Department of Mechanical & Chemical Engineering (MCE)
ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

Organisation of Islamic Cooperation

STUDY OF ERGONOMICS AND DESIGN OF A DRIVING SEAT IN A VEHICLE CONSIDERING ERGONOMICS

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بسم الله الرحمن الرحيم

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Department of Mechanical & Chemical Engineering (MCE)

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October, 2013

DECLARATION

It is hereby declared that the undergraduate project work reported in this thesis has been performed by us and this work has not been submitted elsewhere for any purpose (except for publication).

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Dedicated

To

Our Beloved Parents & Teachers

ACKNOWLEDGEMENT

All praises belongs to the almighty Allah for giving us the strength and courage to successfully complete our B.Sc. thesis

It could never be possible for the authors to complete this thesis without the help of some people throughout these two semesters of final year. At first we want to give thanks and express my sincere gratitude to **Dr. A R M Harunur Rashid,** Assistant Professor, Department of Mechanical and Chemical Engineering, IUT. We are deeply indebted to him for giving us moral support throughout the whole year. His patient guidance and constant supervision made us work in definite direction towards the completion of the project. His care and concern for all the students are appreciated and provided continuous encouragement for me.

We extend our sincere thanks to all other faculty members of the Department for their valuable advice in every stage for successful completion of this project.

We would like to give thanks to all who helped us in many ways during performing the project work. Thanks to our family members for their valuable support and prayers.

Although we have given our best effort to complete this thesis paper, we seek excuses if there is any mistake found in this report.

ABSTRUCT

Automotive seats need to accommodate a wide range of driver sizes over relatively long periods of time and provide isolation from vehicle vibration and shock. To fulfill these requirements, there have been remarkable advances in automotive seat design during the past decade incorporating seatback recliners, lumbar support, motorized multi-axes adjustments, and foam cushions. However, these added features have resulted in increased cost and have been used in only a limited number of seating environments. Even with the progress that has been made, however, many drivers continue to experience significant discomfort in automotive seating, and the factors that contribute to long-term discomfort or improved comfort are still not clearly understood. This study will help the auto drivers to reduce back pain and neck pain. The seat that provided with proper support. proper adjustable height. recline or seat hack. suspension and so on. will make the driver feel comfortable while driving the vehicle. It also help in increasing the drivers motivation.

Most previous seatback design recommendations have been based on physiological rationales intended to reduce lower-back stresses. However, research has not demonstrated that lumbar supports designed to these specifications actually produce the intended postures. In a recent laboratory study (Reed ***et*** al. 1995), the preferred driving postures of volunteer subjects who were selected to be representative of the driving population were measured. The lumbar support geometry of the test seat was varied to determine the effects of changes in lumbar support prominence and vertical adjustability on preferred driving position.

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INTRODUCTION

1.1: Definition of ergonomics:

Ergonomics is the science of work: of the people who do it and the ways it is done; the tools and equipment they use, the places they work in, and the psychosocial aspects of the working situation.

International Ergonomics Association (IEA) defined Ergonomics (or human factors) as the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. An ergonomist is an individual whose knowledge and skills concern the analysis of human-system interaction and the design of the system in order to optimize human well-being and overall system performance (IEA, 2000).

The word 'ergonomics' comes from the Greek**:** ***ergos***, work; ***nomos*** , natural law.
Ergonomics is concerned with the design and by extension with the design of artifacts and environments for human use in general. If an object is to be used by human beings, it is presumably to be used in the performance of some purposeful task or activity. Such a task may be regarded as 'work' in the broader sense. Thus to define ergonomics as a science concerned with work, or as a science concerned with design, actually means much the same thing at the end of the day.

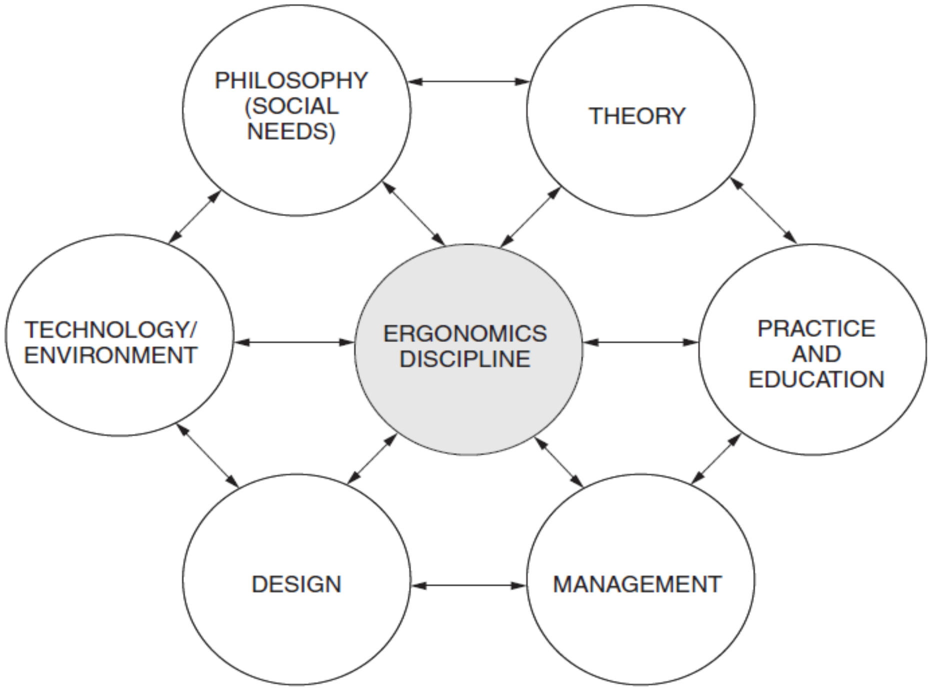

Figure 1: Ergonomic relation with different parameters.

1.2: Domains of Specialization: According to international Ergonomics Association (IEA) ergonomics can be broadly classified into:

• ***Physical Ergonomics*****:** It is concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they related to physical activity. Relevant topics may include working postures, material handling, repetitive movements, work related musculoskeletal disorders, workplace layout, health and safety.

• ***Cognitive Ergonomics*****:** A proper fit of a product to a user does not end with physical interfaces. Cognitive / perceptual ergonomics is concerned with mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system. Relevant topics include mental workload, decision-making, skilled performance, human-computer interaction, human reliability, work stress and training as these may relate to human-system.

• ***Organizational Ergonomics*****:** It is concerned with the optimization of socio technical systems, including their organizational structures, policies, and processes. Relevant topics include communication, crew resource management, work design, design of working times, teamwork, community ergonomics, cooperative work, new work programs, virtual organizations, telework, and quality management.

1.3: Anthropometry:

Anthropometry is the subject which deals with the measurements of the human external body dimensions in static and dynamic conditions. Anthropometric data is used for product and workplace design.

Anthropometry is of two types:

static and dynamic

• **Static anthropometry**: External human body dimensional measurement taken when a man is placed in a rigid static position i.e. standing, sitting, or other adopted postures.

• **Dynamic anthropometry:** The dimensional measurement of human body with various movements taken into consideration in different adopted postures which the work context demands, are termed dynamic anthropometry.

1.4: Somatotypes:

The human body types are classified according to the contents of fat in the body.
These are : ectomorphis , mesomorphs and endomorphs.

- **Ectomorphs:**
  Due to low fat storage the full body appears to be skinny, lean and thin . Abnormal postures are adopted by the people of this category while working, standing, and sitting
- **Mesomorphs:**
  This type of body contains less fat but well balanced and firmed; usually referred to as muscular . Movements are well co-ordinated in all the limbs and in the body as a whole.
- **Endomorphs:**
  This body type has increased fat storage, a wide waist and a large bone structure, usually referred to as fat .

1.5: Discomfort factors are often associated with poor design in the following areas:

1. Seat height from floor (of primary importance)
2. Height and adjustability of armrests
3. Seat back recline adjustability (this also influences the spinal curvature)
4. Seat cushion and cover material characteristics, particularly ventilation
5. Seat cushion hardness
6. Seat cushion contouring
7. Seat back contouring
8. Footrest facilities
9. Pressure distribution
10. Seat rigidity
11. Seat controls
12. Seat geometry and reference eye position
13. Ingress and egress
14. Headrest facility
15. Seat belt and hardness

1.6: Analysis of Anthropometric Data:

Table 1 lists the seat dimensions, also illustrated in Figure 1, that will be analyzed with respect to occupant fit. Although most automotive seat recommendations are focused on driver seats, some of the parameters discussed here are applicable to passenger seats as well.

Table 1: Seat Dimensions and Related Anthropometric Measurements

Seat Dimension	Anthropometric Measurement
Cushion Width	Seated Hip Breadth
Cushion Length	Buttock-to-Popliteal Length
Seat Height	Popliteal Height
Backrest Width	Chest Breadth Interscye Distance
Backrest Height	Shoulder Height

Table 1: Seat Dimensions and Related Anthropometric Measurements

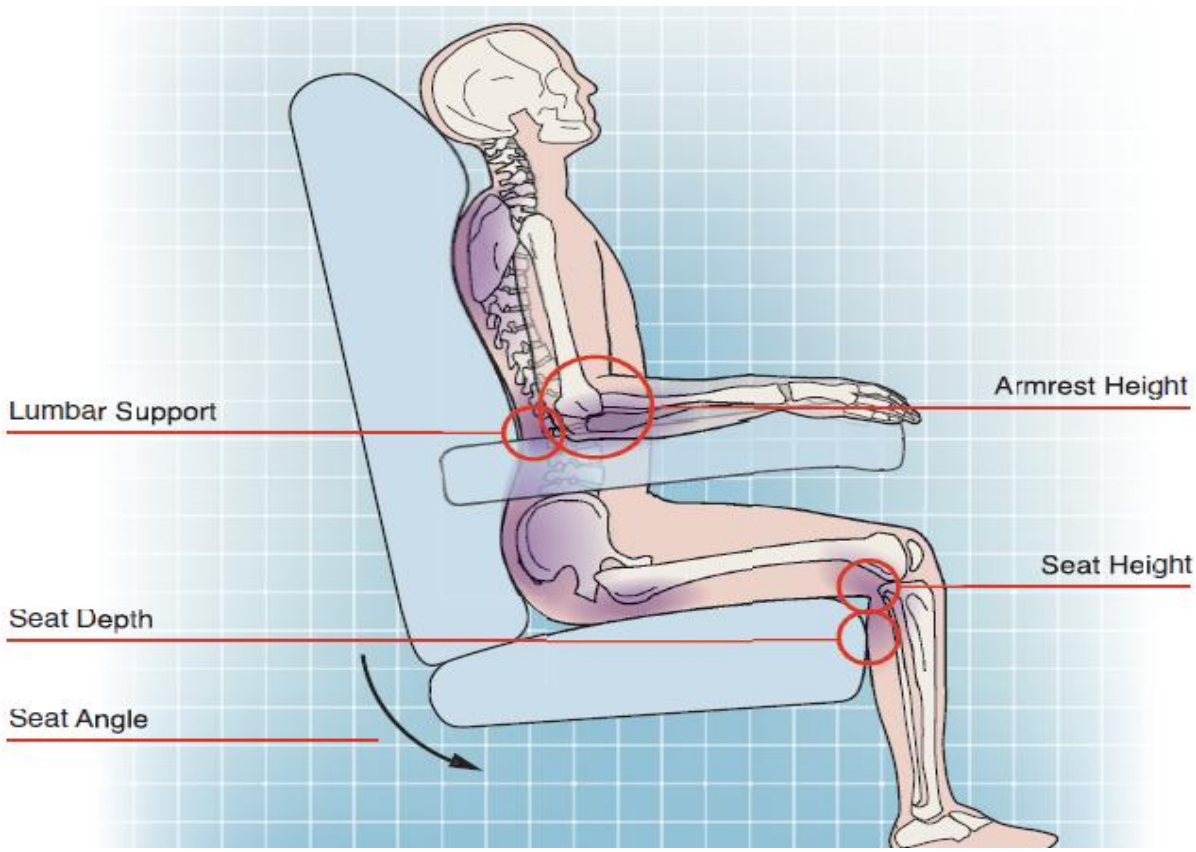

Figure 2: Seating anthropometric terminology.

1.7: Anthropometric data used in seat design:

Sitting elbow height (also known as elbow rest height):

Definition

Vertical distance from the seat surface to the underside of the elbow.

Applications

Height of armrests; important reference datum for the heights of desk tops, Keyboards , etc., with respect to the seat.

Thigh thickness (also known as thigh clearance):

Definition

Vertical distance from the seat surface to the top of the uncompressed soft tissue of the thigh at its thickest point, generally where it meets the abdomen.

Applications

Clearance required between the seat and the underside of tables or other obstacles.

Buttock-knee length:
Definition
Horizontal distance from the back of the uncompressed buttock to the front of the Knee cap.
Applications
Clearance between seat back and obstacles in front of the knee.

Buttock-popliteal length:
Definition
Horizontal distance from the back of the uncompressed buttocks to the popliteal angle, at the back of the knee, where the back of the lower legs meet the underside of the thigh.
Applications
Reach dimension, defines maximum acceptable seat depth.

Knee height:
Definition
Vertical distance from the floor to the upper surface of the knee (usually measured to the quadriceps muscle rather than the kneecap).
Applications
Clearance required beneath the underside of tables, etc.

Popliteal height:
Definition
Vertical distance from the floor to the popliteal angle at the underside of the knee where the tendon of the biceps femoris muscle inserts into the lower leg.
Application
Reach dimension defining the maximum acceptable height of a seat.

Shoulder breadth (bideltoid):
Definition
Maximum horizontal breadth across the shoulders, measured to the protrusions of the deltoid muscles.
Applications
Clearance at shoulder level.

Shoulder breadth (biacromial):
Definition
Horizontal distance across the shoulders measured between the acromia (bony points).
Applications
Lateral separation of the centers of rotation of the upper limb.

Hip breadth:
Definition
Maximum horizontal distance across the hips in the sitting position.
Applications
Clearance at seat level; the width of a seat should be not much less than this.

Chest (bust) depth:
Definition
Maximum horizontal distance from the vertical reference plane to the front of the chest in men or breast in women.
Applications
Clearance between seat backs and obstructions.

Abdominal depth:
Definition
Maximum horizontal distance from the vertical reference plane to the front of the abdomen in the standard sitting position.
Applications
Clearance between seat back and obstructions.

Shoulder-grip length:
Definition
Distance from the acromion to the centre of an object gripped in the hand, with the elbow and wrist straight.
Applications
Functional length of upper limb; used in defining zone of convenient reach.

Head length:
Definition
Distance between the glabella (the most anterior point on the forehead between the brow ridges) and the occiput (back of the head) in the midline.
Applications
Reference datum for location of eyes, approximately 20 mm behind glabella.

Foot length:
Definition
Distance, parallel to the long axis of the foot, from the back of the heel to the tip of the longest toe.
Applications
Clearance for foot, design of pedals.

1.8: Anthropometric aspects of seat design:

Seat height (H): As the height of the seat increases, beyond the popliteal height of the user, pressure will be felt on the underside of the thighs. The resulting reduction of circulation to the lower extremities may lead to 'pins and needles', swollen feet and considerable discomfort.

Seat depth (D): If the depth is increased beyond the buttock-popliteal length (5th %ile woman=435mm), the user will not be able to engage the backrest effectively without unacceptable pressure on the backs of the knees. Furthermore, the deeper the seat the greater the problems of standing up and sitting down.

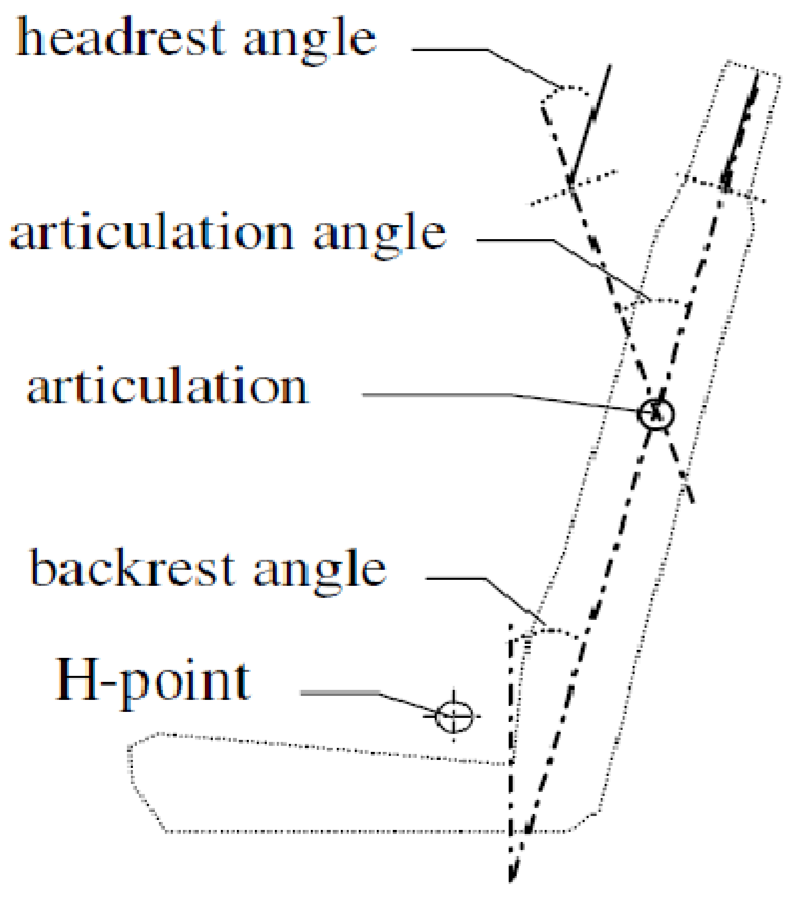

Figure 3: H-point and seat angles.

Seat width: For purposes of support a width that is some 25 mm less on either side than the maximum breadth of the hips is all that is required—hence 350 mm will be adequate. However, clearance between armrests must be adequate for the largest user.

Backrest dimensions: The higher the backrest, the more effective it will be in supporting the weight of the trunk. This is always desirable but in some circumstances other requirements such as the mobility of the shoulders may be more important.
The *low-level backrest* provides support for the lumbar and lower thoracic region only and finishes below the level of the shoulder blades, thus allowing freedom of movement for the shoulders and arms.

The *medium-level backrest* also supports the upper back and shoulder regions.
Most modern office chairs fall into this category, as do many ‘occasional’ chairs, auditorium seats, etc.

The *high-level backrest* gives full head and neck support—for the 95th %ile man an overall backrest height of 900 mm is required.
Whatever its height, it will generally be preferable and sometimes essential for the backrest to be contoured to the shape of the spine, and in particular to give ‘positive support’ to the lumbar region in the form of a convexity or pad.

Backrest angle or ‘rake’:
As the backrest angle increases, a greater proportion of the weight of the trunk is supported—hence the compressive force between the trunk and pelvis is diminished (and with it intradiscal pressure).

Seat angle or ‘tilt’:
A positive seat angle helps the user to maintain good contact with the backrest and helps to counteract any tendency to slide out of the seat. Excessive tilt reduces hip/ trunk angle and ease of standing up and sitting down. For most purposes 5–10° is a suitable compromise.

Seat surface:
The purpose of shaping or padding the seat surface is to provide an appropriate distribution of pressure beneath the buttocks. The consensus of ergonomic opinion suggests the following:
(i) The seat surface should be more or less plane rather than shaped, although a rounded front edge is highly desirable;
(ii) Upholstery should be ‘firm’ rather than ‘soft’ (it is sometimes said that a heavy user should not deform it by more than 25 mm);
(iii) Covering materials should be porous for ventilation and rough to aid stability.

H-Point:
The H-point is a reference point with respect to a seat that is defined and measured with the SAE J826 H-point manikin. The Seating Reference Point (SgRP) is a particular H-point location

within the range of seat travel that is used for a variety of design purposes. Unlike the SgRP, which is stationary with respect to the vehicle, the H-point moves with the seat. The H-point is defined and measured only at one manufacturer-specified seat configuration, including the angles and settings for all adjustable components. Changes in component adjustments (for example, seatback angle) can affect the H-point location with respect to the seat. H-point is closely related to human hip joint location in the seat, but human hip locations are necessarily variable due to anthropometric and seat design factors.

CHAPTER 2

BACKGROUND STUDY

2.1 RELEVANT ANATOMY AND TERMINOLOGY:

Following figure illustrates the typical position and orientation of the pelvis and lumbar spine in an auto seat. This figure is intended to show the relative positions of the pelvis and vertebral bodies, although the shapes of the structures have been simplified. The dimensions used to construct this figure are approximately those of a midsize U.S. male, 50th percentile by stature and weight. There are, of course, considerable variations in the skeletal dimensions even among individuals who match those characteristics. Schneider et al. (1985) and Robbins et *al.* (1985a, 1985b) are sources of more specific information regarding population norms and variability in auto-seated anthropometry. Figure illustrates the important components of the skeleton that will be referred to in this report. The thorax is the upper part of the torso, generally delineated by the ribcage. The thoracic spine consists of 12 vertebrae referred to as T1 through T12.

The spinouts processes are the bony prominences at the back of each vertebrae that can be palpated through the slunk. Because the tissue over these points is relatively thin, they can be reliably palpated to determine the position of the spine.

Two ribs (one on each side of the body) attach to each thoracic vertebra. At the front of the chest, the first 10 ribs on each side attach via costal cartilage to the sternum, a vertically-oriented, relatively flat bone at the front of the chest.

The angle of the sternum provides a useful and reliable measure of the spatial orientation of the thorax. The pelvis is comprised of two symmetrical hip bones connected anteriorly at the pubic symphysis and posteriorly by the sacrum.
Each hip bone consists of three fused bones: the ileum, pubis, and ischium. The superior edge of each ilium forms a prominent ridge called the iliac crest. The pubis bones connect the ilia together via the pubic symphysis, while the Ischia form the rocker-shaped structures at the bottom of the pelvis that are the primary skeletal load-bearing surfaces in sitting.

The sacrum consists of five fused vertebrae at the base of the spinal column. The sacroiliac joints on either side of the sacrum connect the sacrum to the hip bones (ilea). The lumbar spine lies between the thoracic spine and sacrum and consists of five vertebrae referred to as L1 through L5.

The lumbar inter vertebral joints have considerably more mobility than the joints in the thoracic spine, so changes in orientation between the thorax and pelvis result primarily from flexion or extension of the lumbar spine.

Flexion refers to the spine movement in the sagittal (side-view) plane that occurs when the sitter bends forward at the waist (i.e., a slumping motion). Extension occurs when the sitter bends rearward.

When the spine is curved inward, as is the case with extreme extension, the spine posture is referred to as lordotic, or the spine is said to exhibit lordosis.

Hypnosis is a convex curve of the spine profile, such as occurs in the lumbar area with extreme flexion. The thoracic spine posture is normally hypnotic.

In this report, lumbar lordosis refers to the maximum displacement of the back profile from a reference line drawn tangent to the back profile in the buttock and thorax areas .Spine flexion or extension is accompanied by deformation of the flexible disks between the vertebrae.

Each inter vertebral disk consists of a gel-like nucleus surrounded by fibrous connective tissue. The inter vertebral joint center is not actually a single point, but rather moves somewhat during flexion or extension of the joint. However, for seating analysis, the joint center can be reasonably approximated as a single point near the center of the inter vertebral disk.

Torso geometry varies widely across the driving population. Figure shows the typical torso skeletal geometry of females who are 5th percentile in the U.S. population by stature and males who are 95th percentile by stature, based on linear scaling of the model in Figure, using the distance from the hip joint center to the T4 spinous process given in Schneider ***et*** al. (1985) as the scaling criterion. More accurate representations of small female and large-male anthropometry are available in Schneider ***et*** *al.* (1985), but this method gives estimates of the range of torso geometry in the driving population that are sufficiently accurate for lumbar support design.

2.2: Anatomy of Spinouts Process:

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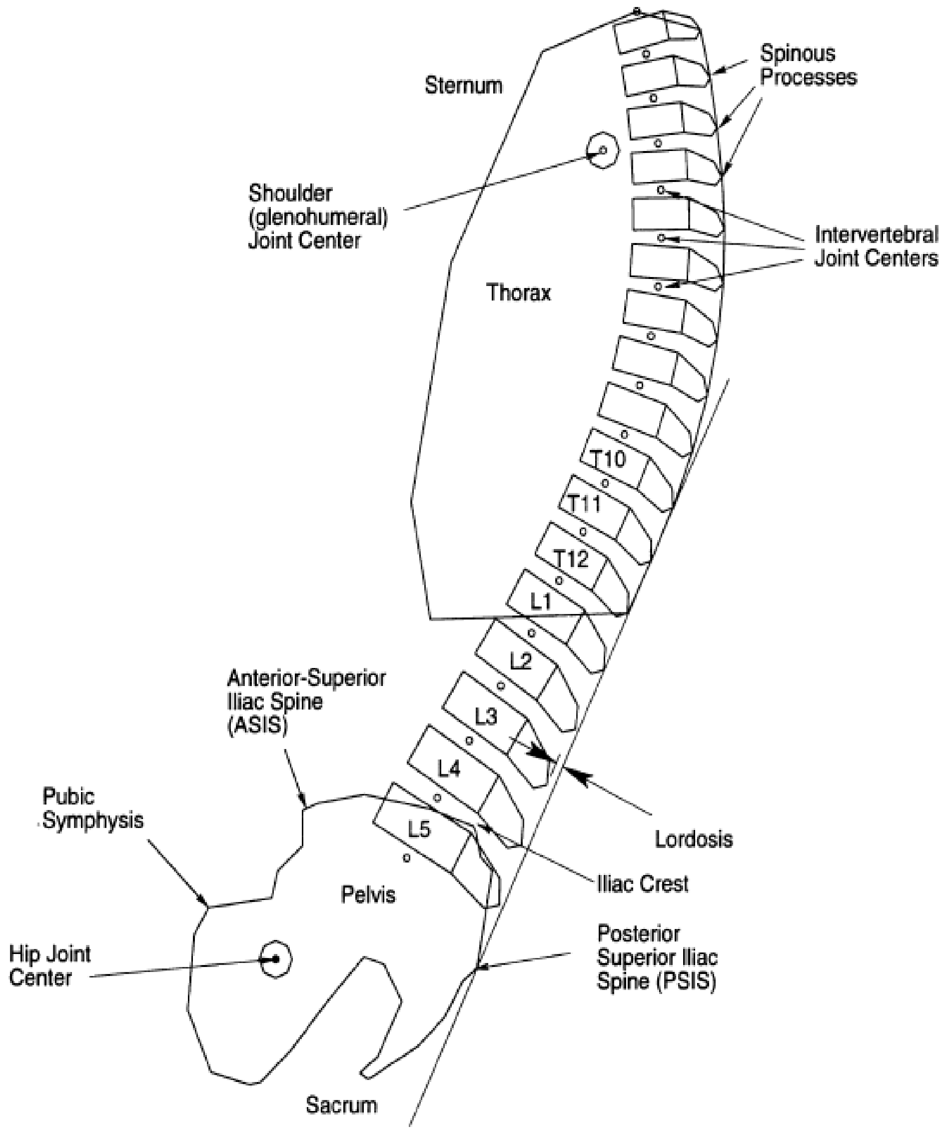


Figure 4: Relevant anatomy, illustrated on a simplified model of the torso skeletal geometry of a midsize male. The orientations of the pelvis, thorax, and lumbar spine are representative of the average posture obtained with a 25-mm lumbar support prominence. Preferred postures with other lumbar support prominences from 0 to 45 mm differ only slightly.

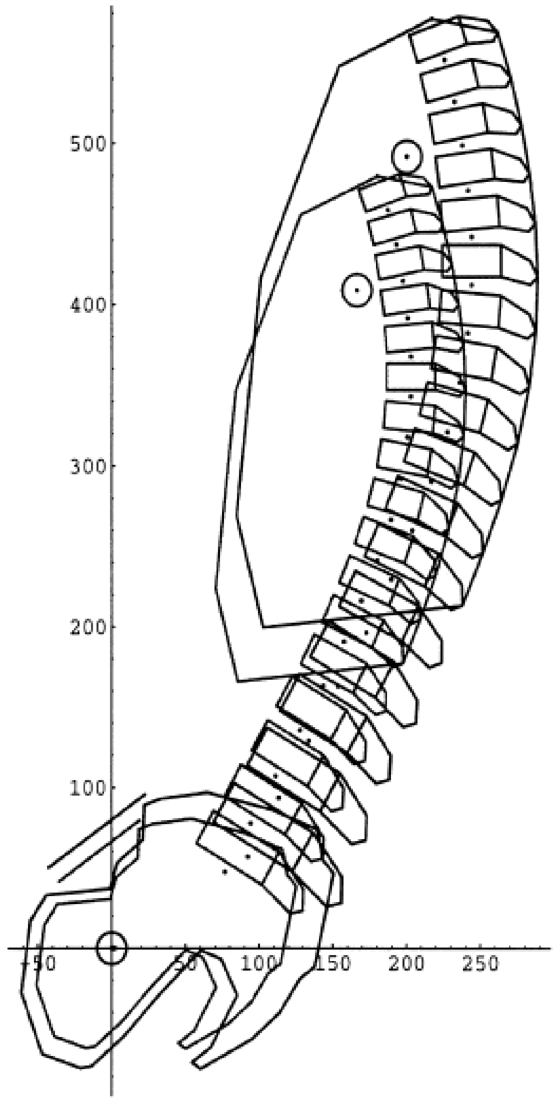


Figure 5: Relevant anatomy, illustrated on a simplified model of the torso skeletal geometry of a midsize female.

2.3: Basic accommodation and health requirements:

Muscular activity:

The interest in studying muscular activity to characterize seat comfort is based on the hypothesis that reduced muscular effort promotes sitting comfort. In order to assess the relationship between these two variables, Reed *et al.* (1991) carried out an electromyography study of the activity in the torso muscles of a sample of 8 people of the male sex. The subjects performed sitting trials in four different automobile seats, during a period of 3 hours in each seat. The study reveals that EMG measurements were confounded with subjects' voluntary motions, hence preventing assessment of variance in the levels of muscle activity.

Posture (postural angles):

The amount of posture change that occurs during sitting has been sought for use as an aspect of behavior and indicator of seat comfort. However, difficulties have been found with using this concept – it is generally agreed that some changes in posture are desirable, and of course some are necessary due to task demands (Corlett, 1990). Orthopedics, as well as ergonomics, recommends frequent or at least occasional changes of position. This calls for a 'dynamic' seat that allows easy changes of sitting posture (Grand jean, 1993). Seat dimensions, contour, stiffness and cover materials should enhance the occupant's ability to change positions, since comfortable support for many postures is essential.

Interface pressure:

Interface pressure results from the contact between the human body and the seat, and is influenced by the physical characteristics of both. The body is composed of soft and hard tissues that have different load-deflection characteristics. The seat contour, the presence of upholstery seams, the different foams used in the padding and the seat suspension combine in promoting a heterogeneous load-deflection relationship throughout the seat area which gets in contact with the occupant. Thus, the distribution of interface pressure represents a complex interaction between the occupant and the seat.

Elasticity and damping of the seat:

Exposure to vehicle vibration has been linked to the occurrence of low back pain(Troup, 1978). Thus, seat design must consider seat dynamic properties, the vibration transmitted to the seat occupant and their effect on comfort (and health) of the occupant. A study by Park *et al.* (1998) found significant correlation between subjective comfort of the seated person and some technical properties of seats. The sample was composed of 35 male subjects, with sitting trials lasting 30 minutes in 7 different seats. The main variables significantly associated with comfort were the level of deformation of the seat and its backrest and also the dynamic constant of elasticity and the hardness of the foam padding in the seat and backrest.

Seating comfort:
For occupant's comfort and health, good seat design should be applied by considering sitting postures . Static and dynamic anthropometry data are considered for proper design of a comfortable and safe seat.

2.4: Factors to be considered for driver's seat

1. The seat should position the driver with unobstructed vision and within reach of all vehicle controls. For this purpose appropriate seat adjustment features should be there.

2. Proper back support, head rest, thigh support should be provided but there should not be and obstruction/hindrance during arm or leg movement.

3. Seat must accommodate the driver's size and shape.

4. Seat should be comfortable for extended period.

5. Seat should provide a shape zone to the driver in a crash.

Passenger in the front and rear seats need comfortable supporting surfaces for a variety of postures unconstrained by the vehicle operation. Postural stress, vibration, muscular effort, impact and shock are the causes for backache and lower back pain in drivers. Safety should be taken into account while considering the design of seats without compromising the comfort.

Different factors considered for Seat design:

• Human geometry both in static and dynamic are considered for designing seats. The static geometry describes the physical size to be accommodate in the seat and dynamic geometry describes the functional position to be accommodate in the seat.

Body size:

Seats are mostly designed as per the body weight and anthropometry of the targeted user population to fit at least 90 percent of population. The 95th percentile of male and 5th percentile female anthropometric data are generally considered for accommodation on seats.

Human linkage system: Rigid human body can be specified according to the joint centre position and the angle between adjacent links. The movements and dimensions of human linkage system helps to define the curvature of seats and comfortable position for sitting.

Position of the body:

Driver's seat position is dependent on the vision and reach of the driver. Clear view and comfortable sitting posture are the factors considered for designing seat. The dimensioning is mostly depends on eye, hand and foot positioning. For different body vertical, back angle adjustments are provided.

Posture of the body:

Seat should reduce postural stress and optimize muscular effort. Postural stress occurs due to adopting one posture for long period of time, so comfortable support for many postures is essential and this can be accommodated by manipulation of anthropometric data and the linkage system.

Vibration and ride comfort:

Vibration, shock and impacts are major factors for judgments of comfort ability according to most users. Thus, the seat design also must consider the vehicle suspension system and the vibration transmitted to the seated user.

Geometric features of seat design:

Seat design can be divided into accommodation and comfort. Accommodation refers to seat size and adjustments for horizontal distance from controls, height and back angle. Comfort, however refers to stiffness, contour, climate and vehicle features that promote users comfort.

The seat height, width and back angles are based on the human anthropometry data collected from the research. its important to provide sufficient space for physical and psychological comfort.

• Cushion’s length from seat back to the waterfall line is 440-550mm is recommended (Grandjean, 1980).

• The breadth of the cushion is recommended 480mm (Grandjean,1980) for clothing and leg splay. The measurement is based on 95th percentile of female hip breadth and additional space for comfort since female hips are greater than male hip breadth.

• Seat back height is recommended 509mm (Grandjean, 1980) by considering the small female, sitting shoulder height.

• Seat back breadth may be divided into lower and upper regions. The lower must accommodate a tapered shape from 432mm at the hip to 367mm at the chest (Grandjeans, 1980). 480mm is recommended for seat back breadth (Grandjeans, 1980).

• Horizontal adjustments accommodate differences in leg length that are associated with seat height and preferred knee angle. Grandjeans (1980) recommended a minimum of 150mm horizontal adjustment. The joint angles in automobile are typically between 95 and 120 degrees for the hip, and 95 and 135 degrees for the knee (Rebiffe, 1969).

• Horizontal seat travel is a function of seat height and body size. Average seat travel was investigated 148mm approx. (Schneider et al., 1979).

• Vertical adjustments accommodate differences in sitting eye height between the fifth percentile female and 95th percentile male. A simple trigonometric relation can be established with link length and joint angles to compute the amount of seat adjustment needed in the vertical direction.

• Adjusting a flat, non-deformable surface over a range of 163mm maintains a constant eye height. Seat cushion compression and suspension deflection are no-linear function of applied force, as a result the vertical displacement needed in a soft seat are poorly calculated from anthropometric data. Grandjeans (1980) recommended a seat height between 250 and 300 mm.

• Seat back angle adjustments accommodate differences in arm length and occupant preferred hip angle. Grandjean recommended a seat cushion angle of 19 degrees with a range from10 to 22 degrees.

All the seat design criteria and dimensions mentioned above are for general understanding of the subject. Presently, various SAE standards are followed in automobile industries all over the world.

Both subjective and objective methods of discomfort measurements are used to analyze and rate the level of discomfort. Among the various rating scales 'Visual analog Discomfort Scale' or 'Verbal Numerical Rating Scale' for assessment of intensity; 'Body Map' or specific instruction for assessment of discomfort location and repeated measurement for the assessment of temporal pattern of discomfort are generally used (Van der Grinten 1991). Empirical studies of various scientists provide comfort data for quantitative estimation of sitting comfort of vehicle occupants or drivers based on single joint postural analysis (Porter and Gyi 1998, Grandjean 1980, Henry Dreyfuss Associates 1993, Rebiffe 1969) and some based on multiple joints or overall body posture (Krist 1994).

2.5: Limits of visual field:

Driver can turn both eyes and head to gain a wider field of view, and moreover can make use of peripheral vision to see objects or movements even without turning eyes.

In the horizontal plane, the binocular field of view extends some 120 degrees, as in figure given below. Vision is sharp only over a fairly small area directly ahead. So, eyes need to be turned to focus on objects outside the foveal area. According to SAE J985 eyes generally only turn by about 30 degrees before the head is turned, which can comfortably give a further 45 degrees view to either side.

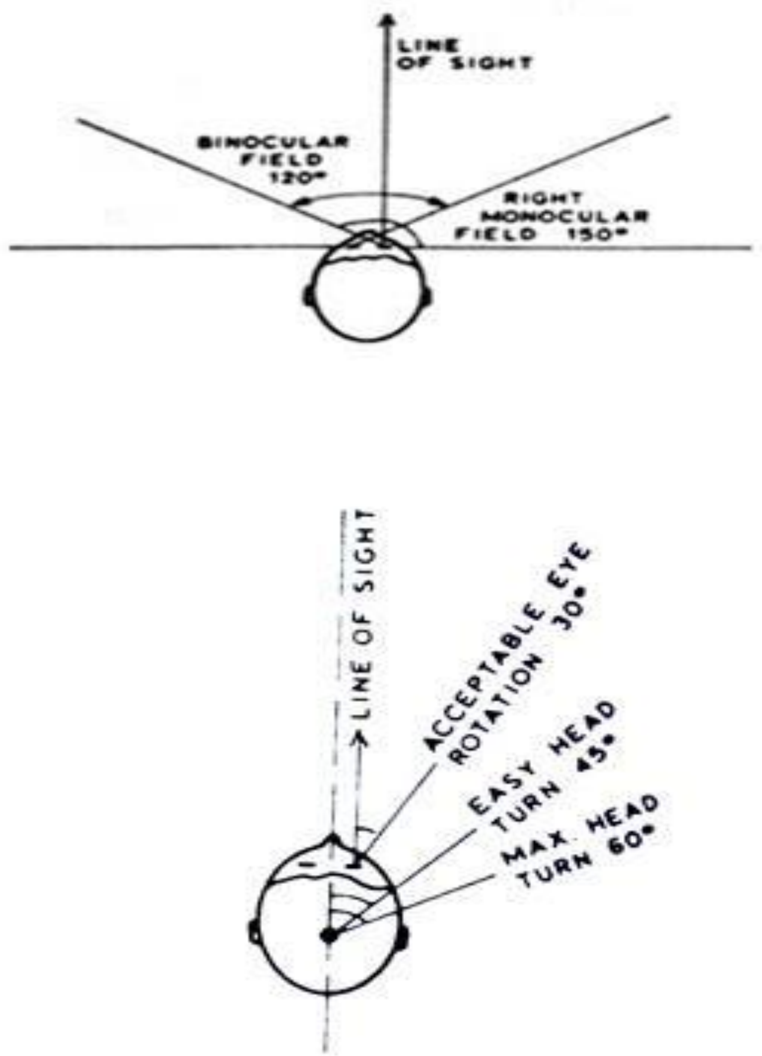


Figure 6: Binocular field view in horizontal plane

Vertical View Of Human Eye

In the vertical plane eye movement (fig. 19) is comfortable within 15 degrees above or below the horizontal, although the eye can see up to 45 degrees upward or 65 degrees downward if necessary.

On the other hand, head can easily incline 30degrees upward or downward. Thus by movement of head and eye, the driver can have extended direct field view. The driver has to concentrate on direct view, that is on road. So glancing away from the road for a short period is possible. Mirror and other instruments should be close to the driver, so that driver does not require a much head and eye turn to have a look.

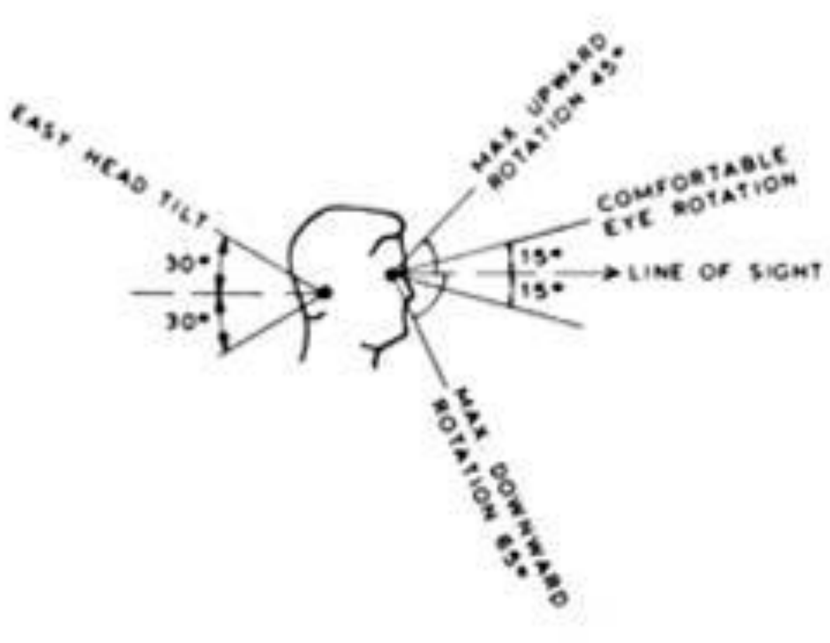


Figure 7: Vertical views of human eye
(Adopted from Peacock and Karwowski, 1993).

Driver's eye location:

Variation of eye positions inside the a vehicle for any driving population is considerable due to variation of seat locations and variable anthropometry of the drivers. In order to address this problem, the SAE J941 'Eyellipse' concept was developed as a drafting tool to define the range of eye positions within the driving population. It is based on the position of eyes of drivers in space. The distribution of eye position in space closely approximated an ellipsoid.

During automobile design, care should be taken to provide maximum view all around either through direct vision or with the help of devices like mirror or camera. It is also important to ensure minimum visual obstruction either by vehicle components or by driver's own body parts. This is particularly important for allowing unobstructed view of the displays on the dash board.

Reach and limitation of human:

In many work situations, individuals perform their activity within a specified 3D space of fixed location which is sometimes referred to as 'work-space envelope' (Sanders and McCormick 1993). This envelope preferably should be circumscribed by the functional arm reach of the operator and most of the things they need to handle should be arranged within this envelope.

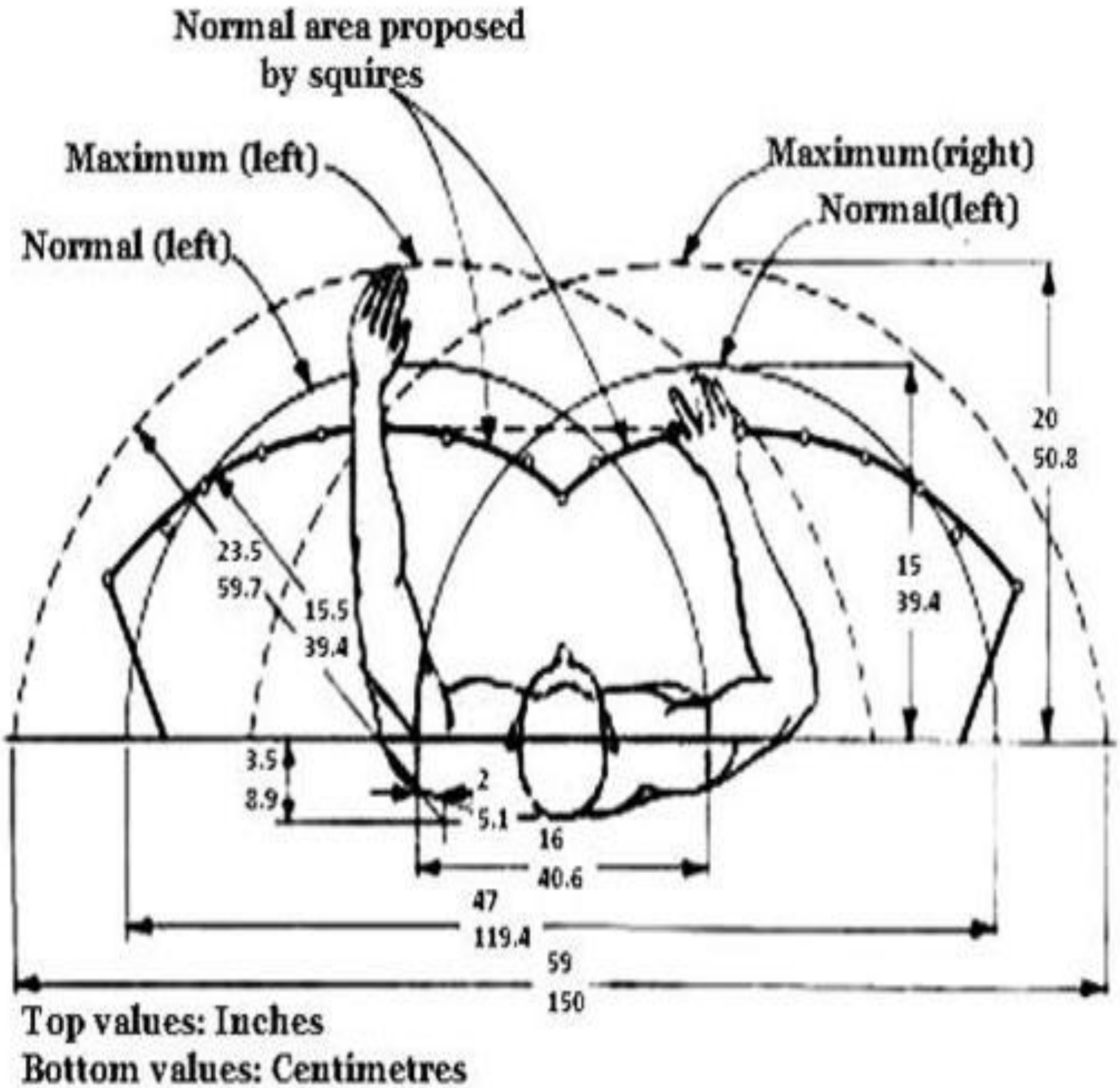
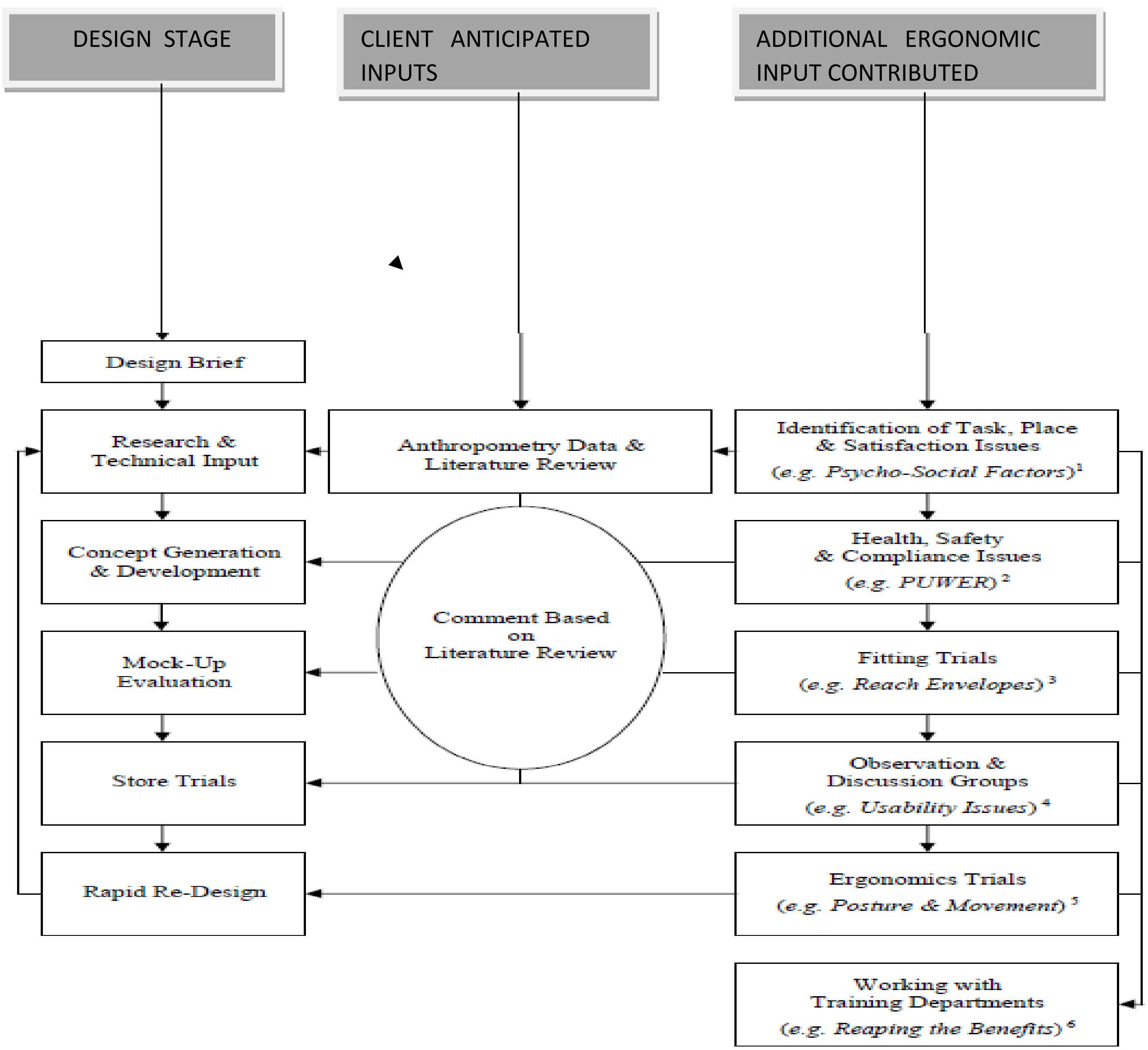


Figure 8: Normal and maximum horizontal reach areas.

CHAPTER 3

FORMULATION OF DESIGN PROCEDURE

3.1: Ergonomics Design procedure Flow Diagram:



3.2: Types of Vehicle Use: 3-Wheeler Auto:

Figure 9: Driving Seat Without Ergonomics

3.3: Basic specification of the vehicle:

- Total Height: 160cm
- Steering height from base: 69cm
- Seat height from base: 46cm
- Steering length: 61 cm
- Total length: 220 cm
- Driving space width: 110cm
- Length of the reach: 76cm
- Seat depth: 42cm
- Lumber support: No
- Head rest: No
- Seat width: 74cm
- Back rest: In adequate
- Seat cushion angle: 0 degree
- Seat back angle: 90 degree
- Seat belt: No
- Leg room: In adequate
- Reach: Too down

3.4: Design problem in traditional vehicle:

Figure 10: Design Problem in Traditional Vehicle

3.5: Complain By CNG Drivers (Data taken from 35 people):

Serial No	Area of Complain	Frequency	Percentage (%)
01	Neck	23	65.72
02	Shoulder	14	40
03	Lower Arm	9	25.72
04	Upper Arm	24	68.57
05	Lower Back	28	80
06	Thigh	8	22.86
07	Knee	7	20

Table 2: Complain By CNG Drivers (Data taken from 35 people)

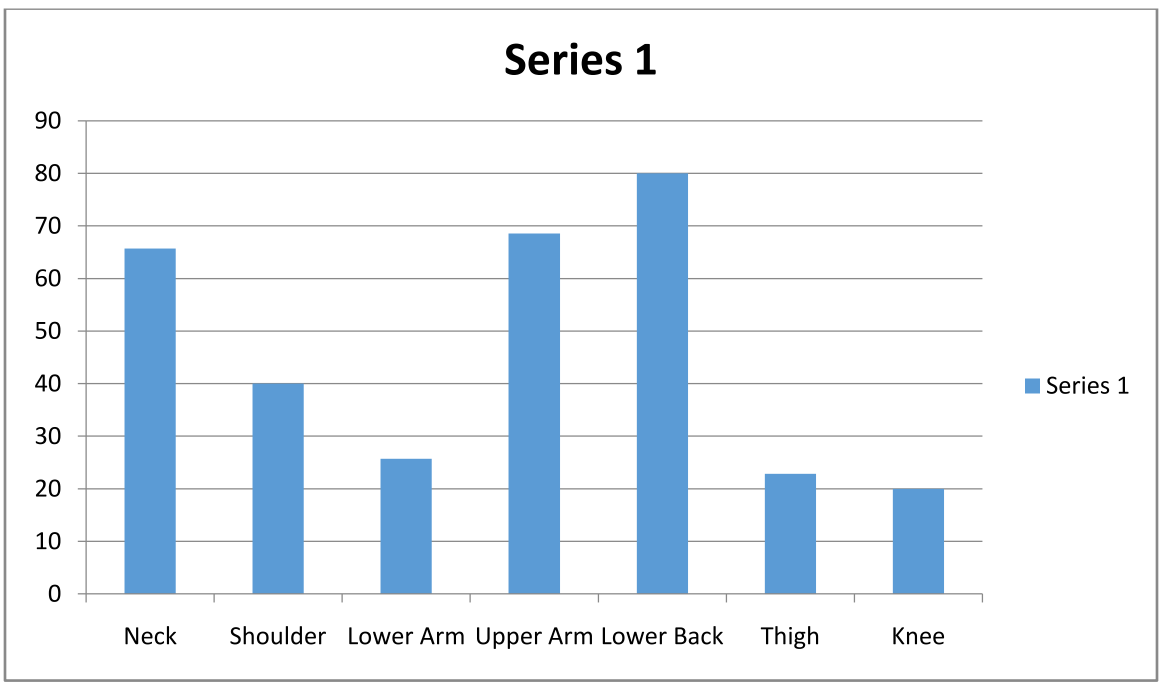


Figure 11: Percentage of Complain Curve

3.6: Out comings of The Survey:

Here we found that about 80% of auto drivers complain about lower back pain.

Possible reasons are:

- Absence of lumber support
- In sufficient seat depth
- Improper reach
- Lower seat strength
- Excessive vibration
- Small legroom

Ergonomic design of the driver's workstation is a necessary component of driver safety and health protection. From the previous studied show that, there is a need of modification or redesigning the seat with considering the ergonomic approach in order to reduce the back pain, neck pain and vibration level that contribute to health problem among Malaysian Bus drivers particularly that can interfere with productivity.

3.7: Problem Study:

Musculoskeletal disorders are among the leading causes of occupational injury and disability, with back pain the most common reason for the filing of workers' compensation claims. Back pain accounts for about one fourth of all claims and for about 40 percent of absences from work. In the United States, in 1990, the cost of back pain was estimated between $50 billion to $100 billion. (Saporta, 2000) .

There is strong evidence of an association between musculoskeletal disorders, workplace physical factors, and non-work related characteristics. Non-work related characteristics include physical fitness, anthropometric measures, lumbar mobility, physical strength, medical history, and structural abnormalities of the individuals. Workplace physical factors include heavy physical work, lifting and forceful movements, awkward postures, whole-body vibration, and static work postures. Static work postures of prolonged standing, sitting, and sedentary work are isometric.

Several studies have investigated back pain among professional drivers. The occupational physical factors of postural stress, muscular effort and long ten exposure to whole-body vibration were consistently associated with driving motor vehicles for extended periods of time (Bovenzi et aI., 1992). Anderson, (I 992) found that a higher percentage of reported back and cervical pain among bus drivers than among workers in non-driving positions.

Other studied was found male workers who drove for more than *50* percent of their work time were approximately three times more likely to develop an acute herniated lumbar disc than those who drove less frequently (NIOSH, 1997). Magnusson. (1996), reported higher rates of low back pain (60 percent) and proportionally more work loss among bus drivers than truck drivers.

There are several factor that can caused the lower back pain such as the seat condition, vibration, posture of drivers and so on. The most factor that contributed to back pain is the seat conciliation which is not enough support at lumbar. Lumbar support plays an important role to make the drivers feel comfortable while driving. Neck pain is the second highest of complaint. About 67% of respondent have an experience on neck pain. This is because there is no headrest provided at the current seat.

From the study also, they found that another factor that contributed to discomfort of the seat is the vibration. The vibration was identified came from steering, seat, gear and pedal. The highest vibration reported carne from steering .

3.8: Seat design consideration:

(a). Identifying the target customer, and fully recognizing their needs and requirements for comfort, safety, and accommodation through understanding their physical, cognitive, and behavioral characteristics.

(b). Accommodating the entire range of the target customer population by designing the interior compartment to address their needs and requirements given their characteristics.

For designing the seat. it should be such that it encourages the occupant to adopt a good posture and discourages poor postural habits. The design of the seat as well as the surrounding environment should allow the occupant to make frequent minor postural changes without hindrance (Lusted, 1994). The bus drivers especially, often sit in a cramped space under conditions such that even with a normal spine it is difficult to be comfortable, especially ifrequired to sit for several hours at a time.

CHAPTER 4

DATA COLLECTION & CONSTRUCTION

4.1: Anthropometric Data Collection:

Anthropometric data are used in design standards for new systems and In the evaluation of existing systems in which there is a human-equipment interface. The purpose of the data is to ensure that the worker is comfortable and efficient in working condition.

For the purpose of designing we have to take several anthropometric data from the users. The process is accomplished by the measurements of heights, weights, size of upper back, size of lower back, reach of the professional drivers. The convincing process was not very easy, we have to work hard for the motivation process.

Anthropometric data

Serial No.	Height (cm)	Weight (kg)	Size of Upper Back (cm)	Size of Lower Back (cm)	Reach
1	170	75	71	99	74
2	165	80	69	97	71
3	172	65	74	99	76
4	172	73	71	102	74
5	167	70	69	99	69
6	157	65	66	91	64
7	165	68	69	97	66
8	167	72	66	102	66
9	162	60	66	97	64
10	162	62	64	99	66
11	160	75	66	94	64
12	165	80	69	97	66
13	170	84	69	102	71
14	167	78	66	102	66
15	167	76	69	99	69
16	172	65	66	104	69
17	167	72	69	102	66
18	170	67	69	102	69
19	172	74	66	107	71
20	178	78	69	109	71

Table 3: Anthropometric Data Collection

4.2: Sample Calculation:

Range (cm)	Mid Point (x)	Frequency (f)	f*x
156-160	158	2	316
161-165	163	5	815
166-170	168	8	1344
171-175	173	4	692
176-180	178	1	178
Total		N=20	∑f*x = 3345

$$\text{Average height} = \sum \frac{f*x}{N} = \frac{3345}{20} = 167.25\text{cm}$$

$$\boldsymbol{Average\ Weight = \frac{Sum\ of\ the\ total\ weight\ of\ Individuals}{Total\ Frequency}}$$

$$\boldsymbol{= \frac{1439}{20} = 71.95 \approx 72\ \text{kg}}$$

$$\boldsymbol{Average\ Size\ of\ Upper\ Back = \frac{Sum\ of\ the\ total\ size\ of\ Upper\ Back\ of\ Individuals}{Total\ Frequency}}$$

$$\boldsymbol{= \frac{1363}{20} = 68.15 \approx 68\ \text{cm}}$$

$$\boldsymbol{Average\ Size\ of\ Lower\ Back = \frac{Sum\ of\ the\ total\ size\ of\ Lower\ Back\ of\ Individuals}{Total\ Frequency}}$$

$$\boldsymbol{= \frac{2000}{20} = 100\ \text{cm}}$$

$$\boldsymbol{Average\ Reach = \frac{Sum\ of\ the\ total\ reach\ of\ Individuals}{Total\ Frequency}}$$

$$= \frac{\mathbf{1372}}{\mathbf{20}} = 68.6 \approx 69\ \text{cm}$$

Definition of posture angles in Rabiffe(1969)

Recommended Ranges for Body Segment Angles from Rebiffé (1969)
(See Figure 4 for angle definitions.)

Angle	Recommended Range (degrees)
A. Back	20 – 30
B. Trunk/Thigh	95 – 120
C. Knee	95 – 135
D. Ankle	90 – 110
E. Upper Arm	10 – 45*
F. Elbow	80 – 120

Figure 12: Definition of posture angles in Rabiffe (1969)

4.3: Applied Parameters:

The design parameters are divided into three categories.

(a). ***Fit*** parameter levels are determined by the anthropometry of the occupant population and include such measures as the length of the seat cushion

(b). ***Feel*** parameters relate to the physical contact between the sitter and the seat and include the pressure distribution and upholstery properties.

(c). ***Support*** parameters affect the posture of the occupant and include seat contours and adjustments.

4.4: Design-Compromising of Survey and Standard Ergonomic Data:

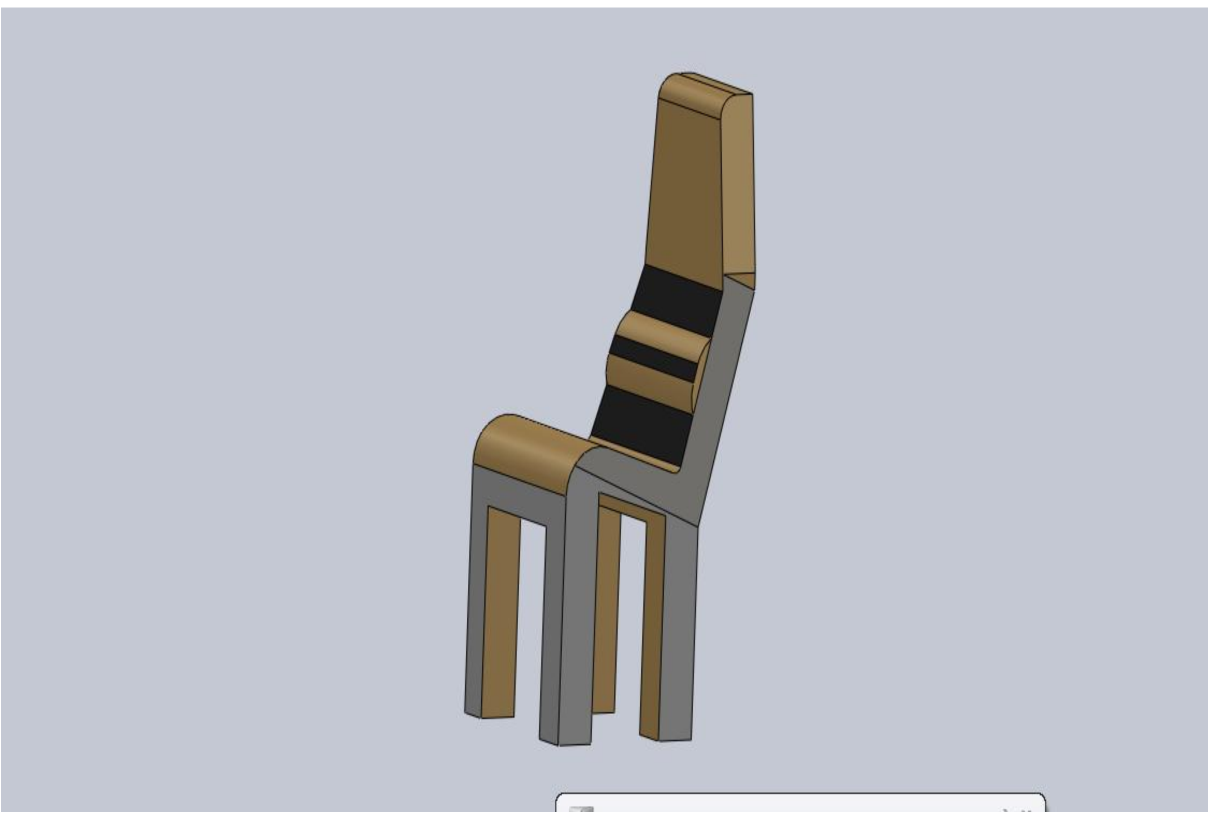


Figure 13: Basic design done in solid works (software).

4.5: Modified Design:

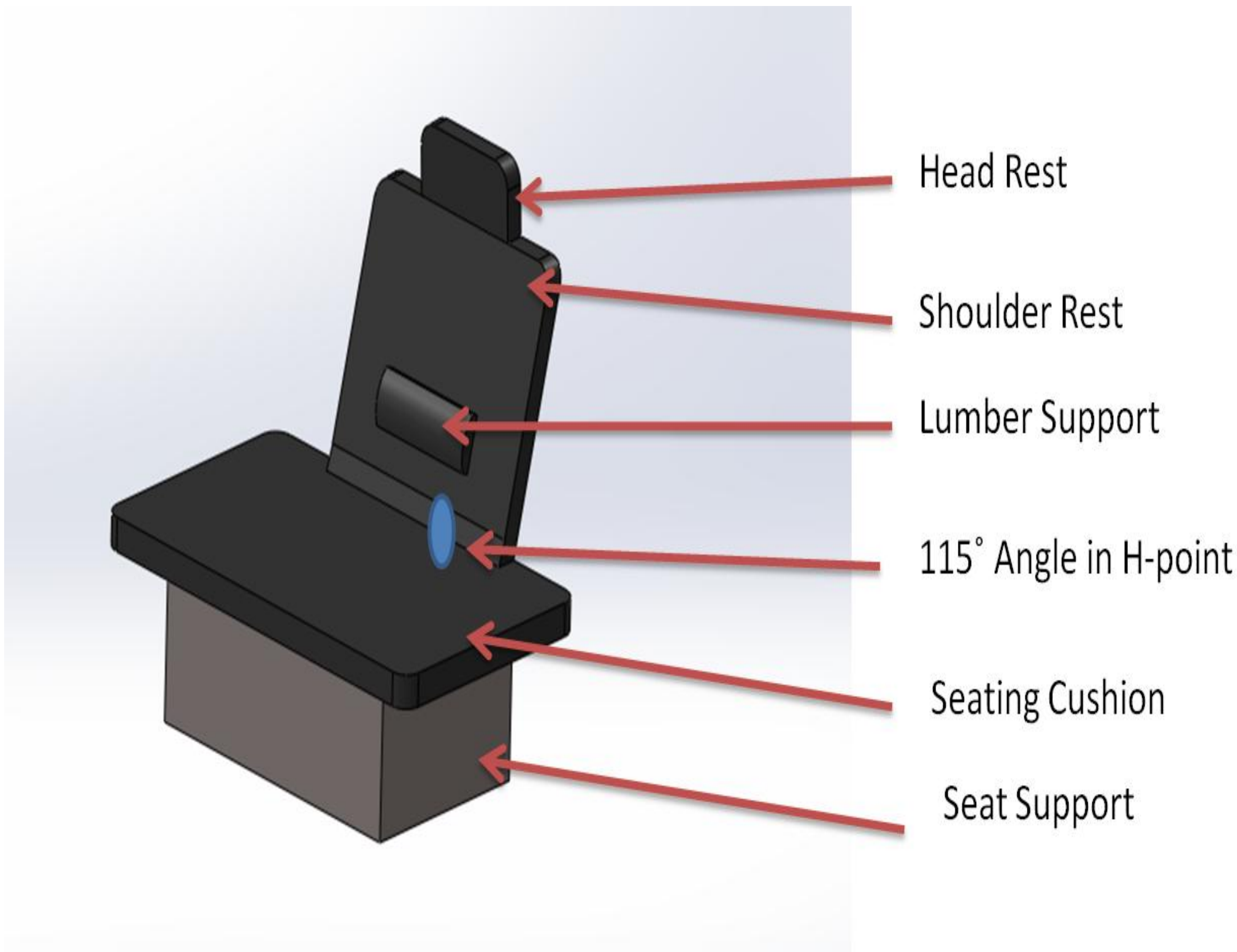


Figure 14: Modified Auto Seat drawing in Solid works (software).

4.6: Design Specification:

- Seat height(base to top) - 1150 mm
- Seat width - 700 mm
- Seat back height - 510 mm
- Seat back breadth
- At hip - 432 mm
- At chest - 367 mm
- The joint angles
  Hip angle - 15 degree
  Knee angle - 105 degree
- Lumber support
  height(from H point) - 100 mm
  thickness - 22 mm
- Seat back angle - 95 deg
- Seat depth - 170 mm
- Head rest height - 200 mm
- Head rest angle - 20 deg
- Seat cushion angle - 15 deg
- Popliteal height - 440 mm

4.7: Construction Work:

Front View

Right side view

Figure 15 : Construction work

4.8: Adjustment of ergo seat in Auto:

Figure 16: Adjustment of ergo seat

CHAPTER 5

EVALUATION & CONCLUSION

5.1: Fit parameters: Fit parameters are linear dimensions related to sitter anthropometry

Summary of fit parameters recommendation

Parameter	Recommendation (mm)	
	Should not be less than:	Should not be more than:
Cushion Width		
• Actual width at H-point	500	--
• Clearance at H-point	525	--
• Width at front of cushion	525	--
Cushion Length		
• Forward of H-point on thigh line	--	305
Backrest Width		
• At waist (220 mm above H-point)	384	--
• At chest (318 mm above H-point	471	--
• Height of side bolsters above H-point	--	288
Backrest Height	410	550
Seat Height at Front of Undepressed Cushion	--	346
Seat Position Width	656	--

Table 4: Summary of fit parameters recommendation

5.2: Feel Parameters: Feel parameters affect local comfort and are related to stimuli detected primarily in the skin and subcutaneous tissues.

Recommendations for Feel Parameters

Parameter	Recommendation
Pressure Distribution	
• Seat cushion patterns	Peaks should be located only in the areas of the ischial tuberosities. No other local maxima should be found.
• Backrest patterns	Peaks should be located only in lumbar area. No local maxima should be found in the shoulder area.
• Peak levels	Peak levels should be determined by subjective comfort testing with target populations. Large differences in pressure distributions and sensitivity among individuals make specifying a quantitative "optimal pressure distribution" difficult.
Surface Shear	Surface shear on the seat cushion should be minimized by increasing the cushion angle and/or by contouring the cushion to achieve the same effect.
Temperature and Humidity	The seat covering should allow heat transfer of at least 75 W/m^2 by conduction and diffusion of water vapor. Foam should not be compressed to more than 80% to allow for maximum vapor diffusion.
Vibration	The seat should minimize the transmission of frequencies between 4 and 8 Hz.

Table 5: Summary of feel parameters recommendation

5.3: Conclusion:

Research related to seating comfort has been conducted for over 100 years, and chair makers have worked for centuries to increase the comfort of their products. Åkerblom(1948) provides a thorough review of work that preceded his own. In spite of the large body of research published in the intervening decades, recent recommendations on seat design echo those published in articles from the 1940s and early 1950s (*e.g.*, Lay and Fisher 1940; Åkerblom 1948; Keegan 1953; Cleaver 1954). And yet the number of journal articles published on seating research shows no sign of abating.

Some ergonomic knowledge is being applied in automotive seat design. Most current seats appear to be designed more in keeping with ergonomic recommendations than seats from previous decades. For example, at the time Keegan (1964) raised the issue of lumbar support in auto seats, most seats had fixed backrest angles and a uniform stiffness along the vertical length of the backrest or "squab" as it was then called. Keegan pointed out that such seats produced kyphotic lumbar postures and were more likely to cause back discomfort than seats that provided a firm lumbar support in the lower-back area. *Support* parameters, particularly lumbar support location and curvature, will probably continue to receive the greatest emphasis, both from researchers and manufacturers, because of the importance of low-back pain to consumers and the importance to seat makers of alleviating that pain.

As during our survey we found that lower back pain is the highest percentage of complain from auto drivers, so we give more concentration on that .Ergonomics of related setting anthropometry is studied clearly and imposed properly on the seat design. We hope that in future we can able to make our vehicle more comfortable in the line of human health.

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