

REVIEW ARTICLE

Likert Scale vs. Visual Analogue Scale on Vehicle Seat Discomfort Questionnaire: A Review

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ABSTRACT

Discomfort measurement has usually been attempted by asking the participants to rate the scale of their discomfort which commonly termed as a subjective scale. Various studies had conducted the discomfort level on vehicle seat by using Visual Analogue Scale (VAS) and Likert scale. VAS is a tool that use to measure a discomfort or characteristics in range across a continuum of values. Meanwhile, Likert-scale is a tool consist of items that require respondents to rate their degrees of comfort or discomfort with various declarative statements. Thus, the purpose of this study is to review, discuss and compare between the VAS and Likert scale used on the development and assessment of sitting discomfort survey in seat vehicles. The literature on various topics related to questionnaire development on discomfort in seat vehicle were collected from electronic databases. Four high-quality studies were eligible and met the inclusion and exclusion criteria. Overall, there is no evidence and conclusion that neither visual analogue scale nor Likert scale are better to one another. Therefore, it can be concluded that either of this scale still applicable for the ergonomic research application as both of this scale have their own pros and cons.

Keywords: Car, Motorcycle, Rating scale, Reliability, Validity

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INTRODUCTION

In recent decades, comfort in products has become into a crucial factor for customers. Producers and company recognize comfort as their key selling point which the factor has increasingly play dynamic role in product-buying decision. Besides, many employers have awareness in creating a healthy working environment for their employees. Based on Holmes et al. (2013), workers need to finish the task and perform their duties in a seated posture for many hours in a day which prolonged sitting has been associated with risk in getting low back pain (LBP) (1,2). In addition, the perceived discomfort increases for occupation linked with prolonged riding and driving (3). A sitting discomfort in vehicles has become a big issue and need distinguished due to limited space, more restriction to posture, vibration and multiple task which can lead to a Musculoskeletal Disorders (MSD) (4). However, there is no broadly specified definition on discomfort and sitting discomfort (5).

A term discomfort usually showed in scientific literature

since it is used in many study (6). In ergonomics field, the terms discomfort is a unique measurement because they involve the human perception to the machine and system of work environment (7). Several methods are used in studies in order to measure drivers and riders' discomfort. Based on Sammonds (2017), objective measurements have more advantages than subjective measurements (8). However, Deros et al. (2009) argued that it is crucial to get human feedback and perception with information from subjective evaluation by using a questionnaire (9).

Discomfort measurement has usually been attempted by asking the participants to rate the scale of their discomfort which commonly termed as a subjective scale. There are several subjective methods in assessing the level of discomfort. However, for this review, only focus on Likert scale and Visual Analogue Scale (VAS) because these two types of scales are usually used in discomfort rating questionnaire. Therefore, the aim of this paper is to review, discuss and compare between the VAS and Likert scale the on the development and assessment of sitting discomfort survey in seat vehicles.

MATERIALS AND METHODS

The literature on various topics related to discomfort in seat vehicle were collected from electronic databases

such as Scopus, Research gate and SAGE journal as shown in Fig 1. Seat discomfort, automobile, discomfort questionnaire keywords were used in electronic search. The researches were screened between year 1969 until 2018. The great span of years would inflate the list of related articles and research to this review.

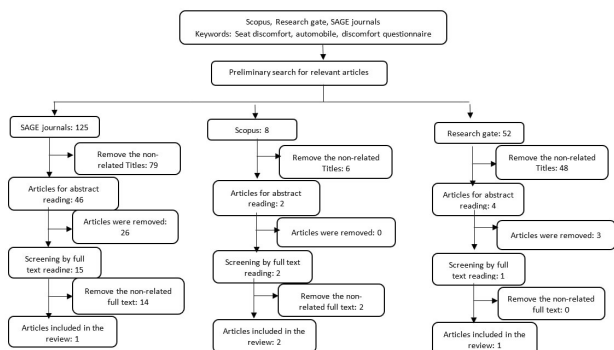


Figure 1: Flowchart of study selection procedure. The electronic search resulted in 185 totals of potentially relevant papers, which was reduced to 96 after the removal of non-related articles. After reviewing these full-articles and abstract, four articles met the inclusion and exclusion criteria.

REVIEW FINDINGS

Comparison

All studies have their own opinions in choosing type of outcome measure either Likert scale rating or VAS in development of automobile seat comfort questionnaire as shown in Fig 2. Thus, this research would like to review the advantages and disadvantages of both methods in development of discomfort questionnaire.

i. Visual Analogue Scale (VAS)

VAS is an instrument that use to measure a pain or characteristics in range across a continuum of values (10). It is widely used in scientific research to measure the intensity or frequency of various symptoms (11). This method can be performed in several ways. However, the simplest VAS is a straight horizontal line of fixed length usually 10cm length line was used. It consists of a straight line often anchored at the endpoints with expressions such as no discomfort and extreme discomfort (12). The method may have interval properties and has even been postulated to work as a ratio scale (13). However, this had been met with criticism, as has the assumption of congruence in meaning of scale values (14).

In some studies, horizontal scales are orientated from right to left, but many investigators use vertical VAS. However, there is no difference between these two types of VAS has been shown in a survey but other authors have suggested that the two orientations differ with regard to the number of possible angles of view. There is a different result in reproducibility has been shown along a horizontal VAS and along a vertical 10-cm VAS. The VAS scale is widely used in subjective evaluation of many variables. One crucial aspect to be considered

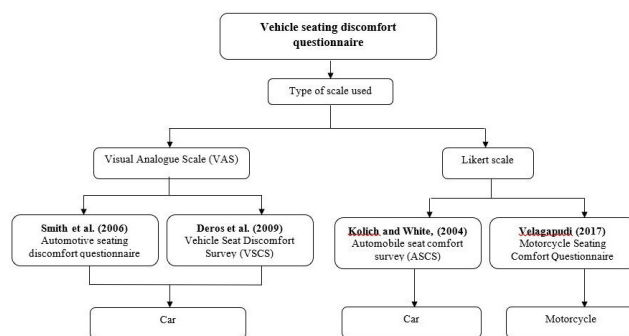


Figure 2: A conceptual framework on the vehicle seating discomfort questionnaire. The flowchart from several studies showed there is two different types of scale used in development discomfort seating questionnaire for car and motorcycle.

when using this method is the right choices of terms that will be used as anchors. In the ergonomic design field, at least two criteria of perception must be emphasized; one should may involve a negative concept such as greater effort of discomfort and another one with a positive concept such as less effort and comfort.

ii. Likert Scale

Likert scale is a non-comparative technique of scaling and unidimensional in nature. In this method, respondents were asked to indicate their level of discomfort with a given statement and situation. This tool is the most widely used scaling technique in various health research studies. These scales typically consist of items that require respondents to rate their degrees of agreeing or disagreeing with various declarative statements. Usually five to seven response alternatives are used ranging from “Strongly Disagree” on one end to “Strongly Agree” on the other with “Neither Agree nor Disagree” in the middle, but there are different opinions about the optimal number of response alternatives. In addition, wording of the answers most probably affects the responses.

Advantages and disadvantages

VAS and Likert Scale both have specific advantages and disadvantages as tabulated in Table I. Major advantage of VAS is easy to understand and use especially by less educated respondents (15). Vickers (1999) has suggested that VAS has a better responsiveness than a Likert Scale which might be more reliable and valid (16). Besides, most researchers claim that VAS and Likert Scale are different and comparable in reliability and validity but still yield a similar result (17). Onhaus and Adler (1975) stated that VAS shows more accurate results to what respondent’s experience or feel compare to other method (18). However, the disadvantages for the VAS are it require a high commitment, time and work for instruction to respondents who have difficult to understand. Moreover, the problem with the VAS is, the mark on the VAS have no specific and interpretable meaning which can lead to worse precision than scale.

However, most of the researchers and respondents agreed

Table I. Advantages and disadvantages of VAS and Likert Scale in discomfort questionnaire

Method	Advantages	Disadvantages
VAS	<ul style="list-style-type: none"> • More sensitive to small changes than Likert scale • Results are more distinct when looking at change within individuals • Save time: Usually takes less than one minute to complete • No training or details explanation is required compared to Likert scale • Assess more closely what respondent actually experience 	<ul style="list-style-type: none"> • clearly highly subjective • It could be argued that a VAS is • It can only be administered face-to-face which it cannot be administered verbally or by phone. • Caution is required when scale is constructed as this may change the length of the centimetre line and the same alignment of scale should be used consistently within the same respondent.
Likert Scale	<ul style="list-style-type: none"> • Does not have require any special equipment • Easy to understand the scale compare to VAS • Easy to administer for the researcher as well as respondents • The result is more uniform and fixed compare to VAS • Can be administrated verbally, by phone or on paper 	<ul style="list-style-type: none"> • Too many choices of scale may lead to difficulties in choosing the answer • Less sensitive than VAS

that Likert Scale method is easier to use and understand since it is used the coding as an interpretation compare to VAS. It also takes less time to explain to respondents. The scale also has been found are suitable to use to young children since it is easier to understand which the results are more accuracy compare to VAS. Besides, Likert Scale seems better than the VAS with respect to facilitate communication and its ability to discriminate among the maximal intensities.

Validity and Reliability

The validity and reliability for both VAS and Likert scale have been measured and evaluated in all studies. Generally, these two methods are reliable and valid (19-22). In comparing different types of VAS and Likert scales criteria have included consistency of adjectives and scale ratings relationship (19), magnitude of between-subject variability (23), reliability of test-retest (24), correlations strength with other measurements (25), factor analysis performance (26), and achieving a uniform response distribution. It is not surprising that all these different criteria have resulted to different conclusions about the methods ' relative value, and each method has its advocates. However, there have been consistently high correlations between various methods of presenting response options.

Although the VAS is most used and recommended in research, it still has been criticism regarding the reliability and validity in interpreting the results. Many studies have been conducted in comparing these two methods for their validity and reliability in different setting and the results are different from each other. The different results between two methods might occur because the VAS is a more sensitive in value compare to the scale

(27). Based on Grant et al., (1999), they found that VAS was higher sensitivity than Likert scale but there were no significant differences between them (21).

Meanwhile, van Laerhoven et al. (2004) found that the Likert scale is more reliable and recommended to use among children (20). This is because this scale is easier to complete among children regardless of their age compared to VAS. Shen and Parsons (1997) stated that the Likert Scale rating can provide a basis for industrial engineers and ergonomists in selecting rating instruments for product usability as well as seating comfort (28). The validated category partitioning scale is very sensitive and accurate. It will find wide application in comfort evaluation and in industrial benchmarking activities.

Seat Discomfort in Vehicles

From the previous study, it has shown that motorcyclists in Malaysia had discomfort experience on several part of their bodies especially in the lower part of the back (lumbar) area during the riding process (29). Prolonged sitting in driving and riding cause the rider or driver to maintained their fixed posture causing increased muscle discomfort, reduced blood flow in muscles and increased risk of MSD (30). This is because in a seated position, our body in the pelvis part will rotate posteriorly, and the lumbar lordosis flattens out, which this condition will increasing the pressure in the posterior aspect of the disc of spine as well as strain in the posterior passive elements. Then, the pressure in the lumbar region of the spine are will be greater when seated than standing (29). Sitting position and poor posture are both associated with the development of muscle discomfort and MSD in the human body. Previous study done by Kyung et al. (2008) have mentioned that seated postures have been regarded as potentially unhealthy and considered as one of the major contributing factors for discomfort (4). Due to increased exposures to seated postures, particularly in the vehicle, sitting discomfort has turned into a vital issue that requests satisfactory ergonomic interventions.

Existing seating discomfort questionnaires on vehicles

i. Car

There are three studies that had developed statistically significant level of reliability and face validity using proven method for questionnaire development (9,31,32). Smith et al. (2006) and Deros et al. (2009) were focused this questionnaire development on car drivers and chose Visual Analogue Scale (VAS) (9,32) as their outcome measurement. , However, Kolich and White (2004) chose rating ordinal scale as their method used. The different between these three studies was the number of items used in discomfort seat questionnaire development as shown in Table II.

Based on Smith et al. (2006), there is many weaknesses on Kolich and White study. They found that the Automobile Seat Comfort Survey by Kolich and White (2004) has been shown to be a reliable questionnaire

Table II: The items used in development of car and motorcycle seat discomfort surveys

Kolich and White, 2004 (Revision level 2)	Smith et al., 2006 (ASDQ)	Deros et al., 2009 (VSCS)	Velagapudi and Ray (2017)
<ul style="list-style-type: none"> Amount of lumbar support Back tailbone comfort Lumbar comfort Upper-back comfort Back lateral comfort Cushion tail-bone comfort Thigh comfort Ischial comfort Cushion lateral comfort 	<ul style="list-style-type: none"> Cushion width Cushion length Cushion firmness Cushion bolster Cushion centre Cushion contour Trim Trim friction Trim feel Backrest height Backrest width Backrest firmness Backrest bolsters Backrest contour Lumbar stiffness Lumbar prominence Lumbar support Lumbar height Lumbar pressure Overall discomfort 	<ul style="list-style-type: none"> Cushion width Cushion length Cushion contour Seatback width Seatback height Seatback contour Headrest support Buttock comfort Thigh comfort Under-knee comfort Lumbar support Upper-back support Physical design Texture and material Overall discomfort 	<ul style="list-style-type: none"> Overall seating comfort Seat contour Seat width Seat length Seat cushion firmness Tendency to slide Burning sensation Pressure under buttock

in providing Likert type ratings of seating comfort (31). However, the scale selection, variable omission, seat selection, and subject size used during the development of this tool need further consideration. Besides, discomfort is continuous and should be measured on a continuum, a 7-point Likert scale, is unfavourable due to the intermediate anchors, implying that discomfort is a divisible construct and not continuous. However, this type of scale has been used in Kolich (2000,2003, 2004), and Kolich and Taboun, (2004) all studies showed a good significant result (33-36).

Smith et al. (2006) also agreed that VAS is a good method in measuring automotive seating discomfort outcome because it is a direct estimation method scale that is designed to elicit from a subject a direct quantitative estimate concerning the magnitude of an attribute (9). This opinion was really opposite with Kolich and White study. This tool is accomplished by using a 10 cm line length, with anchors located at the extreme ends and no description in the intermediate positions. Although both of this study vary in term of rating scales types and contents, both studies have shown the significant results. However, Deros et al. (2009) argued to this both of the studies because they found that the application of Likert scale in Kolich and White (2004) questionnaire require further consideration and they found that Smith et al. (2006) survey was quite lengthy with twenty numbers of items used. Moreover, the ASDQ by Smith et al. (2006)

was not suitable for developing country since Malaysia manufactures have its own car locally which have different specification of the car. In order to achieve the suitable tool for discomfort survey in local car, the authors had decided to develop vehicle seat discomfort.

ii. Motorcycle

Seating comfort of passenger cars has extensive research providing insights into the criterion for comfort and guidelines for the design of seats as discussed before. However, unlike car, motorcycle only have one study on develop a reliable seat comfort questionnaire by Velagapudi and Ray (2017) from India (37). This questionnaire also known as Motorcycle Seating Comfort Questionnaire (MSCQ) which is aim to evaluate the comfort of motorcycle seats. The list of items used in this study is shown in Table III.

This study was most preferable using comfort term than discomfort. This is because they found that comfort term showed to be more effective on distinction automotive seat features (4,37). However, Velagapudi and Ray (2017) argued that ordinal scale is most suitable for evaluation of comfort as human perspective and judgement of subjective attributes is Likert in nature which this opinion was opposite with Smith et al. (2006) and Deros et al. (2009). The Likert scale with five to seven point is most suitable for subjective rating. Thus, they decide to used five-point scale only for this questionnaire which divided into bad, poor, acceptable, good, and excellent words. The details of these four studies was summarised in Table IV.

CONCLUSION

Overall, there is no evidence and conclusion that neither visual analogue scale nor Likert scale are better to one another. The circumstances and application context that use in discomfort questionnaire seems greater importance aspects. The interesting parts are both methods showed significant results in subjective assessment on sitting discomfort in vehicles for all of the previous studies and there is no uniform agreement which method is the best.

Thus, more research is needed to found the pattern of strength and weakness for both of this method clearly in relation to different exposures and different context of interest in automobile seat discomfort questionnaire. Besides, more development and evaluation of the motorcycle seat discomfort questionnaire and other transportation are needed since there is still lack of research and literature in this type of vehicles compare to car.

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Table III: Previous studies in Development and Evaluation of the seat vehicles seating discomfort questionnaire

Author (Year)	Country	Title	Type of vehicle	Method used	No of item	Sample size	Outcome	Advantage of method used
Kolich and White, 2004	USA	Reliability and validity of a long-term survey for automobile seat comfort	Car	Likert scale	9	15	Significant in that it considers principles associated with good survey design and produces a survey with an acceptable level of test-retest reliability, internal consistency, criterion-related validity, and construct validity.	<ul style="list-style-type: none"> respondents can indicate, degree of preference for a particular seat design and numerical scores are assigned to the scaled positions, the question, inevitably, turns to the meaning that can justifiably be attached to the score.
Smith et al. (2006)	Canada	Development and evaluation of the automotive seating discomfort (ASDQ) questionnaire	Car	VAS	20	24	the ASDQ reliably and repeatedly measures the construct of automotive seating discomfort, contains face validity, has established a foundation for construct and content validity development, and provides a comprehensive objective measure of occupant discomfort in automotive seating	<ul style="list-style-type: none"> VAS provide accurate quantitative estimate concerning the magnitude of attributes.
Deros et al. (2009)	Malaysia	Evaluation of car seat using reliable and valid vehicle seat discomfort survey	Car	VAS	15	9	Newly developed and tested vehicle seat discomfort survey (VSCS) is valid and reliable. Items used were found to be understandable without further explanation.	<ul style="list-style-type: none"> Survey length is fairly appropriated compared to Likert Scale More understandable compared to White's revision 2 survey.
Ve-lagapudi (2017)	India	Development of a Seating Comfort Questionnaire for Motorcycles	Motor-cycle	Likert scale	8	31	A Motorcycle Seating Comfort Questionnaire is developed in this study with statistically established reliability and validity.	<ul style="list-style-type: none"> The anchor words in scale: <i>bad, poor, acceptable, good, and excellent</i> are simple, easy to understand, and use the subjects' experience and expectation from a motorcycle seat as a basis for rating.

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REFERENCES

- Holmes MWR., McKinnon CD, Dickerson, CR, Callaghan JP. The effects of police duty belt and seat design changes on lumbar spine posture, driver contact pressure and discomfort. *Ergonomics*. 2013;56(1):126-136.
- Lis A, Black K, Korn H, Nordin M. Association between sitting and occupational LBP. *European Spine Journal*. 2007;16:283–298.
- Porter JM, Gyi DE. The prevalence of musculoskeletal troubles among car drivers. *Occupational medicine*. 2002; 52(1): 4-12.
- Kyung G, Nussbaum MA, Babski-Reeves K. Driver sitting comfort and discomfort (part I): Use of subjective ratings in discriminating car seats and correspondence among ratings. *International Journal of Industrial Ergonomics*. 2008;38(5-6):516-525.
- De Looze MP, Kuijt-Evers LF, Van Dieen, JAAP. Sitting comfort and discomfort and the relationships

- with objective measures. *Ergonomics*. 2003; 46(10): 985-997.
- Vink P, Hallbeck S. Comfort and discomfort studies demonstrate the need for a new model. 2012.
- Karmegam K, Sapuan SM, Ismail MY, Ismail N, Bahri MS, Shuib S, et al. Anthropometric study among adults of different ethnicity in Malaysia. *International journal of physical sciences*. 2011 Feb 18;6(4):777-88.
- Sammonds GM, Fray M, Mansfield NJ. Effect of long term driving on driver discomfort and its relationship with seat fidgets and movements (SFM). *Applied ergonomics*. 2017 Jan 1;58:119-27.
- Deros BM, Daruis DD, Nor MJ. Evaluation of car seat using reliable and valid vehicle seat discomfort survey. *Industrial Engineering and Management Systems*. 2009;8(2):121-30.
- Gould D, Goldstone L, Kelly D, Gammon J. Examining the validity of pressure ulcer risk assessment scales: a replication study. *International Journal of Nursing Studies*. 2004 Mar 1;41(3):331-9.
- Paul-Dauphin A, Guillemin F, Virion JM, Brianzon S. Bias and precision in visual analogue scales: a randomized controlled trial. *American journal of*

- epidemiology. 1999 Nov 15;150(10):1117-27.
12. Murphy CA, Coover D, Owen SV. Development and validation of the computer self-efficacy scale. *Educational and Psychological measurement*. 1989 Dec;49(4):893-9.
 13. Price DD, Bush FM, Long S, Harkins SW. A comparison of pain measurement characteristics of mechanical visual analogue and simple numerical rating scales. *Pain*. 1994 Feb 1;56(2):217-26.
 14. Williams AC, Davies HT, Chadury Y. Simple pain rating scales hide complex idiosyncratic meanings. *Pain*. 2000 Apr 1;85(3):457-63.
 15. Van Laerhoven H, Van Der Zaag-Loonen HJ, Derkx BH. A comparison of Likert scale and visual analogue scales as response options in children's questionnaires. *Acta paediatrica*. 2004 Jun;93(6):830-5.
 16. Vickers AJ. Comparison of an ordinal and a continuous outcome measure of muscle soreness. *International Journal of Technology Assessment in Health Care*. 1999 Oct;15(4):709-16.
 17. Bolton JE, Wilkinson RC. Responsiveness of pain scales: a comparison of three pain intensity measures in chiropractic patients. *Journal of manipulative and physiological therapeutics*. 1998 Jan;21(1):1-7.
 18. Ohnhaus EE, Adler R. Methodological problems in the measurement of pain: a comparison between the verbal rating scale and the visual analogue scale. *Pain*. 1975 Dec 1;1(4):379-84.
 19. Guyatt GH, Townsend M, Berman LB, Keller JL. A comparison of Likert and visual analogue scales for measuring change in function. *Journal of chronic diseases*. 1987 Jan 1;40(12):1129-33.
 20. van Laerhoven H, van der Zaag-Loonen HJ, Derkx BH. A comparison of Likert scale and visual analogue scales as response options in children's questionnaires. *Acta Paediatr*. Jun 2004;93(6):830-835.
 21. Grant S, Aitchison T, Henderson E, Christie J, Zare S, Mc Murray J, Dargie H. A comparison of the reproducibility and the sensitivity to change of visual analogue scales, Borg scales, and Likert scales in normal subjects during submaximal exercise. *Chest*. 1999 Nov 1;116(5):1208-17.
 22. Hasson D, Arnetz BB. Validation and findings comparing VAS vs. Likert scales for psychosocial measurements. *International Electronic Journal of Health Education*. 2005;8:178-92.
 23. Lewis RV, Jackson PR, Ramsay LE. Quantification of side-effects of beta-adrenoceptor blockers using visual analogue scales. *British journal of clinical pharmacology*. 1984 Sep;18(3):325-30.
 24. Revill SI, Robinson JO, Rosen M, Hogg MI. The reliability of a linear analogue for evaluating pain. *Anaesthesia*. 1976 Nov;31(9):1191-8.
 25. Woodforde JM, Merskey H. Some relationships between subjective measures of pain. *Journal of Psychosomatic Research*. 1972 Jun 1;16(3):173-8.
 26. Downie WW, Leatham PA, Rhind VM, Wright V, Branco JA, Anderson JA. Studies with pain rating scales. *Annals of the rheumatic diseases*. 1978 Aug 1;37(4):378-81.
 27. DU TOIT RI, Pritchard N, Heffernan S, Simpson T, Fonn D. A comparison of three different scales for rating contact lens handling. *Optometry and vision science*. 2002 May 1;79(5):313-20.
 28. Shen W, Parsons KC. Validity and reliability of rating scales for seated pressure discomfort. *International journal of industrial ergonomics*. 1997 Dec 1;20(6):441-61.
 29. Karuppiyah K, Salit MS, Ismail MY, Ismail N, Tamrin S. Evaluation of motorcyclist's discomfort during prolonged riding process with and without lumbar support. *Anais da Academia Brasileira de Ciencias*. 2012 Dec;84(4):1169-88.
 30. Durkin JL, Harvey A, Hughson RL, Callaghan JP. The effects of lumbar massage on muscle fatigue, muscle oxygenation, low back discomfort, and driver performance during prolonged driving. *Ergonomics*. 2006 Jan 15;49(1):28-44.
 31. Kolich M, White PL. Reliability and validity of a long term survey for automobile seat comfort. *International Journal of Vehicle Design*. 2004 Jan 1;34(2):158-67.
 32. Smith DR, Andrews DM, Wawrow PT. Development and evaluation of the automotive seating discomfort questionnaire (ASDQ). *International Journal of Industrial Ergonomics*. 2006 Feb 1;36(2):141-9.
 33. Kolich M. Ergonomic modeling and evaluation of automobile seat comfort. 2000.
 34. Kolich M. Automobile seat comfort: occupant preferences vs. anthropometric accommodation. *Applied ergonomics*. 2003 Mar 1;34(2):177-84.
 35. Kolich M. Predicting automobile seat comfort using a neural network. *International Journal of Industrial Ergonomics*. 2004 Apr 1;33(4):285-93.
 36. Kolich M, Taboun SM. Ergonomics modelling and evaluation of automobile seat comfort. *Ergonomics*. 2004 Jun 22;47(8):841-63.
 37. Velagapudi SP, Ray GG. Development of a seating comfort questionnaire for motorcycles. *Human factors*. 2017 Dec;59(8):1249-62.