Art and Design Review, 2022, 10, 419-435
https://www.scirp.org/journal/adr
ISSN Online: 2332-2004
ISSN Print: 2332-1997

First Stage of Automotive Concept Design; Driver Positions (H-Point)

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How to cite this paper: Paker, F. A. (2022). First Stage of Automotive Concept Design; Driver Positions (H-Point). *Art and Design Review, 10,* 419-435.
https://doi.org/10.4236/adr.2022.104033

Received: August 30, 2022
Accepted: October 9, 2022
Published: October 12, 2022

Abstract

For drivers with different anatomical features in the use of vehicles, the seating position includes many important variable parameters from safety to comfort, from cost to customer preferences, from vehicle class to vehicle entry-exit. In addition, the driver's height from the ground or the driver's standing position (H-Point), which is included in the initial decisions of the automotive concept design stages, constitutes the anatomy and structure of the vehicle, together with many ergonomic setups from vehicle class to vehicle weight, from view to wind resistance. Taking part in the initial decisions of the automotive concept design stages; driver's ground clearance or driver's standing position (H-Point): from vehicle class to vehicle weight, from visibility to wind resistance along with many ergonomic installations, it creates the vehicle anatomy and structure. Therefore, within the discipline of automotive design, the vehicle structure and character are determined by the driver's position, the h-point (the driver's seat height from the ground and the seat angle). In the automotive concept design flow, ergonomic decision and analysis methods determine the vehicle design process and the structural proportion of the vehicle, as well as direct the vehicle analysis and studies. The ergonomic decision in question creates important relations that increase efficiency in the structural model of the vehicle, together with the problems that affect the resource use of the entire new product development process, the project structure and time. Ergonomics science due to increasing interdisciplinary efficiency, has become a common field of study for many disciplines such as anatomy, medicine, psychology and physiology, especially industrial design, automotive concept design, industrial design engineering. Therefore, the angle of view, the steering wheel diameter or the ergonomics of use of the instrument panel functions, which are affected by the driver's position in the research results, constitute the safety elements in vehicle driving. The automotive industry is one of the areas where ergonomic designs are most needed. In addition to affecting safe driving, non-ergonomic vehicle designs can cause many fundamental variables, from discomfort to the driver's musculoskeletal system to vehicle accidents. In order to show the expected driver usage performance from the designed vehicles, analyzing the driver's position or driving positions with the help of computer aided programs has important results.

Keywords

Vehicle Occupant Package, Automotive Concept Design, Anthropometrics Vehicle Design, Ergonomics Vehicle Design, Vehicle H-Point Design, Driver Posture Analysis, Driver Comfort Angles

1. Introduction

The initial step of the automotive concept design process is determining the driver seat height (H-point). The driver seat height in question includes the common definition of many variables, from the class of the designed vehicle to the windshield angle or the aerodynamic wind resistance of the vehicle. H-point, the first step of automotive concept design, in the vehicle development process; drivers and passengers, engine and powertrain, cargo area inside and outside the vehicle or ease of access inside the vehicle and all similar design decisions. The research comparatively evaluates the structural vehicle functions and human anthropometric values, which are affected by the driver seat height configured during the automotive concept design process, in the products of companies in the 3 local and 3 global commercial vehicle manufacturing industries included in the field study. In addition, the information collected in the study was analyzed in the vehicle-driver ergonomics module of the computer aided design program (Catia-Ramsis). Modelling of vehicle interior living space, together with company-specific design styles, has been studied within the scope of research in international standards. Therefore, considering the parameters that the driver H-point seat height affects during the automotive concept design stages, as well as the boundary conditions stipulated by the international specifications; similar ergonomic parameters of in-vehicle placement, such as ergonomic accessibility, friability and visibility, were compared on a company basis. The targeted ergonomic variables of the driver's seat height (H-Point) within the functional vehicle boundary conditions were evaluated with automotive concept design stages and working alternative vehicle comparisons. Compared to the clay model, virtual viewing angle, package and similar methods used in traditional automotive concept design stages, it has been observed that the comparison method used in the research accelerated the ergonomics stage results or optimization studies of the analysis process in the company-specific design. Therefore, with the newly developed comparison structure, it is foreseen that the functions that remain in the seat-driver-vehicle relationship or the usability, accessibility, status are examined in depth and that it will benefit the modelling of the interior living space of the autonomous vehicles that have just started to come into life.

The increase in the time spent in the vehicle with the changing life model brings with it the necessity of applying long-term comfort requirements to new vehicles for the health of the musculoskeletal system in human anthropometry. Therefore, the calculation of seat height and angle or seat comfort angles in vehicle use allows the driver to have a better command of the road in traffic. In addition, the H-Position has been examined through different scenarios in daily life, the different ergonomic positions and joint angles created by the driver in the functional interface with the vehicle, through the skeletal model that connects the usage reference points with the function. Within the scope of the study, one-to-one evaluations were made with 60 employees of 6 automotive industry companies over different approaches, using H-points used in automotive concept design or project inputs. According to the research findings, it was revealed that insufficient driver seat height creates narrower angles for female users' comfort angles during automotive use than for male users. Vehicle ergonomics or the science of ergonomics in the automotive industry; aims to create the functional interface of human-machine or driver-vehicle relationship in use values.

In particular, the main purpose of vehicle ergonomics or the science of ergonomics: is in the human-machine interface; rather than positioning people in relation to the machines, it is to ensure that the machine design is appropriate (Singh, 2015; Née et al., 2019; Beanland et al., 2013; Lu et al., 2016; Cabrall et al., 2019).

In the automotive concept design stages, it is aimed to plan the priority flow steps during driver tasks or driving under the functional structure of the vehicle and usage scenarios suitable for human ergonomics. Therefore, designing all peripherals that support vehicle driving within the ergonomics of use ensures that possible negative traffic accidents are minimized. While the living space between vehicle and driver is one-way, 3-way adjustable product design for drivers with different human anthropometry is modelled during concept development. In addition, autonomous driving or autonomous driving support systems, which have just started to be included in the automotive industry, come to life in the driver's seat structure and indicators. The study aims to evaluate the ergonomic condition and current situation of automotive products in today's manufacturing. Therefore, problems related to deformation or strains in the musculoskeletal system that occur in the driver's position or vehicle driving and solutions are mentioned. While the automotive industry has been in existence for more than a century, developments and measurements in vehicle ergonomics provide today's vehicle comfort. It has been observed that damage to the musculoskeletal and endocrine systems occurs in long-distance driving due to seat designs that are not suitable for human anatomy (Yoon & Ji, 2019; Khan & Lee, 2019; Large et al., 2017; Filatov et al., 2019; Wu et al., 2020). In the study, unlike the previous research, the focus on the differences and similarities created by the driver seat heights and angles determined in the automotive concept design stages, in the concept design stages realized in 6 different automotive industry companies was aimed. In addition, the ergonomic measurements used in the concept design phase of 6 automotive companies that participated in the evaluation were evaluated on CAD software (Catia-Ramsis).

Analyzing the driving positions or examining the different stances of the driver's position and understanding the functional uses of the sitting positions in the company constitute an important input for analysis studies.

When the previous publications were examined, research structures in which drivers' positions or seat angles were examined using different criteria such as age, height, weight, gender, region, temperature, etc. were encountered; however, it has been observed that there is no study in which the driver position is evaluated comparatively according to the scenarios designed by different company structures. In order to contribute to the literature, driver positions and postures or comfort angles in different company applications have been investigated. When the literature is examined, the use of the seat while driving and its ergonomic design, which are one of the three most important points in driver seat design as a vehicle interior trim part, have attracted the attention of many researchers (Jiang et al., 2020; Wang et al., 2021; Ding et al., 2017; Okabe, 2018; Vergnano & Leali, 2018). The differences or similarities in the ergonomic sitting posture based on the driver's position and ergonomics of use, driving and usage comfort angles designed by the 6 rival companies in the research will reveal topographic optimization. In this study, it is aimed to find optimum angles with statistical support on CAD software. The new vehicle product project in the automotive industry, which matures within the design setup and manufacturing requirements, defines the market requirements until the mass production process, starting with the preliminary design stage, extending to the detailed design stage and digital models, is associated with a long and complex design activity (Wang et al., 2021). The digital models designed during the automotive concept design process need to be verified until the mass production process according to the project target values, and any errors that may arise should be resolved. The formation of each trim piece on the new vehicle along with functional use scenarios in the automotive concept design process reveals the thought of the whole system. Therefore, it starts with determining the ergonomics target values of the driver needs of the vehicle interior living space, which is one of the most important design parameters studied in the automotive concept design stages (**Figure 1**). The automotive designer carries out the virtual and physical flow steps in order to obtain the concept design that will provide the ergonomics target values for the new vehicle determined on a project basis, until it is at a level that can be mass assembled on the production line, that is, until it makes acceptable models. Although the automotive company's design database contains many in-house procedures and guidelines for designing and evaluating vehicles and parts, the practices recommended by the Society of Automotive Engineers (SAE) form the basis of many general design procedures (**Figure 1**). Among these applications, there are important definitions at basically 5 different points, as shown in **Figure 1** (SAE, 2005).

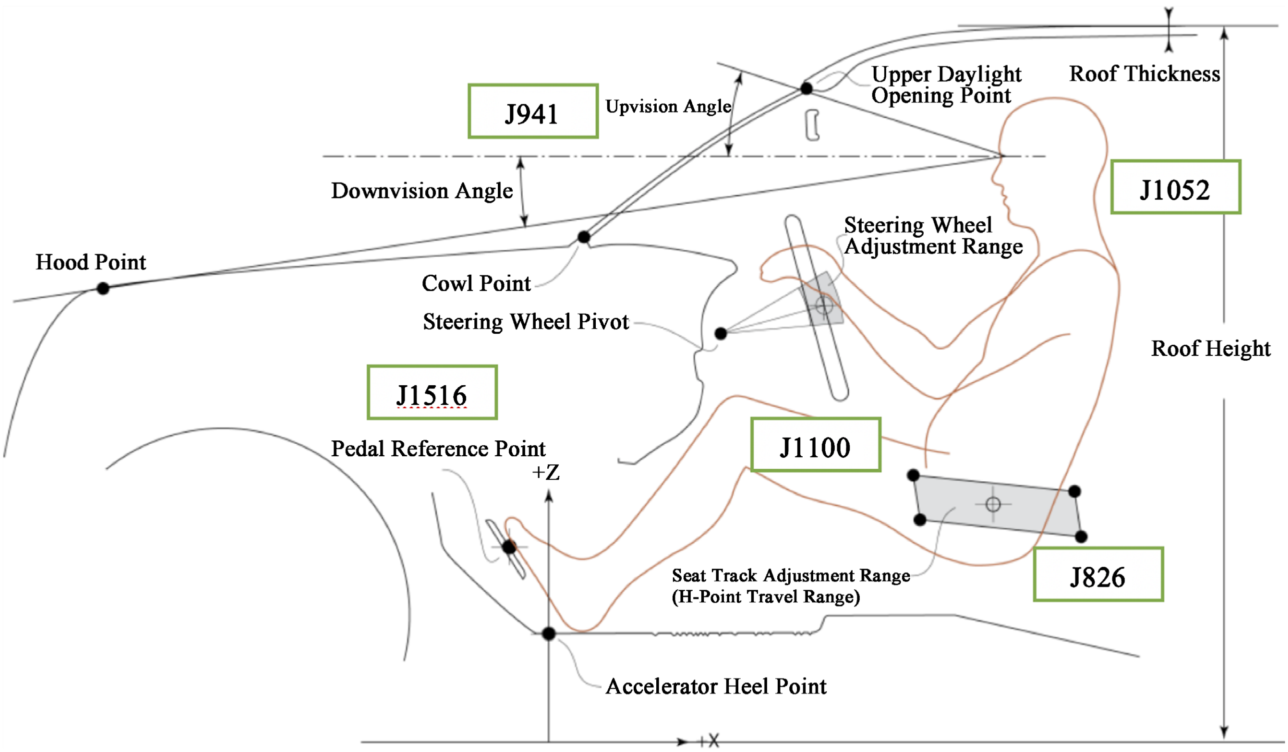


Figure 1. SAE specification of driver position (SAE, 2005).

In Figure 1 above, international regulation values are given for the driver area in the interior of the vehicle. In Figure 1: There are J182 Vehicle coordinate system, J287 Driver reach distance, J826 H-point and passenger in-vehicle placement, J941 Driver view angle, J1052 Driver and passenger head clearance, J1100 Vehicle size, J1516 Pedal reference points. In order to realize concept designs (which creates an interface for driver-H point-driving functions) by considering the size differences of all vehicle classes or the driver area (which varies for different user groups such as height, weight, age, gender, etc.) Ergonomics and Anthropometry are used. Anthropometry, which consists of the Greek words Anthropos (human) and metikos (measure), is a science that deals with the determination and application of human body measurements. Anthropometry, which evaluates human measurements in terms of engineering in designs that create vehicle or machine interfaces, is the most important subject of ergonomics (Cabrall et al., 2019). The use of anthropometric data in the first automotive concept design phase ensures that the changes that occur in costly modification works during the new product development process that come into play later on are minimized. In order to use the knowledge of ergonomics and anthropometry effectively in the concept design stages, a basic priority order is made about the driver and driving positions, possible scenarios in vehicle driving, and the relations between usage and user (Singh, 2015). As shown in Figure 2, Anthropometric data has been recorded by dividing people into various percentiles according to their geographical location (Bittner, 2000). Anthropometry shapes all basic dimensions and information in vehicle design or the entire vehicle design (Figure 2).

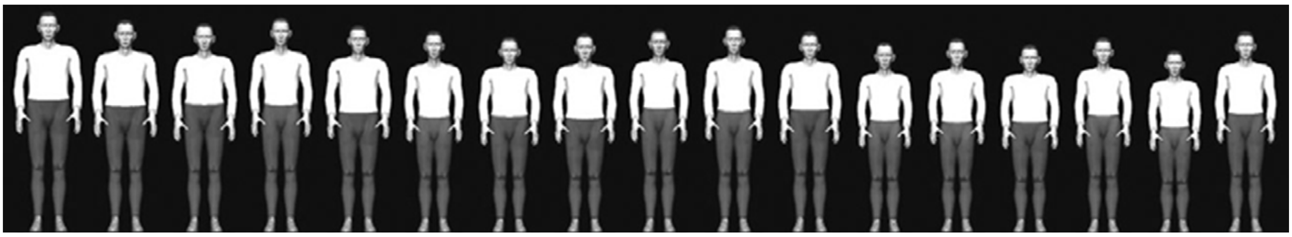


Figure 2. Differences (%5, %50 and %95 Percentile) according to percentile values (Bittner, 2000).

The measurement methods of traditional automotive concept design can be completed during the project process according to the part designs of the vehicle and the concept development capabilities of these designs (Figure 2). Since a completed part design does not communicate with the peripheral part designs, the errors that may occur cannot be predicted in the driver position editing. These errors can cause unprecedented losses in the concept design and development process, and in such a case, they cause delays in the time of the project in resource management.

2. Driver Position (H-Point)

The increase in the use of vehicles together with the changing life model has made it an important issue to examine the driver's position from an ergonomic point of view. Anthropometric information and ergonomics have a significant contribution to the development of the most appropriate design for the driver's position in the vehicle structure. Automotive industry companies, which are in competition with each other in line with the increasing demand, create alternatives according to the standard human form in vehicles, instead of human dimensions that vary from person to person. Although vehicle equipment that can be adjusted from person to person is planned as modular, different size variability may be insufficient for different societies. Anthropometric criteria and measures, together with ergonomics, can vary greatly according to nations. For example, while the size difference (height, full arm length, lower region length) between different societies is over 30 cm, the size of the adjustable equipment in vehicles varies between 10 cm (Bittner, 2000). This measure is insufficient to ensure the driver's position, which is vital for safe driving (Figure 3). Seat height or back angle or adjustment in the driver's position supports safe driving. In vehicles, the angle or gap between the driver's back and the seat, the contact between the knee and the steering wheel or the gas-brake pedal access constitute the basic driver's position (Figure 3). Therefore, the anthropometric dimensions of the targeted customer group or society are considered in the vehicle design. The position of the driver in the vehicle, variants according to the anthropometric measurements, is given in Figure 3.

Within the scope of the research, 6 points that form the basis for the driver's position were determined, and ergonomic and statistical evaluations were made with 60 automotive industry employees on 6 rival vehicles (Figure 3). The angle change in the neck area, which may be caused by the change in vision distance,

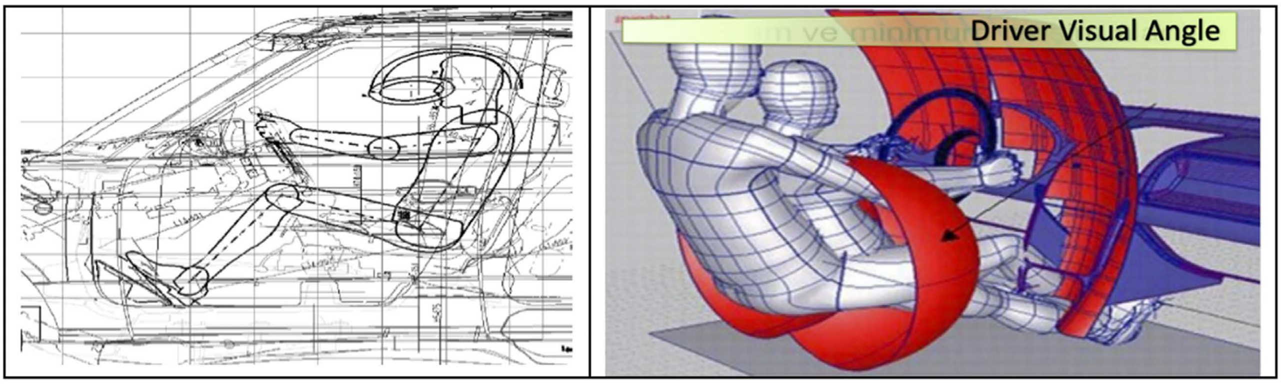


Figure 3. H-point Driver position and functions zone of the model in automobile.

and the angle change in the knee and leg area, which may occur with the differentiation of the gas-pedal usage measure, were evaluated (**Figure 3**). Calculations were made using tables depending on the determined angle values. Ergonomic analyzes of the drivers during vehicle use were made by placing digital human models at different positions on the vehicle driver model created with the CAD supported modeling and analysis program cattie software. The position of the digital human model created in the study while driving; gas pedal distance and visual angle distance are given in **Figure 2**. Automotive industry companies; to improve driver ergonomics or driving comfort along with vehicle design; seat design-oriented vehicle use and body movements in driving values gave importance to investigate (Vogt et al., 2005; Bibbo et al., 2019; Ma et al., 2017; Roh et al., 2018; Bourahmoune & Amagasa, 2019; Zemp et al., 2017). Therefore, the most important element in vehicle use and automotive concept design is the driver's position and the alternative body posture that creates the usage reactions (Roh et al., 2018). Vehicle interior comfort and safety depend on ergonomic risk factors (Zemp et al., 2017; Zhao, 2021; Jeong & Park, 2020; La Rocca, 2012). If a good seat is not designed for automotive, low back pain, back pain and neck pain become chronic and permanent problems arise in the musculoskeletal system (Gravina & Li, 2019). In addition, in vehicle use, the waist and back must be in a supported structure due to the continuous use of gas, clutch or brake pedals. In the absence of sufficient support in the waist and back parts, the body balance is lost and too much load is placed on the right or left regions. Various additions are made in the seat design in order to balance the load distribution in the driver's position, and these additions to the seats also restrict the driver's movements. However, the driving safety of drivers whose movements are restricted weakens after a certain period of time. In vehicle seat design, it is aimed not only to ensure the comfort of the driver, but also the visibility of the driving functions in the traffic and the function and control ability in the vehicle (Chang & Lin, 2011). In the driver's position, deformations in the lumbar region cause pain in the neck and back regions of the body. At the end of long journeys, cramps in the leg muscles and deterioration in blood circulation are experienced due to constantly pressing the gas pedal.

In urban vehicle use, degeneration occurs in the spinal discs in case of moving forward by stop-start (Bourahmoune & Amagasa, 2019). Therefore, it turns out that the most accurate working method in investigating healthy body or driver posture is to examine the angles in the joints. Chang & Lin (2011), in their study, with the participation of 250 people, stated that the hip joint angle should be between 104-107 degrees (Chang & Lin, 2011). The most striking work on the subject was done by Matthew in 1999, calculations and measurements of the angles of all joints were made (Matthew & Ron, 1999). This study shed light on the SAE standard and the optimum angles were standardized (SAE, 2005). In recent years, RAMSIS software has been created with digital modelling, and optimum angles have been calculated in the computer environment (Seidl, 1997; Roh et al., 2018; Bittner, 2000; Beanland et al., 2013). Guenaelle (1995) examined five different daily sitting actions and conducted research on body postures (Guenaelle, 1995). In order for our body posture to be healthy, our joints must take the correct position in every movement of our body (Seidl, 1997). Our body ensures that many muscles work in harmony in order to stay stable with the support of ligaments during muscle activity (Sun et al., 2012). Pahl & Grote (1996) conducted a method analysis to investigate body postures in automotive use and to measure the pressure values on the automotive seats used (Pahl & Grote, 1996). In the imaging method used within the scope of the research, phosphorescent marker balls were placed at 21 points on the body and 7 points on the driver's seat, and the angles of 14 different regions on the body were calculated (Robinette, 2012). It has been claimed that the pelvis region exerts 66%, the lumbar region 27% and the back region 7% pressure (Pahl & Grote, 1996). Robinette (2012) investigated the body angles that automotive users are uncomfortable with (Robinette, 2012). In this study, 2 different vehicle cockpit samples were created, steering angle, seat angle, placement and angles of the pedals were examined, and ideal usage conditions were suggested (Robinette, 2012). The study was carried out with BMW, 21 participants were studied and 3 different seat models were designed (Pahl & Grote, 1996). He stated that users expect the vehicle seat to be comfortable, stylish, sporty and protective during an accident (Babbs, 1979). Seidl (1997), in his study, explained the development process of the RAMSIS software and the optimum angle values (Seidl, 1997). While preparing the RAMSIS software, driving angles, which are the most important elements in the driver-vehicle combination, were discussed (**Figure 4**). The user interface of the RAMSIS software is given in **Figure 4**.

Robinette (2012) reviewed and compiled 30 articles on comfort angles that make up the driver's position (Robinette, 2012). In the review, 14 comfort aspects that deal with the studies were emphasized (Robinette, 2012). In the driver position measurements of the sample research, virtual and physical dummies define the sitting position of the driver or passengers in the cabin, which is defined as the body curvature point located at the center of rotation between the body and the leg, which determines the seat height (**Figure 4**). In addition, a computer-aided design program (3D CAD Ramsis), which contains special

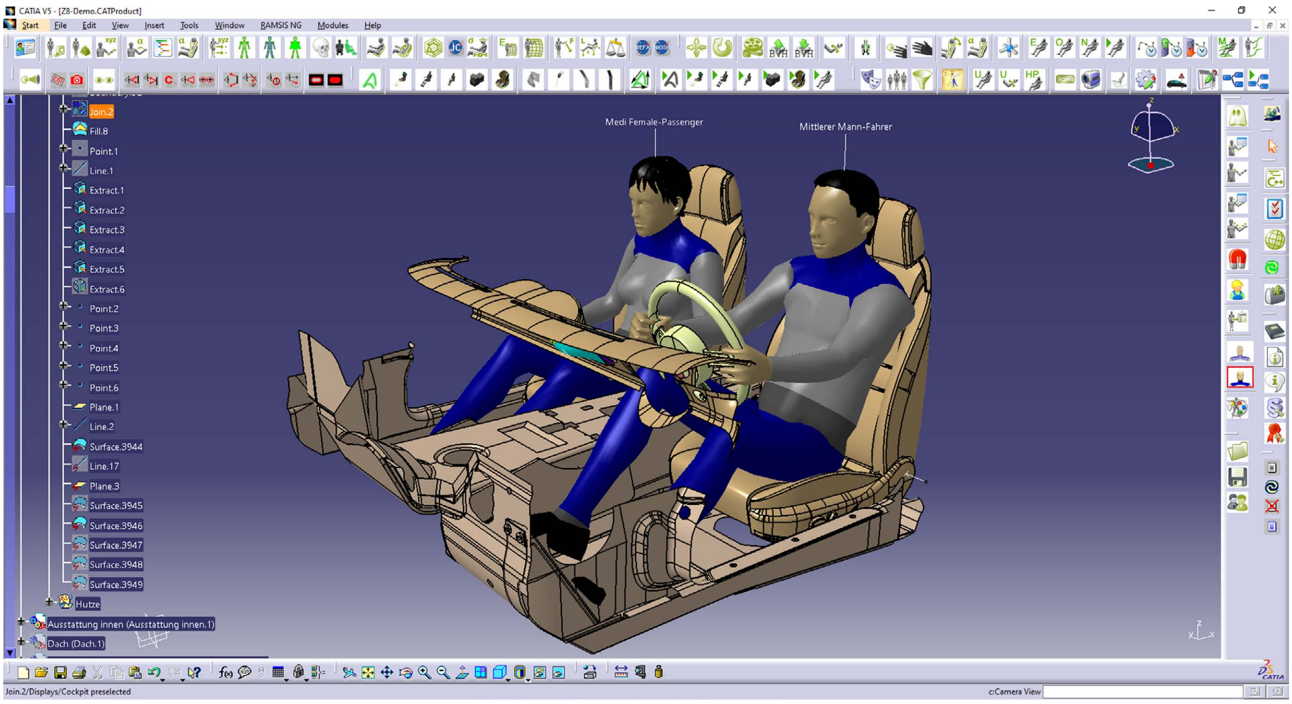


Figure 4. 3D CAD Ramsis software view.

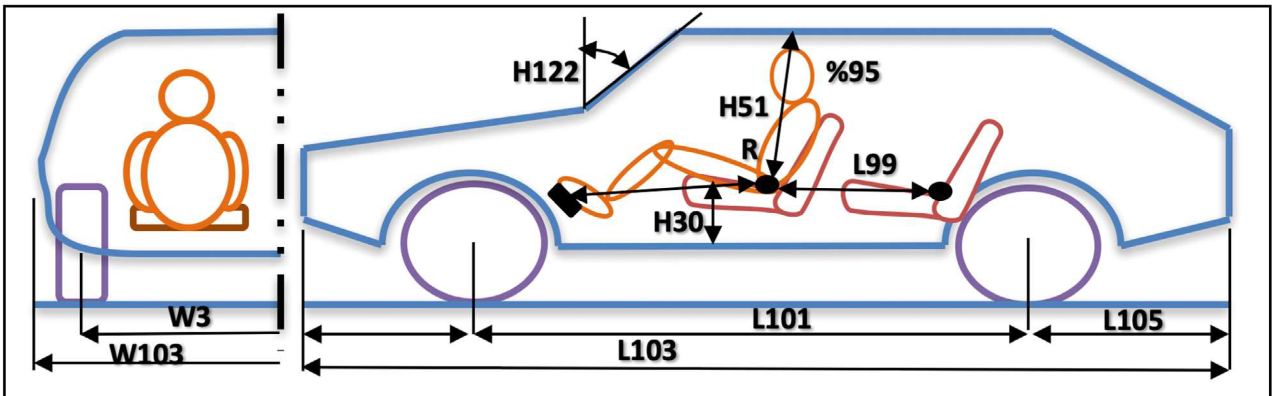
ergonomics values for driver position measurements, is used and their positioning or analysis can be controlled (**Figure 4**). When the existing studies in the literature are examined, the parametric design values are determined for the driver's position, but the usage and solution suggestions remain in the background. Therefore, in the study, the current situation assessment in automobiles and commercial vehicles was developed in an easier and faster system in comparison to 6 competitor vehicle applications under ergonomic criteria.

3. Research Method

Before In this study, with 60 product development managers from 3 local and 3 global automotive industry participating in the field research, 6 driver positions of 6 automotive products currently in production, together with H-Point, were examined and measured comparatively. The measured values were compared digitally in the 3D CAD Catia-Ramsis program (**Figure 4**). In addition, the methods used in positioning the H-point driver position with the managers involved in the design of 6 vehicles were evaluated under one-to-one interviews. As a research method, the comparisons led to the result in solving the problems obtained as a result of the analysis of the driver's posture positions. With this method, values varying between the steering wheel or instrument panel area and the variety of seat angle position created by the driver position and H-point positioning were determined during the study. When the different driver position values obtained were examined, different seat applications supplied from the same supply channel made these differences clear.

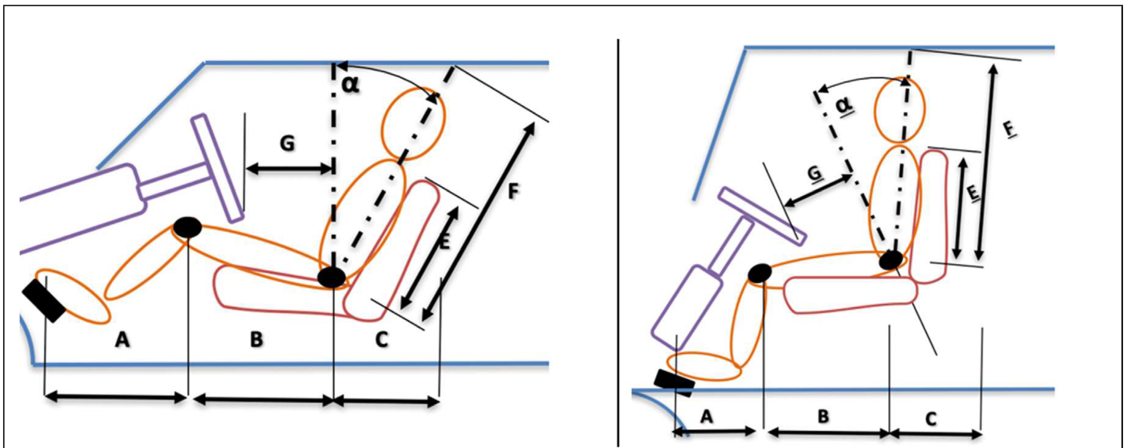
Therefore, in vehicle applications that make up the said comparison structure, measurements were made at a 90-degree seat angle. In order to determine the varying score of the driver's position in different vehicle applications, the interior and exterior reference points were determined together with the seat height (Figure 5). It has been observed throughout the research that the interior and exterior dimensions of the vehicle have significant effects on the driver's position and H-point position. In addition, the H-point height and angles, as well as seat widths, were added to the vehicle application point value comparison table to obtain the final score (Figure 5). The final value was obtained from the combination of the comparison scores (Figure 5). By adding the last value of activity intensity score in Figure 5, the total score was obtained (Figure 5).

Considering the driver position comparison values to be made with the measurement method in Figure 5, musculoskeletal problems that may occur in vehicle use can be determined (Pahl & Grote, 1996). Insufficient proportion sizes in the vehicle driving position and the effects that may occur on the driver are evaluated with the scoring system. Driver position comparison analysis; reveals the driver's driving movements, the driver's basic posture and the risk factor of the load on the skeletal musculature. The final score value obtained after the completion of the analysis defines the differences rather than the similarities in the comparison structure (Figure 6). The meaning of these score values is as follows; the driver position determined during the automotive concept design phase is developed based on the customer profile and the anthropometric measurements of the society



cm	GC1			GC2		GC3			LC1			LC2			LC3		
	B	C	D	C	D	B	C	D	B	C	D	B	C	D	B	C	D
L101	254	254	269	270	276	263	245	252	257	280	304	234	252	260	234	247	252
L103	440	440	479	443	472	491	374	404	442	474	511	362	400	443	265	399	457
L105	95	95	108	99	111	119	69	77	101	113	121	61	72	98	52	71	109
L99	190	190	194	190	190	190	177	181	186	191	196	183	183	189	180	184	200
W103	170	170	178	170	175	185	161	169	188	174	199	154	186	170	156	166	170
W3	135	125	144	136	138	148	132	126	136	142	157	128	136	139	127	136	140
H30	28	28	29	26	25	29	27	27	24	25	27	26	27	29	28	28	27
H51	96	96	97	97	98	97	96	97	97	98	99	95	99	99	94	97	97
H122	60	60	61	61	58	62	58	60	57	57	58	54	57	62	55	54	60

Figure 5. Driver position of global (GC) and local (LC) automotive companies.



mm	α̇	A	B	C	D	E	F	G
Driver	10-25	450-500	460-500	420-490	420-500	500-560	950-1000	360-400
Seat	-	280-370	480-520	390-420	440-520	540-600	930-1000	380-420

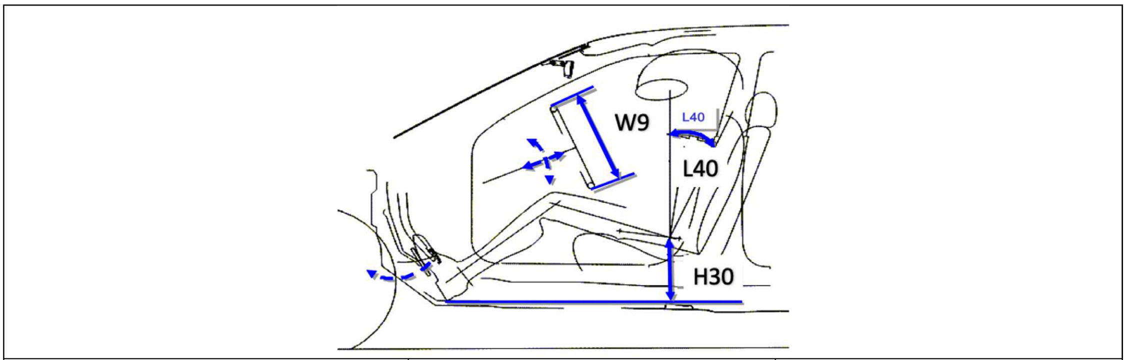
Figure 6. H-Point ergonomics of automobile (M1 class) and commercial vehicle (M2-3/N class).

(**Figure 6**). As long as the ergonomic use of the designed vehicle is not possible, its aesthetic appearance can lead to value losses. Developed comparison analysis model inputs, driver H-point, driver head clearance values and driver field of view values consist of ergonomic performance targets of driver position (**Figure 6**).

The ergonomic driver position or H-point position of the automotive products included in the research revealed 8 different sections in the basic vehicle structure, along with the detection of angles (**Figure 6**). The mentioned vehicle zones in **Figure 6** basically define the driver's position. In **Figure 6**, together with the vehicle regions for which comparison measurements were made, products with common internal structure assemblies were preferred. Therefore, all vehicles in the comparison structure have automatic transmission and the lowest level multimedia screen. The vehicle characteristics of the company LC3 in the comparison structure, seat gear and brake-gas kits were removed and the arrangement was made in accordance with the real conditions by using box profiles. Since the sales figures of automatic transmission vehicles are high in recent years, automatic transmission mechanism has been preferred.

4. Discussion and Comparative Future

The driver positions of 6 automotive industry companies included in the field study were measured, and the drivers' viewing angles (under the steering wheel control indicator viewing angle and windshield viewing angle), and steering wheel sizes were measured according to the H-point seat heights and angles in the comparison analyses (**Figure 7**). In the holistic approach of vehicle design, the driver's seat and position or the seat height together with the driving comfort angles, the ergonomics of use that constitute the functional functions of the vehicle, and the search for the order of importance of the regions in easy access to body movements reveal the driving values (Vogt et al., 2005; Bibbo et al., 2019; Ma et al., 2017; Roh et al., 2018; Bourahmoune & Amagasa, 2019; Zemp et al., 2017).



Driver Posture		M1 class Vehicles (Automobil, SUV, Vans, etc.)	M2-3 & N class Vehicles (Minibus, Omnibus, Truck, etc.)
H30	**Seating (Hip Point)**	127– 405 mm	405–530 mm
W9	**Steering Wheel Diameter**	Max.≤450 mm	450–560 mm
L40	**Seat Degree**	18 – 40 Degree	11–18 Degree

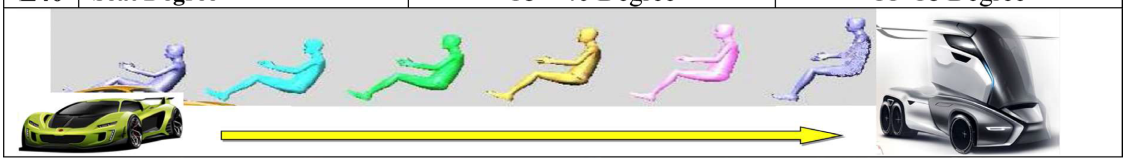


Figure 7. Comparative driver position and functions (vehicles class).

Therefore, according to ergonomic evaluations in the research conducted under the said approach; As the H-point points of the vehicles increase, the viewing angles also increase in positive values, and the steering wheel diameter and driver's seat positions vary at the same value (**Figure 7**). According to the ergonomic evaluations; as the H-point points of the vehicles increase, the viewing angles also increase in positive values, and the steering wheel diameter and driver seat positions vary at the same value (**Figure 7**). Again, in the negative effect of the same approach, as the height of the H-point decreases, the diameter of the steering wheel and the seating and adjustment angle of the driver's position decrease. This approach stems from the finding that the height of the H-point and the ergonomics of use in automobiles are calculated at weaker values than in commercial vehicles (**Figure 7**).

The situation in **Figure 7**, above; As the steering wheel diameter and H-point driver positioning height increase, so does the class of the vehicle. Another finding that constituted the driver position evaluation was the redesign of the distances between the H-point driver's seat and the accelerator pedal in LC automotive industry companies, the arrangement of the back slopes of the driver's seats and the planning of a special footrest for the left foot. It has been claimed by all participant company employees that the driver seating positioning and angles obtained by the comparison measurements of the research are the healthiest solution. When the studies are examined, it has been observed that two-dimensional or three-dimensional models give different results, different results are obtained from country to country, and even different ergonomic angles occur from seat to seat. In the study, 8 different vehicle regions and angles that affect the driver's position and comfort were examined, and it was determined that the data obtained as a result of the measurements were close to the international standard and regulation values. Therefore, in the automotive concept design stages in the automotive industry, the use of internationally valid regulations at lower and upper limits or alternative body postures of driver position and usage reactions are evaluated (Vogt et al., 2005; Bibbo et al., 2019; Ma et al., 2017; Roh et al., 2018; Bourahmoune & Amagasa, 2019; Zemp et al., 2017). Seat position and design or driver H-positioning have an important place in vehicle driving. However, the driver's position or the vehicle interior comfort and safety affected by the driver's seat depend on ergonomic risk factors (Zemp et al., 2017; Zhao, 2021; Jeong & Park, 2020; La Rocca, 2012). When the data is examined, it has been determined that the driver's position and H-point position created by the reduced vehicle interior volume provide use at narrower angles in driving dynamics, while this situation in larger volume commercial vehicles allows users to achieve ergonomic comfort at wider angles.

5. Conclusion

In **Figure 6**, the driver position of the local (LC1, LC2, LC3) and global (GC1, GC2, GC3) automotive industry products participating in the research is compared. It has been observed that the comparison measurements of the H-point distance and angles formed during vehicle driving in the driver positions of global automotive industry companies and field study measurements yield different results. These findings show that the presence of gear, multimedia device and some signals on the right and the rear-view mirror on the left affect the driver's posture during the use of the H-point height of the driver position in LC automotive company products. When the numerical values of the driver position angles were examined, it was seen that the smallest value was in the LC1 automotive company product and the hip joint angle with the H-point was 10.43˚. The highest value is in the GC1 automotive industry product, with the H-point the hip joint angle being 17.1˚. According to the results of the deviation analyses made with the comparison method; it has been revealed that changes should be made in the driver position part of the vehicle model of LC local automotive industry company products. The analyses will be repeated as a result of the improvements in the height of the H-point positioned during the automotive concept design stages. When the comparison analysis of GC automotive industry products is compared with each other, values close to each other have emerged instead of results at high levels in terms of risk. But for heavily competitive automotive industry products, small dimensional improvements can result in great customer satisfaction.

Based on automotive vehicle analyses and calculations made in anthropometric criteria, driving position and driver H-point height and angles, to eliminate ergonomic vehicle-driver differences; driver H-point height (seat height) and gas-pedal distance of LC1-2 products can be adjusted to appropriate levels. In LC2 and LC3 local automotive industry products, the H-point can be brought to the appropriate distance, provided that the distance between the driver's seat and the ceiling provides adequate visibility. LC1 local automotive company product H-point driver's seat backrest tilt angle can be adjusted to appropriate levels and the footrest can be adjusted to appropriate levels to prevent contractions for the less used left foot. The said regulatory needs consist of deficiencies in ergonomics work in the design and product development teams of automotive industry companies. When an incorrect seat position for automotive is designed, low back pain, back pain and neck pain become chronic and cause permanent problems in the musculoskeletal system (Gravina & Li, 2019). As observed in the research, the fact that the main part of the driver's position is the seat and the design and development of the seat in the outsourcing channel of the automotive industry company causes significant ergonomic problems in practice. Outsourcing designs of vehicle parts or repeated control of ergonomic proportions in design or competitor comparisons are an important approach that should be included in the automotive concept design stages. Therefore, the ergonomic vehicle design brought about by the said approach will have a positive impact on production and use under competition today, and may produce productive results for different and variable autonomous driver positions tomorrow.

Acknowledgements

Author (F. A. Paker) served before: Iveco otoyol (Fiat Group), BMC, Ford Otosan, Denso ALJ (Toyota group), Chevrolet, etc., automotive companies as a design and project manager for 25 years. These and other automotive company's employees, thank for their support to the study.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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