole group.

The level of impact violence is known to influence the severity of whiplash symptoms [22–24]. However, this factor was eliminated in the present study, since both occupants in the struck car were exposed to the same impact violence; in order to ensure this, the only rear-end

Table 1

Age, stature, and weight (mean, standard deviation, and number of cases) and BMI of the mean case, divided by gender and seating position, among the 444 medically impaired occupants.

Seated position–gender	Age			Stature			Weight			
	Mean (yrs)	SD (yrs)	No. of cases	Mean (cm)	SD (cm)	No. of cases	Mean (kg)	SD (kg)	No. of cases	BMI
Driver – female	38	12	127	166	6	128	66	12	127	24
Driver – male	45	16	103	178	7	107	82	11	106	26
Passenger – female	44	15	169	165	7	173	67	14	172	25
Passenger – male	38	16	36	178	8	36	81	15	36	26

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