IEMS Vol. 8, No. 2, pp. 121-130, June 2009.

Evaluation of Car Seat Using Reliable and Valid Vehicle Seat Discomfort Survey

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Received Date, September 25, 2008; Accepted Date, February 26, 2009

Abstract. Subjective evaluation has always been regarded as a branch of social science research. Hence, in scientific and especially engineering points of view, its development is always taken for granted despite the importance of its effects on the design and development decisions. In the past, at least two automotive seat survey questionnaires have been developed with high statistical validity and reliability. Nonetheless, both were not local while subjective perception very much depends on demographic background factors. It is felt that since vehicle seat comfort is an important aspect in a seat design, a local sense should be put into the survey that is used as the subjective tool. The proposed vehicle seat discomfort survey questionnaire was developed in dual languages; English and Malay. Malay language is the national language of Malaysia, where the survey was tested. Beside inputs from literatures, key informant interviews helped in establishing the appropriate terms used as survey items. Three experimental runs on two different seats by 22 paid subjects showed that the developed questionnaire is reliable and valid. Furthermore, criterion validity analysis on the survey and previously developed survey showed significant correlation at 0.01 significance level.

Keywords: Seat Survey, Comfort Survey, Seat Comfort, Car Seat, Automotive Survey

1. INTRODUCTION

Seat comfort or discomfort evaluation is a key aspect in seat design. Functionality of the seat can easily be evaluated through available state-of-the-art technology solutions but comfort or discomfort and aesthetic factors are still very much relying on human's perception (Jiao *et al.*, 2007; Nagamichi 1995). Although there are efforts on developing intelligent systems, it still needs to be fed with information from human's subjective evaluations. Human perception changes with time, hence updated information from new subjective evaluations are always needed (Kolich and White 2004).

Seat design procedure depends largely on the basic mechanical aspect such as geometric parameters of seat, choice of suspension system and cushion material used. However, the mechanical parameters can show certain data in terms of seat design but how it affects the user is still unknown. It was cited that Muckler and Seven (1992) suggested that objective measures tell us what is happening, but subjective measures can tell us how we are coping and thus provide a warning of possible future changes in performance (Annett 2002).

The literatures showed previous sitting comfort surveys were based on working chairs meant for offices, industry or schools (Drury and Coury 1982; Drury and Francher 1985; Helander and Zhang 1997). Helander and Zhang (1997) reported that they had used subjective evaluation tools such as General Comfort Rating (GCR) by Shackel *et al.* (1969), Body Part Discomfort (BPD Scale) by Corlett and Bishop (1976) and Chair Evalua-

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tion Checklist (CEC) by Zhang *et al.* (1996) for assessment of chair comfort/discomfort. Nevertheless, there is yet an ideal standard of subjective evaluation tools for vehicle seats in the automotive industry although from product development point of view, generic framework is recently published (Helo *et al*., 2007; Lim *et al*., 2007; Khalid *et al*., 2007). Given its important role, a well-documented thorough development of a subjective evaluation tool is very important (Kolich 2000; Kolich and White 2004; Smith *et al*., 2006).

In the last decade, there have been very few attempts to establish and document automotive seat comfort or discomfort questionnaire survey. Until recently, the most referred to is the automobile seat comfort survey done by Kolich (2000) which is then has been further revised (Kolich and White 2004) and the automotive seating discomfort questionnaire (ASDQ) by Smith *et al.* (2006). Although they vary in terms of contents and type of rating scales, both have shown significant results. The automobile seat comfort survey (Kolich 2000) has been shown to be statistically reliable tool in giving a numeric rating for seat comfort. However, as suggested by Smith *et al.* (2006), the application of the Likert scales particularly and certain variable omission in the automobile seat comfort survey requires further consideration. On the other hand, although the automotive seating discomfort questionnaire (Smith *et al*., 2006) provides continuous scales, the survey is quite lengthy with twenty numbers of variables used. Moreover, the few attempts were from abroad and not local, whereas Malaysia as a developing country manufactures its own car locally. In order to gain insights into local views, the tool itself should have local essences; hence the authors had taken this effort to develop the vehicle seat *dis*comfort survey (VSCS).

The objective of this study was to develop a local vehicle seat discomfort survey that is reliable and valid which could be applied together with objective measurements such as seat pressure distribution or vibration analysis in later stage. In order to test the survey questionnaire, static seats evaluations had been carried out in the laboratory between two different seats from two different cars using the VSCS. It is hypothesized that results should show some differences of discomfort between the two different seats. Any seat development process should utilize only valid and reliable set of survey questionnaire as the subjective evaluation tool. It is hoped that future local vehicle seat development process will utilize the VSCS for the subjective evaluation part.

2. METHODOLOGY

2.1 Questionnaire Design

Brigham (1975) highlighted that firstly, a survey must be designed so that the data are in suitable form for the analysis and are free from the effects of bias; secondly, the analysis is statistically appropriate given the nature of the data and the conditions under which it was collected. The most important part in survey or questionnaire design is the items selection. VSCS was designed based on information gained through literatures (Brigham 1975; Drury and Coury 1982; Shen and Parsons 1997; Kolich 2000; Smith *et al*., 2006). The survey items were pre-selected based on previous studies. Those items were used many times in different surveys and had been shown to be significantly related to seat comfort or discomfort evaluation (Ng *et al*., 1995; Kolich 2000; Mehta and Tewari 2000; Kolich and White 2004; Smith *et al*., 2006). Most importantly, inputs from key informant were gathered to improve the selected items. This is important in order to maintain high face validity especially when the survey was established for dual language (Malay and English sets) and to get local perspectives into the survey since all literatures were from abroad.

Key informant survey was carried out by sending a set of questionnaires to few organizations which are involved directly and indirectly with automobile or vehicle seat development. Key informant involves seat designer/engineer from local car manufacturer and OEM seat manufacturer, automobile magazine editor as well as academia. The key informant survey was sent mostly by mail and some by emails. The items listed were thought to have impacts on seat comfort perception and rating scales were adopted from previous study by Ng *et al.* (1995).

The first few pilot tests after receiving feedback from key informant (N = 9 same subjects) were carried out to further improve the VSCS. Subjects were briefed especially on the terms used in the survey. Two pilot tests were conducted. Test-retest evaluations were carried out to check for reliability. It was conducted with a separation period of more than 24 hours. Internal consistency was calculated using a correlation method with resultant Cronbach's alpha values establishing significance ($\alpha > 0.7$). After the pilot survey and verbal response as well as written feedback from key informant interviews, the items finalized for VSCS are as shown in Table 1 and Appendix 1 (Figure A1-1 VSCS in Malay and Figure A1-2 VSCS in English). One of the main approaches is that the wordings used in VSCS are less technical and easier for a layman (inexperience subjects) to understand the meanings.

Shen and Parsons (1997) suggested a continuous scale for intensity and discomfort survey. Both Shen and Parsons (1997) and Annett (2002) remarked that the balanced Likert-type five-or seven-point scale with a central indifference point can be wasteful since it can reflect the unwillingness of the participant to make judgment. Scale selected for the main part of VSCS is continuous 10cm lines; just like in the survey by Smith *et al.* (2006) however with different anchoring tags. From the pilot survey, subjects has no difficulty with the con-

Table 1. The items used in VSCS and other international car/vehicle seat surveys.

Ng *et al*., 1995	Kolich 2000	Smith *et al*., 2006	VSCS 2008
Lumbar support	Amount of lumbar support	Cushion width	a. *Cushion width*
Seatback firmness	Back tailbone comfort	Cushion length	b. *Cushion length*
Seat cushion firmness	Lumbar comfort	Cushion firmness	c. *Cushion contour*
Thoracic support	Upper-back comfort	Cushion bolster	d. *Seatback width*
Presence of armrest	Back lateral comfort	Cushion center	e. *Seatback height*
Seatback size	Cushion tailbone comfort	Cushion contour	f. *Seatback contour*
Buttocks support	Ischial comfort	Trim	g. *Headrest support*
Thigh support	Thigh comfort	Trim friction	h. *Buttock comfort*
Physical appearance of the seat	Cushion lateral comfort	Trim feel	i. *Thigh comfort*
Head/neck support		Backrest height	j. *Under-knee comfort*
		Backrest width	k. *Lumbar support*
		Backrest firmness	l. *Upper-back support*
		Backrest bolsters	m. *Physical design*
		Backrest contour	n. *Texture and material*
		Lumbar stiffness	o. *Overall discomfort*
		Lumbar prominence	
		Lumbar support	
		Lumbar height	
		Lumbar pressure	
		Overall discomfort	

tinuous scale even though it is rarely found in usual local commercial surveys.

It is a consensus from previous literatures that discomfort is more tangible and can be more readily identified as compared to comfort hence the use of discomfort as verbal tag (Reed *et al*., 1991; Shen and Parsons 1997; Helander and Zhang 1997; Kolich 2000; El Falou *et al*., 2003; Smith *et al*., 2006). However, it is felt that the survey should be presented in a positive manner hence the characteristics of the seat is described in that approach e.g. item *g. headrest support* instead of *headrest lack-of-support* or item *h. buttock comfort* instead of *buttock discomfort*.

The survey is multidimensional where items *a-g* (refer Table 1 and Appendix 1) investigates about the adequacy/inadequacy of the physical features of the seat, which is important in seat design benchmarking at least at general level. This is supported by Drury and Coury (1982) who made citation of Branton (1969) whom suggested that seat assessment should include overall comfort, body part comfort and specific chair features. The second part for items *h-o*, seat discomfort questions especially on pressure-induced sensations and supports were asked.

For seat physical features questions i.e. from cushion width (item *a*) to headrest support (item *g*), the scale were anchored with verbal tags too little and too much at both ends and just right in the middle. Since VSCS total numerical value is discomfort value, for items *a-g* the right side of the scale is considered as negative, just right as zero and the left side as positive. For items *h-o*, the anchors are at the beginning and end with verbal tags; no discomfort with value zero and extreme discomfort with value 10. Both scales are shown in Figure 1. The scales should be one dimension instead of a bipolar scale because it was believed that a study of pressure induced concerned with discomfort only. Shen and Parsons (1997) quoting Poultan (1977) suggested that the bipolarity of a comfort-discomfort scale may alter the construct and reduce the available rating space for discomfort.

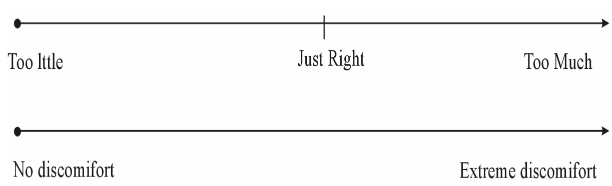

Figure 1. The two types of continuous line scales used in VSCS.

Items *m* and *n* asked about the appearance and texture of the upholstery which also affect seat discomfort perception (Tada *et al*., 1998). Therefore when evaluating different seats with different type of upholstery with different materials, it will not bias the whole survey result. Overall discomfort question was also an item in the VSCS as a conclusion remark for the subjects after evaluating items *a-n* which are actually hierarchical.

2.2 Subjects

Twenty-two final year university students were used as paid subjects. The driving experience of the subjects is between four to five years. Brigham (1975) described halo effect as favorable or unfavorable attitude towards an object or person or situation. Lack of driving experience might reduce the common halo effect bias since human perception and expectation are very much influenced by their previous experience. Furthermore, Porter and Sharp (1984) reported that the assessment of sitting comfort is not critically dependent upon the age and sex of the subject, given that stature is controlled for. The mean height for male subjects was 164.1cm and the mean height for female subjects was 158.5 which were both in the 50^{th} percentile of Malaysian adults (Deros *et al*., 2008). The range of heights of the subjects is from 150cm to 175cm which is within the 5^{th} percentile to 95^{th} percentile of Malaysian adults.

2.3 Experimental Procedure

After the items were finalized as shown in Table 1, an experimental evaluations were carried out on two different driver seats, seat A and seat B, set up in the laboratory as shown in Figure 2 and Figure 3. Seat A is an imported sedan car seat, whereas seat B is a local premium sedan car seat. Seat A has only two adjustment features, the seatback angle and distance from front/ pedal. The headrest is adjoined to the seat, hence it is not adjustable. It has a moderate sporty look but the upholstery is fabric. Seat B has two extra adjustments which can give further depth to the buttock or height to the thigh. However these adjustments were set to normal which is minimum for both buttock and thigh height so that it is more comparable to the other seat. The seat has a luxury look with leather upholstery and the headrest is adjustable.

Each subject has to attend experimental sessions on three different days. Minimum day interval was 24 hours. In order for the subject to really feel the seat and not giving first impression respond in the survey, they were required to sit on each seat for 20 minutes. As an entertainment as well as a distraction, a movie is played during each session.

The subjects were first briefed on what they have to do, which is to sit as if they were driving and then answer the questionnaire after 20 minutes. The 20 minutes sitting session allows the seat foam to approach its baseline properties. It was shown that 82.5% comfort score variance was accounted for after being seated for 20 minutes (Reed and Massie 1996).

The subjects were allowed to adjust only the seatback angle and distance of seat from pedal. Other adjustments were not allowed. Apart from answering VSCS, they were also given automobile seat comfort survey revision 2 from Kolich and White (2004). Although the layout and scale used in VSCS was more similar to the ASDQ by Smith *et al.* (2006), the key items in the questionnaire were much closer to Kolich and White's revision 2 (2004) at least for items *h-l*. Furthermore, full layout of Kolich and White's (2004) survey questionnaire could be easily required from their paper, whereas other literatures did not publish the full layout of their survey questionnaires. Hence for more accurate result, the Kolich and White's (2004) survey questionnaire was chosen to be used together with the VSCS to check for construct validity. Answering both survey questionnaires took about 5~7 minutes. All subjects preferred the Malay sets for VSCS. The survey by Kolich and White's (2004) were only available in its original language, English. After that, few important sitting anthropometrical measurements were taken before subjects sit again to evaluate the other seats. This also acted as a short break for the subjects so that they are refreshed before sitting on the other seat.

Figure 2. A female subject in seat A.

Figure 3. A male subject in Seat B which is next to seat A.

2.4 Data Analysis

In order to check for criterion validity, for the reason mentioned earlier, Kolich and White's revision 2 (2004) survey was used and the overall comfort indexes were summed and computed into percentages. Then the discomfort percentages were calculated by subtracting the comfort percentage. The VSCS overall discomfort values were also transformed into percentages. Criterion validity is based on showing that there is a statistical association between the proposed measurement and some other criterion or standard that the authors believe already accurately measures the concept being studied.

The statistical technique used for this VSCS results was parametric although Kolich (2000) discussed at length about disagreements of the practice. It was concluded that there was one school of thought that strongly suggested the application of non-parametric statistical techniques to ordinal data and there was another that believe if there is error introduced by the use of parametric techniques on ordinal data, it can be offset by the application of more robust statistics (Kolich 2000; Kolich and White 2004). Despite the emphasis on the application of correct statistical techniques, for example non-parametric statistics (ranking tests or order tests) for ordinal scale data and parametric scale only for interval scale data, the authors themselves applied parametric statistics to their ordinal data as most of other studies (Helander and Zhang 1997; Shen and Parsons 1997; Smith *et al*., 2006)

The analyses performed on the data among others are:

1) Cronbachs's alpha for measure of reliability and validity.
2) ANOVA for comparison of seat A and seat B.
3) Pearson correlation to assess difference between Kolich and White's revision 2 (2004).

3. RESULTS AND DISCUSSION

3.1 VSCS Questionnaire Design

From key informant feedback received from five representatives of expert in seat and automotive industry in Malaysia, two from the academics and three from the industry, 15 from 26 items listed in the first draft of the survey were rated as very important and greatly affects the perception of overall seat comfort. As a result, the terms were minimized and more layman languages were used for both English and Malay sets of survey questionnaire to replace the scientific jargons, for example, under-knee to replace popliteal. This step was also done to ensure high face validity of the survey, especially when the terms were translated into Malay language as shown in Figure A1-1 in the Appendix 1. As compared to Kolich and White's (2004) survey which is in its original language, English; VSCS Malay sets receives less enquiries for explanations on the items. This is understandable because people usually are more comfortable in their own national language.

For internal consistency of the survey, Cronbach's alpha was found to be 0.8 averages for all runs as well as for both seats. Internal consistency is one way of assessing reliability which estimates the extent to which the various items all measure the same thing (Shen and Parsons 1997; Kolich 2000; Field 2005; Smith *et al*., 2006). Therefore, the authors believe that the survey questionnaire is reliable.

However, inter-items correlations are low if all items were analyzed together. As mentioned earlier, items *a-g* is meant for the physical features of the seat whereas items *h-o* is more about the seat attributes, hence it should be analyzed separately. A rotated Varimax factor analysis proved that items *a-g* belongs in the same group and items *h-o* in another, which was also shown by (Solaz *et al*., 2006). This analysis can be shown in plots as shown in Figure 4.

The main part of the overall discomfort value is the evaluations of items *h* to items *o*. Item *a* to item *g* is meant to measure in benchmarking seats at macro level, and also to eliminate the bias from overall discomfort value. When analyzed separately from the physical attributes, the inter-items correlations were found to be much better, 0.6 average. The vehicle seat evaluations presented here was just to test the survey by benchmarking two seats in static environment. In the case where VSCS is used to investigate a particular seat to study the pressure distribution or whole body vibration effects, items *a-g* could be omitted and focus can be given to items *h-o*.

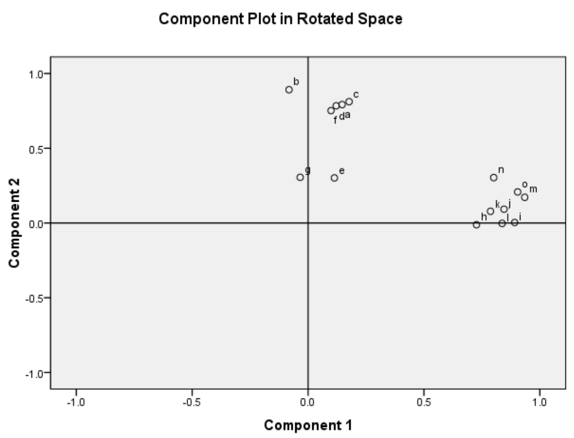

Figure 4. VSCS items are composed of two different components.

A split-half reliability analyses also reveal coefficient alpha for part 1 (the physical part) as only 0.3 but 0.9 for part 2 (the attributes discomfort part) with the

Spearman-Brown coefficient at 0.863. Table 2 shows internal consistency values of each run for both seats and the values when items of part 1 and part 2 were analyzed separately. The consistency of subjects' responses shown in all runs also showed that the continuous scale used is reliable.

3.2 Vehicle Seat Evaluation

Between the two surveys answered by all subjects in this evaluation, VSCS and Kolich and White's (2004) overall survey discomfort value in percentage showed significant correlation at least for seat A but less significant for seat B. It is figured that this might be caused by the physical and support attributes of the two different seats. As compared to Seat A, Seat B has more obvious support attributes or side bolsters on the seatback and seat cushion, hence different people have different views about this according to past experiences, body size and personal preference. Another reason might be caused by the imbalance number of subjects for the different runs. Smith *et al.* (2006) concluded in their study that sample size and seat selection had an impact on resultant questionnaire content. The values are shown in Table 3 with significant level at 0.05 (2 tailed). Items to items correlation analysis showed items *h-l* which are similar to items in Kolich and White's (2004) survey correlated significantly with items at least for Run 2 and Run 3 of seat A which are shown in Table 4.

Table 2. Items internal consistency for all runs for Seat A and Seat B.

	Items	Values	Seat A	Seat B
Run 1	*a-o*	Cronbach's α	0.854	0.763
		IIC	0.273	0.159
	a-g	Cronbach's α	0.806	0.679
		IIC	0.387	0.236
	h-o	Cronbach's α	0.911	0.860
		IIC	0.562	0.431
Run 2	*a-o*	Cronbach's α	0.849	0.809
		IIC	0.263	0.199
	a-g	Cronbach's α	0.663	0.562
		IIC	0.235	0.176
	h-o	Cronbach's α	0.932	0.924
		IIC	0.631	0.605
Run 3	*a-o*	Cronbach's α	0.876	0.917
		IIC	0.296	0.448
	a-g	Cronbach's α	0.742	0.867
		IIC	0.324	0.528
	h-o	Cronbach's α	0.967	0.933
		IIC	0.788	0.650

Note) IIC = inter-item correlations.

These findings suggest that both questionnaires are measuring the same thing. However, for buttock vs. ischial and upper back vs. upper back, the results were consistent for all runs; not significantly correlated. For buttock and ischial, the different terms used might be the main cause since buttock represents the whole area of the bottom whilst ischial was defined as two bony prominences which ones can feel with their hands under the buttock. There is no conclusive explanation for upper back items; however it most probably due to the different scale used. Kolich and White's (2004) survey provides only 5-pre-defined intervals with a neutral option for the subjects to select an anchored point, removing the freedom to give an exact representation of their perception. The VSCS continuous line provides the freedom and it is a discomfort scale with no neutral option. Through Kolich and White's (2004), median feedback for upper-back question for all runs was 3 which are neutral, whereas VSCS median feedback for the same item for all runs was 4.13 which is 41.3% discomfort.

Table 3. Between-questionnaire overall value comparisons.

		Seat A	Seat B	Both seats
Run 1	r	0.368	0.479*	-0.405**
	p	0.093	0.024	0.006
	N	22	22	44
Run 2	r	0.548*	0.044	-0.364*
	p	0.01	0.850	0.018
	N	21	21	42
Run 3	r	0.540*	0.074	-0.321
	p	0.017	0.762	-0.38
	N	21	21	42

Note) * Correlation is significant at 0.05 level (2-tailed).
** Correlation is significant at 0.01 level (2-tailed).

Overall comparison between both means and medians of responses for Seat A and Seat B were found to be as having no statistical significant difference. The evaluations consistency is shown through comparisons between each items (*item h-n*) and overall discomfort (*item o*), which were found to be not significant for both seats. Median range for seat A physical feature (*item a*-g) is -0.2 to 0.13 and discomfort attributes (*item h-o*) is 4 to 4.45. For seat B item *a-g* median range is -0.2 to 0 whilst item *h-o* median range is 4.47. The data are depicted in Figure 5. Both seats were found to be comfortable as the discomfort values are between 30.7 and 33.7 for all three runs. The percentage values are less than 30% or it can be concluded that both seats are 70% comfortable. A discomfort value equals to or more than 50% should be an alarm for seat designers' team.

According to Brigham (1975) rankings data should not be averaged as is often done, but median is a more appropriate statistic. Both seats provide sufficient rooms for subjects both at seat pan and seatback, hence the almost Just Right feedbacks for all seat features questions while seat attributes differ slightly between two seats. However there are exceptions; for cushion width and backrest height for both seats (refer Figure 5) which were thought to be slightly inadequate (Figure A1-2; narrow and low). Individually, based on the survey medians counts, improvements can be focused on headrest support for Seat A. Whereas Seat B were found to be more uncomfortable than Seat A especially at the lumbar area with 0.78 difference of median. Comparison between the two seats for item *j-l* showed a significant difference in which Seat A is more comfortable (one-tailed t-test $p < 0.05$). In terms of physical appearance and upholstery materials, Seat B is better significantly than Seat A (one-tailed t-test $p < 0.01$). There was no significant difference between gender responses. It is presumed that results were almost similar for both seats because all the subjects were from the 50th percentile group. It is common to find that most things were designed for the 'average' users or basically from the 50th percentile onwards despite it is not a good design practice.

Table 4. Between-questionnaire items-to-items correlation.

Runs	VSCS vs. Kolich and White's		Pearson's correlation Seat A
Run 1 (N = 22)	Buttock vs. Ischial Comfort	r p	.263 .237
	Thigh vs. Thigh Comfort	r p	-.188 .402
	Under-knee vs. Thigh Comfort	r p	-.231 .302
	Lumbar vs. Lumbar Comfort	r p	-.307 .164
	Upper-back vs. Upper-back Comfort	r p	-.254 .253
Run 2 (N = 20)	Buttock vs. Ischial Comfort	r p	-0.238 0.312
	Thigh vs. Thigh Comfort	r p	-0.628** 0.003
	Under-knee vs. Thigh Comfort	r p	-0.633** 0.003
	Lumbar vs. Lumbar Comfort	r p	-0.450* 0.047
	Upper-back vs. Upper-back Comfort	r p	-0.196 0.408
Run 3 (N = 19)	Buttock vs. Ischial Comfort	r p	-0.423 0.071
	Thigh vs. Thigh Comfort	r p	-0.699** 0.001
	Under-knee vs. Thigh Comfort	r p	-0.570* 0.011
	Lumbar vs. Lumbar Comfort	r p	-0.405 0.085
	Upper-back vs. Upper-back Comfort	R p	-0.293 0.224

Note) * Correlation is significant at the 0.01 level (2-tailed).
** Correlation is significant at the 0.05 level (2-tailed).

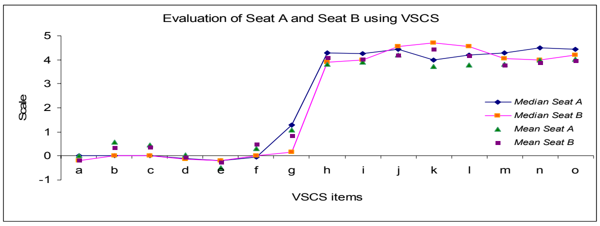

Figure 5. Median and mean average for all three runs for Seat A and Seat B.

4. CONCLUSION

There are not many literature that have documented the development of the survey questionnaire used in the automotive industry with the exception to the few mentioned earlier. It was shown through statistical analyses that the newly developed and tested VSCS is valid and reliable. Favorable responses were shown to be for VSCS sets in Malay language, the national language of where the survey was tested. The items used were found to be understandable by the subjects without the need for further explanations of each item in the survey. Furthermore, the survey length is fairly appropriate instead of the usual Likert scale, continuous scale is applied.

Although the layout and scale used in VSCS was more similar to the ASDQ by Smith *et al.* (2006), the key items in the questionnaire were much closer to Kolich and White's revision 2 (2004). Hence, it was chosen to be used together with the VSCS to check for construct validity. It was found that subjects need more explanation of technical terms used with that survey as compared to VSCS. Nonetheless, this survey results showed a good correlation between the two surveys. A single value is desirable in benchmarking procedure, at least at the macro level. From the VSCS, an overall discomfort index is obtained. A value in percentage should be a natural indication for anyone to understand.

Based on the two seats evaluation, it can be said that seat nowadays can be perceived as in the range of acceptable to excellent. Seat A and Seat B were perceived to be having only more than 30% of discomforts using VSCS and there were no significant difference between the two seats. However, there are room for improvements especially for headrest support for Seat A and lumbar support for Seat B.

Through test-retest approach, internal consistency measure and criterion-related validity calculation, this survey proves to be reliable and valid and most importantly suitable for local vehicle seat comfort assessment. Further test would be pairing the assessment tool with objective measures in both static and dynamic environment to examine the correlation between them so that relationship between survey items, seat design and subject feelings can be established.

ACKNOWLEDGMENT

The authors would like to thank the Ministry of Science Technology and Environment (MOSTE) Malaysia and Universiti Kebangsaan Malaysia for their support in providing research grant for the project entitled "Establishment of Malaysian Anthropometrics Data for the Design and Development of Safe and Comfortable Driver's Seat for Road Vehicles" (Science Fund 03-01-02-SF0073).

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APPENDIX. 1

a	Lebar kusyen (sisi ke sisi)	Terlalu sempit	Sedang elok	Terlalu luas
b	Panjang kusyen	Terlalu pendek	Sedang elok	Terlalu panjang
c	Kontur kusyen	Terlalu sedikit	Sedang elok	Terlalu banyak
d	Lebar penyandar belakang	Terlalu sempit	Sedang elok	Terlalu luas
e	Tinggi penyandar belakang	Terlalu rendah	Sedang elok	Terlalu tinggi
f	Kontur penyandar belakang	Terlalu sedikit	Sedang elok	Terlalu banyak
g	Sokongan penyandar kepala	Terlalu sedikit	Sedang elok	Terlalu banyak
h	Keselesaan punggung	Tiada ketakselesaan		Ketakselesaan melampau
i	Keselesaan peha	Tiada ketakselesaan		Ketakselesaan melampau
j	Keselesaan bawah-lutut	Tiada ketakselesaan		Ketakselesaan melampau
k	Sokongan lumbar (belakang ping-gang)	Tiada ketakselesaan		Ketakselesaan melampau
l	Sokongan bahagian-atas belakang-badan	Tiada ketakselesaan		Ketakselesaan melampau
m	Bentuk rekabentuk/ rupa fizikal	Tiada ketakselesaan		Ketakselesaan melampau
n	Tekstur dan bahan sarung kusyen	Tiada ketakselesaan		Ketakselesaan melampau
o	Tahap ketakselesaan keseluruhan	Tiada ketakselesaan		Ketakselesaan melampau

Figure A1-1. VSCS in Malay *(*not the real size).

a	Cushion width	Too narrow	Just right	Too wide
b	Cushion length	Terlalu short	Just right	Too long
c	Cushion contour	Too little	Just right	Too much
d	Backrest width	Too narrow	Just right	Too wide
e	Backrest height	Too low	Just	Too high
f	Backrest contour	Too little	Just right	Too much
g	Headrest support	Too little	Just right	Too much
h	Buttock comfort	No discomfort		Extreme discomfort
i	Thigh comfort	No discomfort		Extreme discomfort
j	Under-knee comfort	No discomfort		Extreme discomfort
k	Lumbar support (back of waist)	No discomfort		Extreme discomfort
l	Upper-back support	No discomfort		Extreme discomfort
m	Shape design/ physical appearance	No discomfort		Extreme discomfort
n	Texture and upholstery material	No discomfort		Extreme discomfort
o	Overall discomfort level	No discomfort		Extreme discomfort

Figure A1-2. VSCS in English (*not the real size).