VEHICLE DESIGN AND INJURIES SUSTAINED BY FEMALE DRIVERS

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ABSTRACT

It has long been recognised that male drivers are at greater risk of being killed in a road crash than female drivers. What is less well recognised is that female drivers have a higher risk of being seriously injured in a road crash.

One factor that has been identified as contributing to this trend is that women tend to be less robust than men. Female drivers also tend to sit closer to the steering wheel and this may increase the likelihood of injury in a crash. The issue has taken on greater significance with recent reports of children and small adults, mainly women, killed or injured by the deployment of airbags in crashes.

The current study analysed the factors relating to the seating position of male and female drivers.

INTRODUCTION

In Australia during 1995, female drivers of cars were 17 per cent more likely than male drivers to be seriously injured in a road crash for every kilometre travelled (FORS Monograph 12). Female driver fatalities also rose in 1995. During 1995, there were 209 female drivers of cars killed on Australia's roads. This represented a substantial increase over the number killed in the previous year (177) and was the highest since 1991 (219). Generally, road crash fatalities have been declining since 1989, so this marked increase in female driver fatalities evident in 1995 was a disturbing trend.

A similar trend has been noted in the United States of America. The US Department of Transportation's National Highway Traffic Safety Administration released a report in 1994 which found that the risk of being fatally injured has been increasing for female drivers.

Another important consideration is the relative physical robustness of men and women. Female drivers are more likely to be killed or seriously injured than male drivers in crashes of equivalent severity. Thus some of the apparent levels of risk may relate to their vulnerability rather than their actual driving behaviours.

In the USA, Evans (1991) has suggested that between the ages of 15 and 45, women are 25 per cent more likely to be killed than men when subjected to the same physical impact. Evans also cited Foret-Bruno who compared injury outcomes for similar severity crashes, finding that women were around 20 per cent more likely to be injured than men.

Part of the greater vulnerability of women could be that they tend to sit closer to the steering wheel than men and the chance of a head strike is greater. The introduction of airbags has added a new dimension to the problem. There have been incidences of children and small adults being fatally injured by airbag deployment, in part due to their proximity to the airbag, which in the case of drivers is located in the steering wheel. A number of authorities, including the Federal Office of Road Safety, have issued warnings on the danger of sitting too close to the steering wheel (FORS Monograph 13).

Parkin, Mackay and Cooper (1993) have shown that women do indeed sit closer to the steering wheel than men and are therefore more prone to head strikes. Parkin et al did not investigate possible explanations for the observed difference in sitting distance. The current study considered a number of issues. Is the observed difference a genuine sex difference? If women drive smaller cars than men, do they sit closer because of the smaller occupant space of the vehicle? Or is the difference related to physical size of the individual so that, in fact, the observed difference is not one of sex but rather one of physical size? If the observed difference is due to physical size, is the length of the arm more important than the length of leg or vice versa?

METHOD

Design

The research involved measuring the driver's position in the car and driver characteristics such as sex, weight, height, length of leg, length of upper arm and length of lower arm. The model of car was also recorded.

Sample

Data were collected by volunteer students of the University of Newcastle from 300 drivers in the car parks of popular shopping centres in Newcastle, New South Wales. Participants were stratified by the size of the car they were driving and sex. Table 1 has details.

Table 1.
Sample size by characteristics of drivers.

	Male driver	Female driver
Small car	50	50
Medium car	50	50
Large car	50	50

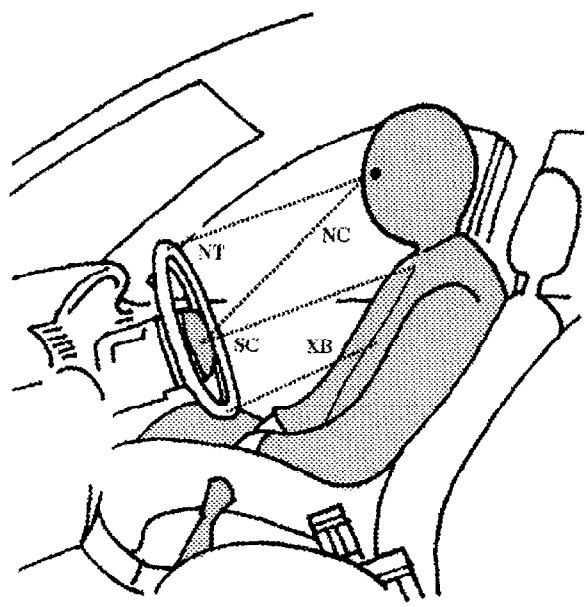
Drivers were approached to participate in the study. They were asked to sit in a normal driving position and measures were taken with a tape measure. The driver's weight was recorded on the basis of self report.

Measures

The distances measured in the study are illustrated in Figure 1. All distances given are in centimetres. Weight is in kilograms. Distances measured included from the nasion to the top of the steering wheel (NT), from the nasion to the centre of the steering wheel (NC), from the sternum to the centre of the steering wheel (SC) and from the xiphistemum to the bottom of the steering wheel (XB).

The driver's height (H), weight (W), length of upper arm (UA), length of lower arm (LA), and length of leg (L) were also recorded.

Figure 1
Measures of distance of driver from the steering wheel.



RESULTS

Analysis confirmed that men and women differed on most of the attributes measured in the study. Table 2 has details of means, standard deviations (SD) and statistical significance (p-value of t-test). Figures 3-5 plot distance from the steering wheel by percentiles for male and female drivers.

Table 2
Comparison of male and female drivers.

	Male drivers		Female drivers		
Measure	Mean	SD	Mean	SD	*p-value*
H	178.1	7.3	164.6	7.3	*.001*
W	77.0	11.7	65.0	13.2	*.001*
UA	32.2	3.2	30.5	4.2	*.001*
LA	25.4	3.6	23.1	2.3	*.001*
L	51.9	5.5	48.6	4.7	*.001*
NC	51.0	4.7	46.4	4.9	*.001*
NT	48.6	5.2	44.0	5.1	*.001*
SC	50.0	4.8	45.1	5.4	*.001*
XB	30.5	5.4	27.4	5.6	*.001*

Male drivers are taller, heavier, have longer limbs and sit further from the steering wheel than female drivers. All these differences are significant at $p<.001$. The difference of 4.6cm for NC is comparable with the difference of 5.2cm found by Parkin, Mackay and Cooper (1993).

Analysis of vehicle size, driver characteristics and sitting distance from the steering wheel is given in Table 3. Drivers of larger cars tended to sit marginally closer to the steering wheel than drivers of smaller vehicles. ANOVA results confirmed that these differences were significant for NC, SC and XB. The results for NT were in the same direction but did not reach statistical significance. Drivers of larger vehicles tended to be heavier than drivers of smaller vehicles. There was no statistically significant difference in height.

Table 3
Vehicle size, driver characteristics and average distance of driver from the steering wheel.

Measure	Small car	Medium car	Large car	*p-value*
NT	47.2	46.0	45.8	*.150*
NC	49.7	48.7	47.8	*.048*
SC	48.8	47.6	46.4	*.012*
XB	30.1	28.6	28.1	*.037*
H	171.7	171.6	170.7	*.716*
W	69.9	68.5	74.7	*.004*

The variables of interest were entered into a MANOVA to test whether sitting distance from the

Figure 2.
Distance from nasion to top of steering wheel (cms)

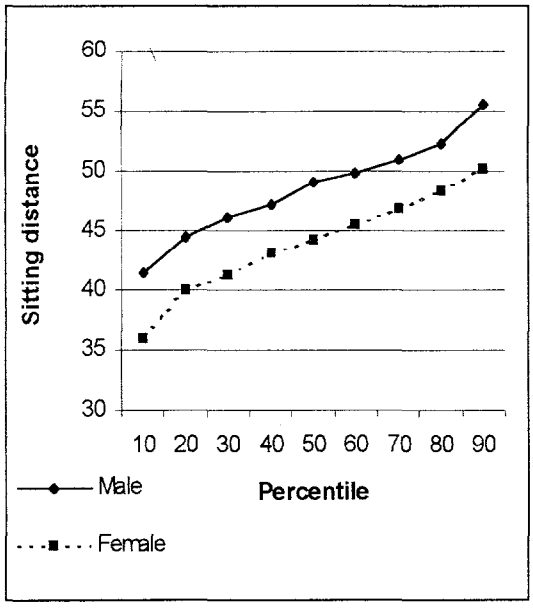
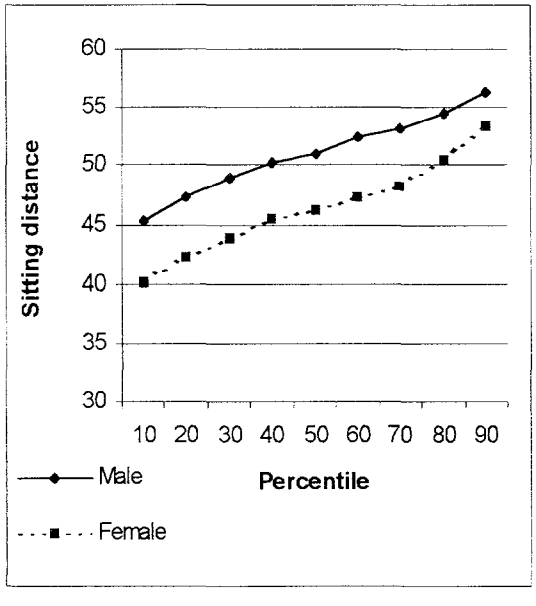


Figure 3.
Distance from nasion to centre of steering wheel (cms)



steering wheel was related to sex and vehicle size when the physical characteristics of the driver were taken into account. NC, NT, SC and XB were the dependent variables in the MANOVA with H, W, UA, LA and L, as covariates.

Overall, sex of the driver is not related to sitting

Figure 4.
Distance from sternum to centre of steering wheel (cms)

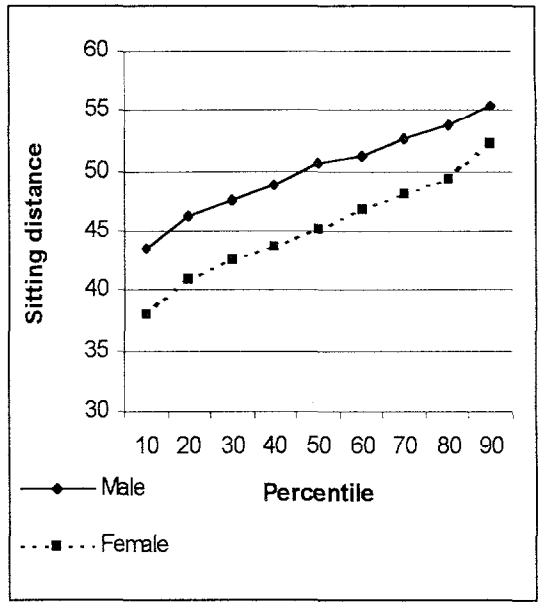
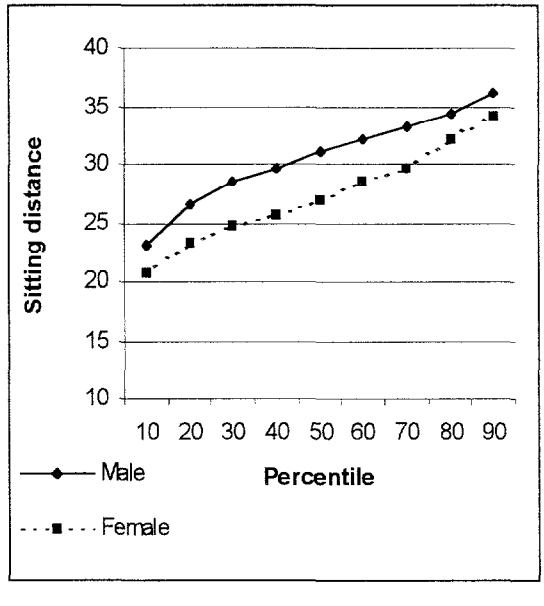


Figure 5.
Distance from xiphistemum to bottom of steering wheel (cms)



distance from the wheel once the covariates are taken into account ($p=.495$). None of the individual measures of distance had a significant F statistic. Vehicle size was related to sitting distance ($p=.034$) although only NC and SC had significant individual F statistics.. The sex by vehicle size effect was not significant ($p=.841$).

In terms of the covariates, it is the height of the driver which is the statistically significant variable. Table 4 summarises the t-value for each of the dependent variables and covariates.

Table 4
t-value for each of the dependent variables and covariates

Covariates	Distance from the steering wheel measures			
	NT	NC	SC	XB
L	t=0.4 *p=.69*	t=0.1 *p=.94*	t=1.2 *p=.23*	t =0.3 *p=.80*
UA	t=1.1 *p=.29*	t=0.8 *p=.45*	t=-0.8 *p=.40*	t=-0.3 *p=.76*
LA	t=1.0 *p=.32*	t=0.2 *p=.85*	t=1.4 *p=.16*	t=2.5 *p=.01*
H	t=6.2 *p=.00*	t=7.5 *p=.00*	t=7.1 *p=.00*	t =7.4 *p=.00*
W	t=0.3 *p=.75*	t=1.1 *p=.27*	t=-0.1 *p=.86*	t=-3.7 *p=.00*

With respect to measures of the distance of the head (NC, NT) and sternum (SC) from the steering wheel, observed differences between male and female drivers can be accounted for by height, and, in fact, no other covariate is significantly related. The results for XB suggest that height, weight and length of the lower arm are significant covariates.

DISCUSSION

The major finding of this study suggests that seating distance from the steering wheel is a function of the driver's height rather than the driver's sex. Men and women of similar height sit at a similar distance from the steering wheel. This is an important finding because it suggests that the debate over the appropriate parameters for dummy placement in crash tests should relate to the height of the driver population rather than its sex composition. This is not to deny that women are disadvantaged by a practice which sets the test parameters at those relevant to the 50th percentile male driver but this disadvantage is due to the fact that women, on the whole, are shorter than men. It is not being a woman per se that is the issue.

In light of this, warnings about sitting distance in vehicles fitted with airbags, such as that issued by the Federal Office of Road Safety (FORS Monograph 13, 1996), should not necessarily single out women. All short drivers are at a greater risk and the message might be better directed without reference to the sex of the driver.

This finding is also important because it suggests that driver height may be a reasonable approximation for sitting distance from the steering wheel. The use of this surrogate variable could be of value in road crash research or vehicle design development related to driver seating position.

Finally, this finding implies that, as height is rather inflexible, it may not be an easy task to design a vehicle so as to maximise sitting distance from the steering wheel. For very short drivers, there may even be an argument that wearing a seat belt is a much preferable strategy to the use of an airbag.

The second finding of the study was that drivers of larger cars tended to sit closer to the steering wheel than drivers of smaller cars. The reasons for this are not clear. Larger cars tend on the whole to have more backward space for seat adjustment and one might expect that this would imply that drivers of larger cars might sit further from the steering wheel.

While there was no significant difference in the height of drivers by vehicle size, the drivers of larger vehicles tended to be heavier than the drivers of smaller vehicles. This could well explain the significant results for SC and XB where body girth would influence the measurement. It does not explain the significant finding for NC. This measure, however, was of borderline significance and given the lack of significance for the associated measure NT, perhaps some doubts remain as to the robustness of this finding. It may simply be that larger people drive larger cars and their girth will influence some measures of sitting distance from the steering wheel.

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