

## **Accommodation of low birth weight babies in dedicated and convertible rearward facing child restraint systems**

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### **Introduction**

Child restraint systems (CRS), are designed to protect a child from injury in a motor vehicle collision. While the use of any restraint is better than no restraint, the best crash protection is provided when the child uses a restraint that is appropriate for the size of the child and the restraint is correctly fitted (to both the vehicle and the child). (Brown et al., 2006; Brown and Bilston, 2007). Current infant restraint systems are designed to fit babies of normal birth-weight; however some babies are discharged from hospital at just over half of this weight. Almost 20% of babies discharged from the special care nursery at one Sydney hospital are < 2.2kg. While it is likely that these lower birth weight (LBW) infants may be poorly accommodated in many child restraints on the market, this has not been studied previously.

All child restraints sold in Australia must comply with the requirements of Australian/New Zealand Standard 1754. Guidelines for the provision of restraints designed for low birth weight babies were recently included in AS/NZ1754 (AS, 2013).. These guidelines were developed based on anthropometric data and there has been no study of the real world fit of LBW infants in restraints complying with these guidelines.

This study aimed to examine the quality of accommodation provided to new born infants by child restraint systems, and specifically the accommodation provided to low birth weight infants.

### **Method**

A cohort of 90 new born infants (median weight 2.4kg) within 1 week of discharge was recruited from the postnatal ward and special care nursery of a Sydney hospital from July 2012 to August 2014. Inclusion criteria required the infants to be within one week of scheduled discharge. Informed consent was obtained from the infant's parent. The study was approved by the North Shore Local Health District Human Research Ethics Committee.

The infants were placed in a selection of 4 infant restraints (2 dedicated and 2 convertible rearward facing restraints). A subset of infants was then also placed in a restraint designed to meet the LBW restraint design requirements of AS1754. Once the child was placed in the restraint, the harness was adjusted to fit the baby and a series of photographs of the baby in the harness were taken. Accommodation was assessed by examining quality of harness fit. The quality of fit of the harness was scored using a 4-point scoring system for 4 different harness fit criteria: buckle position, crotch strap position, shoulder strap height and shoulder strap width. As detailed in Table 1, scores from 1-4 were awarded for each criteria based on the correctness of harness fit. These scores were then collapsed into categories of "good" (scores of 3 or 4, indicating a snug and correctly positioned harness) or "poor" (scores of 1 or 2, indicating non-contact between the harness and the infant).

This collapsed scale was then used to assign a rating for overall harness fit, where a “poor” overall fit was assigned if the harness received a “poor” rating for *any* of the four categories of harness fit, or a “good” overall fit was assigned if the harness received “good” scores for *all* four categories of harness fit (Table 1). The quality of fit of the harness was scored from the photographs by a single researcher. A second researcher used the same scoring system for 10 randomly selected restraints, and reliability between assessors was examined using intraclass correlations (ICC) calculated using two-way mixed effects models for absolute agreement. This demonstrated moderate to good agreement (ICC 0.61–0.80 good, 0.41–0.60 moderate) between assessors and the reliability of the assessment method.

Harness scores were compared between restraint types and between babies weighing  $\leq 2.5\text{kg}$  and  $>2.5\text{kg}$  using McNemars test. The relationship between weight and harness fit was explored using linear regression.

**Table 1: Harness fit scoring criteria**

Score	1	2	3	4
Shoulder strap height	Above top of ear	Between top and bottom of ear	Between shoulder and bottom of ear	At or (just) below shoulder (near jaw / mouth)
Shoulder strap placement	At least one entirely off edge of shoulder	At least one on edge of shoulder	At least one medial or lateral of mid-shoulder but still on shoulder	Both on middle of clavicle
Buckle position	High on abdomen or chest	Bottom of buckle plastic is above but near the top of thighs	Buckle sits slightly high or low on pelvis AND/OR leg straps encroaches on thighs	Buckle directly over middle of pelvis and leg straps not encroaching on thighs
Crotch strap gap (between crotch strap anchorage and nappy/clothing)	Wider than ~20mm or one thumb width	Between ~20mm and ~5mm	<~5mm	At or under clothing

## Results

Results of the harness fit assessments are given in Table 2.

**Table 2: Percentage of infants demonstrated poor harness fit by restraint and weight split**

Harness score type	Restraint Number (split by infant weight of 2.5kg)								
	Restraint 1		Restraint 2		Restraint 3		Restraint 4		Restraint 5
	Convert RF/FF*	Convert RF/FF*	Dedicated RF**	Dedicated RF**	Dedicated RF**	Dedicated RF**	5 LBW**		
	$\leq 2.5\text{kg}$	$> 2.5\text{kg}$	$\leq 2.5\text{kg}$	$> 2.5\text{kg}$	$\leq 2.5\text{kg}$	$> 2.5\text{kg}$	$\leq 2.5\text{kg}$	$> 2.5\text{kg}$	$\leq 2.5\text{kg}$
Shoulder strap height	17%	6%	26%	0%	20%	7%	44%	27%	0%
Shoulder strap width	47%	33%	65%	50%	24%	17%	17%	6%	13%

Buckle position on pelvis	10%	4%	3%	2%	80%	67%	93%	81%	0%
Crotch strap gap	65%	26%	76%	55%	57%	21%	89%	91%	23%

\* RF/FF=Rearward facing/forward facing restraint. \*\* RF=Rear facing restraint.

\*\*\*LBW=Restraint was designed to meet requirements for LBW restraint design in AS1754. Only 17 LBW infants were assessed in this restraint (35% of all infants  $\leq 2.5$ kg in the sample) due to the restraint being unavailable until half way through the study.

The restraint designed for LBW babies provided superior accommodation. Accommodation for LBW infants in the other restraints was generally poor. For LBW infants, harness buckle position was worse in the dedicated restraints than convertible restraints ( $p=0.03$ ) but shoulder strap width was better in convertible restraints ( $p=0.04$ ).

A significantly higher proportion of babies had poor buckle position scores in the dedicated rearward facing restraints than convertible restraints ( $p=0.03$ ) but a significantly higher proportion of babies had poor shoulder strap width in the convertible restraints than dedicated rearward facing restraints ( $p=0.04$ ). There was no clear trend by restraint type for babies achieving poor fit for shoulder strap height and crotch strap gap.

Across all restraints, the scores for shoulder strap height and crotch strap position (gap) were significantly lower (worse) for babies of lower weight ( $p=0.01$  and  $p=0.03$  respectively). The scores for buckle position and the shoulder strap width were not significantly affected by weight.

## Discussion

While a newborn will be provided with better protection in a rearward facing restraint of any type, than in no restraint or a different type of restraint, the results of this work demonstrate scope to further improve accommodation of newborn infants in rearward facing restraints. Poor harness scores demonstrates restraint where infants were not adequately accommodated, and the observed poor harness fit involved harnesses that were not in close contact and/or position on the infant's torso. Such poor fit would likely carry an increased risk of ejection in a crash and therefore a reduction in the injury protection provided in a crash. Comparison of infant anthropometry with shoulder and crotch strap geometry in all restraints identified areas for improving AS/NZ1754 (SA, 2013) LBW requirements.

Limitations to keep in mind include the convenience sample, the limited number of restraints examined and the small number of infants observed in the LBW restraint. Others relate to scoring harness fit from photographs but this method was necessary to minimise time infants spent in each restraint.

Despite these limitations, the results indicate parents of LBW infants should be encouraged to use restraints specifically designed to accommodate small infants.

## References

Brown et al., Serious injury is associated with suboptimal restraint use in child motor vehicle occupants, *Journal of Paediatrics and Child Health*, 2006; 42:345–349;

Brown and Bilston, Child Restraint Misuse: incorrect and inappropriate use of restraints by children reduces their effectiveness in crashes, *Journal of the Australasian College of Road Safety*, 2007; 18:34–42

Standards Australia (SA), Australian/New Zealand Standard 1754 (AS/NZ 1754), Standards Australia 2013.

