The role of comfort in child restraint use practices.

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ABSTRACT
Suboptimal restraint use, particularly the incorrect use of restraints, is a significant and widespread problem among child vehicle occupants, and increases the risk of injury. Previous research has identified comfort as a potential factor influencing suboptimal restraint use. Both the real comfort experienced by the child and the parent’s perception of the child’s comfort are reported to influence the optimal use of restraints. Problems with real comfort may lead the child to misuse the restraint in their attempt to achieve better comfort whilst parent-perceived discomfort has been reported as a driver for premature graduation and inappropriate restraint choice. However, this work has largely been qualitative. There has been no research that objectively studies either the association between real and parent-perceived comfort, or any association between comfort and suboptimal restraint use. One barrier to such studies is the absence of validated tools for quantifying real comfort in children.

We aimed to develop methods to examine both real and parent-perceived comfort and examine their effects on suboptimal restraint use.

We conducted online parent surveys (n=470) to explore what drives parental perceptions of their child’s comfort in restraint systems (study 1) and used data from field observation studies (n=497) to examine parent-perceived comfort and its relationship with observed restraint use (study 2). We developed methods to measure comfort in children in a laboratory setting (n=14) using video analysis to estimate a Discomfort Avoidance Behaviour (DAB) score, pressure mapping and adapted survey tools to differentiate between comfortable and induced discomfort conditions (study 3). The DAB rate was then used to compare an integrated booster with an add-on booster (study 4).

Preliminary analysis of our recent online survey of Australian parents (study 1) indicates that 23% of parents report comfort as a consideration when making a decision to change restraints. Logistic regression modelling of data collected during the field observation study (study 2) revealed that parent-perceived discomfort was not significantly associated with premature graduation. Contrary to expectation, children of parents who reported that their child was comfortable were almost twice as likely to have been incorrectly restrained (p<0.01, 95% CI 1.24 - 2.77).
In the laboratory study (study 3) we found our adapted survey tools did not provide a reliable measurement of real comfort among children. However, our DAB score was able to differentiate between comfortable and induced discomfort conditions and correlated well with pressure mapping.

Preliminary results from the laboratory comparison study (study 4) indicate a positive correlation between DAB rate and use errors. In experiments conducted to date, we have seen a significantly higher DAB rate in the integrated booster compared to the add-on booster (p < 0.01). However, this needs to be confirmed in a naturalistic setting and in further experiments that take length of time under observation into account.

Our results suggest that while some parents report concern about their child’s comfort, parent-reported comfort levels were not associated with restraint choice. If comfort is important for optimal restraint use, it is likely to be the real comfort of the child rather than that reported by the parent. The method we have developed for studying real comfort can be used in naturalistic studies involving child occupants to further understand this relationship.

This work will be of interest to vehicle and child restraint manufacturers interested in improving restraint design for young occupants as well as researchers and other stakeholders interested in reducing the incidence of restraint misuse among children.
INTRODUCTION

Child comfort and/or the parental perception of child comfort has been indicated to play a role in the choice of appropriate child restraint system (CRS) and/or the correctness of use of a child restraint (Bilston et al. 2011; Pettersson and Osvalder 2005; Simpson et al. 2002). It has been suggested that children prefer restraints that are comfortable for them (Bohman et al. 2007; Osvalder et al. 2013; Pettersson and Osvalder 2005). Bingham et al. (2006) reported that parental perception of increased comfort motivates parents to use boosters for their children, and other studies report parent perceived discomfort as a reason for the premature graduation of a child to an adult seat belt (Charlton et al. 2006; Simpson et al. 2002). Discomfort has also been associated with incorrect child restraint use (Klinich et al. 1994; Osvalder et al. 2013). Bohman et al. (2007) suggested that poor restraint fit caused discomfort in children, and the avoidance of discomfort resulted in severe misuse of restraints.

A barrier to the study of comfort among children in child restraints is the lack of validated methods for studying seating comfort in children.

This paper presents an overview of the work we have conducted over the last three years to study comfort and its association with suboptimal restraint use, including the development of novel, validated methods for studying the seated comfort of children in cars.

METHODS

The work presented includes preliminary findings from four studies. All studies were approved by the UNSW Human Research Ethics Committee.

Online Parent Survey

This study used data collected by an online survey of Australian parents and carers, designed to examine and evaluate barriers to appropriate and correct child restraint use. Participants were recruited between May and July, 2014. For inclusion participants had to be over the age of 18, own their own vehicle, have a child between the ages of 0 and 7 years who they transport at least once a week, and regularly use some sort of child restraint. Three questions related to comfort were extracted for this analysis.

Parents were asked to report which of the following factors they would take into account when making a decision to move their child into a different type of restraint: “My child is too big for the restraint; The new restraint is more convenient than my current restraint; The restraint is easier to use than my current restraint; My child is not comfortable in the current restraint; My child is too old for the restraint; My child does not want to use the current restraint any longer; I need the restraint for a younger child”. Data from this question was used to examine how often parents take comfort into account when making restraint transition decisions.

The second question used a five level Likert scale to ask parents whether they thought their current child restraint looked comfortable.

Parents were directly asked if their child is comfortable in their current restraint and to provide reasons if they believed their child is comfortable. The reasons provided by parents were
qualitatively explored and commonly reported reasons why parents thought the child was comfortable were identified using content analysis techniques.

**Field Observation Study**

Previously collected data from a large observational study of how children use child restraints in the real world (see Brown et al. (2010) for more details) was used for this analysis.

Observed appropriate and correct use of restraints together with variables related to parent perceived comfort and other known risk factors for inappropriate and incorrect use were extracted for this analysis. This analysis has been reported in more detail elsewhere (Fong et al, manuscript under review).

Logistic regression modelling (SAS V9.4, SAS Institute 2013) was used to examine (i) the relationship between age appropriate restraint use and parent reported child comfort, and (ii) the relationship between correct restraint use and parent reported child comfort. Both analyses controlled for parent education levels, language spoken at home, parent income and the restraint type.

**Laboratory Comfort Measuring Study**

A specially designed seating rig that allowed for the adjustment of cushion length and seat belt height was used to compare anthropometrically comfortable seating positions with a well-fitting sash belt (Fong et al. 2015) to uncomfortable seating positions due to a long seat cushion and/or the sash belt touching the neck.

The child sat in each position (see Table 1) for 10 minutes, while watching children’s TV shows. There was a 10 minute break between each seating position trial, and one trial was performed without the TV stimulus, after which the self-report survey tool was administered. Each trial was video recorded for later analysis.

*Table 1: Laboratory study experimental conditions, presented randomly. Adapted from Fong et al. (2015).*

<table>
<thead>
<tr>
<th>Condition</th>
<th>n</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fit</td>
<td>14</td>
<td>Anthropometric fit based of stature and buttocks to popliteal length (comfortable)</td>
</tr>
<tr>
<td>Fit+Footrest</td>
<td>14</td>
<td>As above with the introduction of a footrest (comfortable)</td>
</tr>
<tr>
<td>Cushion Long</td>
<td>14</td>
<td>As above but with the cushion length 10cm too long (uncomfortable)</td>
</tr>
<tr>
<td>Seat Belt High</td>
<td>14</td>
<td>As Fit+Footrest but with the seat belt height adjusted to create sash belt contact with neck (uncomfortable)</td>
</tr>
<tr>
<td>No Stimulus</td>
<td>4</td>
<td>As Fit but without video stimulus</td>
</tr>
</tbody>
</table>

We measured comfort in three ways (i) a self-report questionnaire, (ii) pressure distribution mapping, and (iii) a novel video analysis method.
The self-report questionnaire was a modified body discomfort chart (Gyi and Porter 1999) paired with a modified form of the Wong-Baker FACES Pain (Wong and Baker 1988), to be more suitable for children. Pressure mapping of the seat cushion and seat back were performed with a CONFORMat system (Tekscan, Inc South Boston MA, USA), from which change in centre of force ($\Delta$COF - distance), contact area (CA - area) and peak pressure (PP - force) were calculated.

The new video analysis protocol was developed, using Kinovea (V0.8.15, Kinovea.org 2012) software, to calculate a novel metric, called the rate of Discomfort Avoidance Behaviours (DAB). A DAB was defined as any shift in seating position, playing with the seat belt, or the child stretching. These behaviours were totalled for each condition and this total was divided by the video clip duration to calculate the average number of discomfort avoidance behaviours per minute (the DAB score or DAB rate).

Differences between seating conditions for the DAB, pressure and survey protocols were assessed with paired samples T-tests. Correlation between the three measures of comfort was evaluated using Pearson’s r.

**Laboratory Restraint Comparison Study**

This study compared the comfort and usability for 4-8 year old children of an add-on booster and a single stage integrated child restraint, using a purpose built seating buck. The parent was asked to install and adjust each restraint before securing the child in it. The child sat in each restraint for 10 minutes, following the DAB rate protocol outlined in the previous section.

DAB scores, and the errors in restraint installation, adjustment and use were compared between the integrated restraint and the add-on booster, using paired t-tests.

Examples of installation errors include: twisted seat belts and top tether straps, not using the anti-submarining clip, not adjusting the seat height and not using the seat belt guides. Examples of use errors include: unbuckling of the seat belt, holding the seat belt away from the body, and leading either forwards or to the side so that the seat belt moves off the shoulder.

**RESULTS**

**Online Survey**

Data was collected from 470 parents or carers across Australia. The responses obtained to the question about what factors parents consider in making restraint transitions are shown in Figure 1.
Almost one quarter of parents (23%) reported that they would consider transitioning their child to another restraint type if they thought their child was not comfortable in their current restraint.

Most parents (86.4%) responded that the restraint their child was using looked comfortable (agree or strongly agree).

Three quarters (75%) of parents also indicated they perceived their child was comfortable in the restraint because there was a lack of complaint from the child (26%), the ability of the child to sleep in the restraint (22%) and the presence of padding and support in the restraints (22%).

Field Observation Study

The logistic regression analysis indicated that there was no significant relationship between child restraint misuse and reported comfort problems. However, there were significantly increased odds of restraint misuse when a convertible restraint (rearward facing/forward facing or forward facing/booster) was used, irrespective of a reported comfort problem (OR 12.46, 95% CI 6.20-25.05). Parental education, family income, and language spoken at home were not significantly related to incorrect restraint use.

The second regression model found no significant association between parent reported comfort problems and the use of age appropriate child restraints. However, the likelihood that an age appropriate restraint was used was increased when a child restraint was used as opposed to a seat belt, irrespective of any parent reported comfort problem (OR 3.93, 95% CI 2.30-6.71). Parental education, family income and language spoken at home were not significantly related to appropriateness of restraint choice.

Laboratory Comfort Study

Data was collected from 14 participants aged 4-8yrs (M=5.4yrs, SD=1.5yrs), 3 males and 11 females.
The child-reported comfort survey tools did not appear to provide a reliable measurement of real comfort among the children based on our finding that there were no significant differences in scores between seating conditions. It was notable that the children reported being comfortable even in induced discomfort seating conditions.

The addition of the footrest resulted in a significant increase in the ΔCOF for the seat base (p=0.033, n=13) in the ‘fit’ condition. Removing the video stimulus in the ‘fit’ condition resulted in a non-significant trend towards an increase ΔCOF for the seat base (p=0.056, n=4) and for the seat back (p=0.058, n=4). See Figure 3.

The addition of the footrest to the fit condition decreased the average seat base contact area (p=0.007, n=14). The longer seat cushion increased the seat base contact area compared to the ‘fit’ condition (p<0.001, n=14), but reduced the seat back contact area (p=0.023, n=14).

There were no significant differences for peak pressure in either the seat back or seat base.

![Figure 2: Comparison of ΔCOF for the seat base between conditions (No Stimulus, n=4, for all other conditions n=14). A statistically significant difference was observed between the Fit and Fit+Footrest conditions (p<0.05). Adapted from Fong et al. (2015).](image)

A significant increase in the DAB rate was observed with the sash belt touching the neck, compared to the well-fitting condition (p<0.01, n=13). No other significant differences were observed between any conditions (Figure 3). The small sample for the No Stimulus condition may have precluded differences from other conditions being detected statistically (p=0.087, n=4).

Significant correlations between DAB rate and ΔCOF were observed for the seat base (r(10)=0.763, p<0.01) and seat back (r(11)=0.584, p<0.05) with the long seat cushion and in the seat base (r(11)=0.679, p<0.05) of the well fitted seat.
The DAB scoring method is repeatable with an intra class correlation coefficient (ICC) was 0.98 (95% CI 0.954-0.991, \(F(31,31)=61.425\), \(p<0.001\)).

**Laboratory Restraint Comparison Study**

Data has been collected from 15 parent/child groups; 8 male, 7 female children aged 4-8.

Preliminary results show there were no observed errors in installation or adjustment of the integrated booster, however there was an average of 0.7 errors in installation or adjustment of the add-on booster.

There was a significantly higher DAB rate in the integrated booster compared to the add-on booster \((p<0.01, n=13)\) (Figure 4).

The DAB rate increased as observed usage errors increased \((r = 0.63, n = 28, p < 0.01)\) (Figure 5).
**DISCUSSION & CONCLUSIONS**

Taken together, the results from this series of studies indicate: (i) that many parents believe that their child’s current restraint is comfortable, but that they consider their child’s comfort when deciding on transition to the next restraint; (ii) parent perceived comfort is not directly related to age appropriate restraint use or restraint misuse; (iii) child-reported comfort survey methods were not reliable enough to measure child comfort, but (iv) the newly developed DAB score has potential to objectively assess comfort of children in child restraints, as it is reliable, and sensitive to induced discomfort. It is also correlated with restraint use errors. This has set the scene for more rigorous studies of restraint comfort and the relationship between comfort and restraint use practices.
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