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Biomechanical and RULA Analysis of an Office Chair for Computer Users –A Case Study in Indian Context

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Abstract - *Ergonomically designed chairs are important for increasing productivity and to reduce the low back injuries of the human body. It plays a major role in industries, offices, schools, colleges, institutes, universities, etc. to improve the health and safety of the human body in working conditions. The main objectives of ergonomics are to fit the machine based on human comfortability and enhance the performance, reduce risk and fatigue at the working environment. Extensive research has been done in the western world for ergonomically fitted office chair considering western anthropometric data but very few works have been done according to Indian standard. Hence, the objective of this work was to perform the biomechanical single action analysis and RULA analysis of an ergonomic office chair which was modelled by considering Indian anthropometric data. The design of the chair was modelled based on Indian anthropometric standard data in CATIA-V5 and the Human digital model (HDM) was designed by considering Indian anthropometric data in CATIA-V5. Both the biomechanical single action analysis and RULA analysis has been performed in CATIA-V5.*

***Key Words*: RULA, HDM, CATIA-V5.**

1. INTRODUCTION

The comfort zone in work environment mainly depends on physiological movements of the human body with respect to the work environment. These physiological movements include how muscles, bones, tendons, and ligaments work together to produce movements. The computers are the most widely used electronic device used in almost all industry. In the field of the Information sector, a large extent of computers is used. Information Technology (IT) Sector is one of the major industries in India, which has been contributing to the Gross Domestic Product (GDP) of the nation to a major extent. Also, in parallel to the GDP contribution, the IT sector has provided employment to a vast population of India. Out of the total workforce set up in these IT industries, a major section is employed in the software job profile of the IT sector.

The computer user has physiological movements with respective to monitor, keyboard, mouse & chair. The various studied confirms that bad design of office chair leads to various musculoskeletal disorders. Ergonomics in today's world has gained worldwide importance because of its contribution to the workplace to the workplace. It is one of those many fields that are common to almost all kinds of workplaces. Office Ergonomics aims at studying the workplace conditions and try and attempt to change the workplace so as to suit the working preferences of the employees in terms of ease of working while also incorporating the requirements of the organization.

Ergonomic has wide application in almost all industry which plays an important role in reducing human disorder related to work place. This in terms reduces fatigue & increases productivity of the employer. The main aim of this work is to apply ergonomics technology on design of office chair to ensure humans in complete harmony.

1.1 LITERATURE REVIEW

A. Anthropometry data for design

An anthropometric measurement refers to the collection of human external body dimensions such as body shape, size, work capacity and strength in static and dynamic conditions which are used in ergonomic design, physical anthropology, apparel sizing, design of consumer products, design of tools and equipment, etc. [1-4]. The static condition consists the sitting or standing or any adopted postures in which length, depth, breadth, heights, and circumference are measured while in dynamic condition human dimensions in the various movement like speed and ranges of motion is measured [3]. Whenever an anthropometric measurement is considered for design, it helps to improve comfortability level, reduce low back pain, musculoskeletal disorders and increase the performance of the users [1].

B. Biomechanics Single Action Analysis

Biomechanics is the science which deals with the movement of the living body which involves physiology, anatomy, and mechanics, the flow of blood circulation, and other body functions to analyze the forces within the body and muscles activation. Biomechanical analysis is widely used in ergonomic, bioengineering, etc. [5]. The Biomechanics single action analysis is used to evaluate the design and calculate the lumbar spinal loads, forces and moment at the joints. In this, we get output like L4-L5 spine limit, L4-L5 moment, L4-L5 compression, L4-L5 joint shear, abdominal force & pressure, and ground forces, etc. [6, 7,10]. Figure 1.1 shows the outcomes of the biomechanics single action analysis.

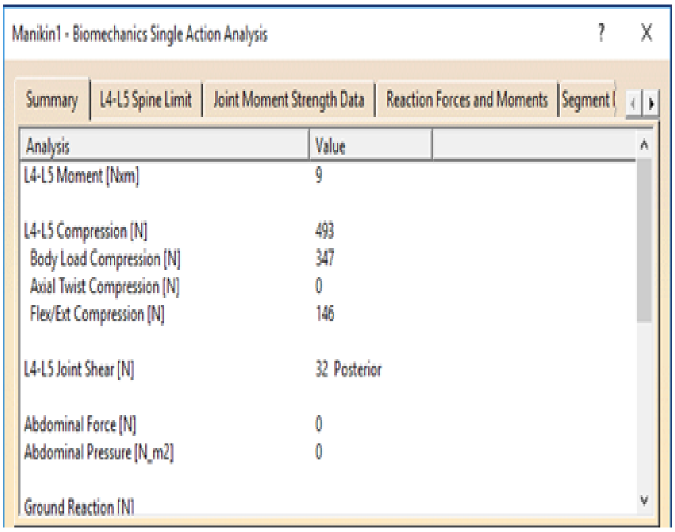

Figure 1.1: Outcomes of Biomechanics Single Action Analysis

C. RULA Analysis

The RULA analysis stands for rapid upper limb assessment which analyzes the upper extremity ergonomic risk [8]. It is a survey method which is used to analyze the upper limb disorder in working conditions. The main purpose of RULA is to assess the postural load requirements and bio-mechanical for human body parts [9]. It generates a scorecard from 1 to 7 along with colour code from green to red. Based on this scorecard the upper limb disorder is analyzed. If the score is 1 or 2 then the work posture is acceptable otherwise further investigation of that posture will require [6, 7, 9, 11,12]. Figure 1.2 shows the scorecard of the human digital modal in a sitting posture.

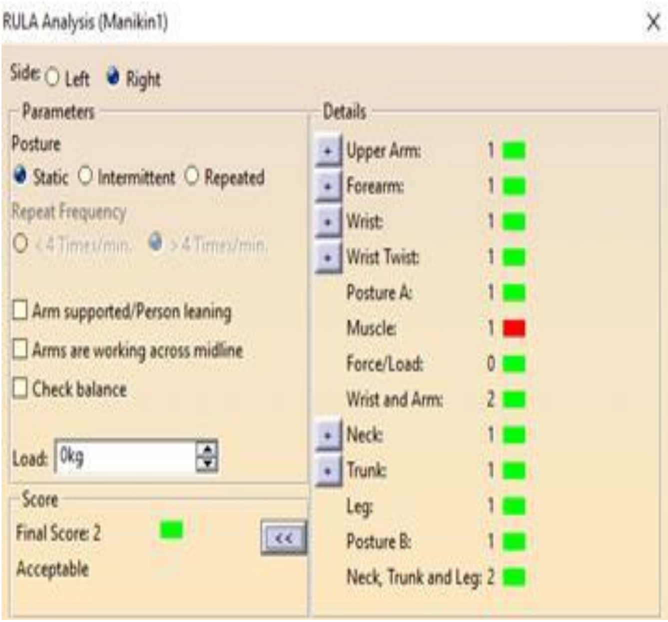

Figure 1. 2: Scorecard Generated in RULA Analysis in a sitting posture

2. METHODOLOGY:

The present study was focused on to design an ergonomically efficient chair for computer users based on Indian anthropometric standard data and perform the Biomechanics Single Action Analysis and Rapid Upper Limber Assessment (RULA) analysis. The entire research methodology has been divided into some categories which are explained below:

2.1 Anthropometric Data collection:

Based on the literature survey, it was found that there are total 13 common anthropometric parameters as shown in Figure 1.3 & Table 1.1 are body height, Sitting height, Shoulder height, Popliteal height, Hip breadth, Elbow height, Buttock-popliteal length, Buttock-knee length, Thigh clearance, Eye height, Shoulder (bideltoid) breadth, Body mass (weight) etc. which are primarily considered during the design of chair. Table 1.2 shows the combined body dimensions of both male & female, which are used to design HDM.

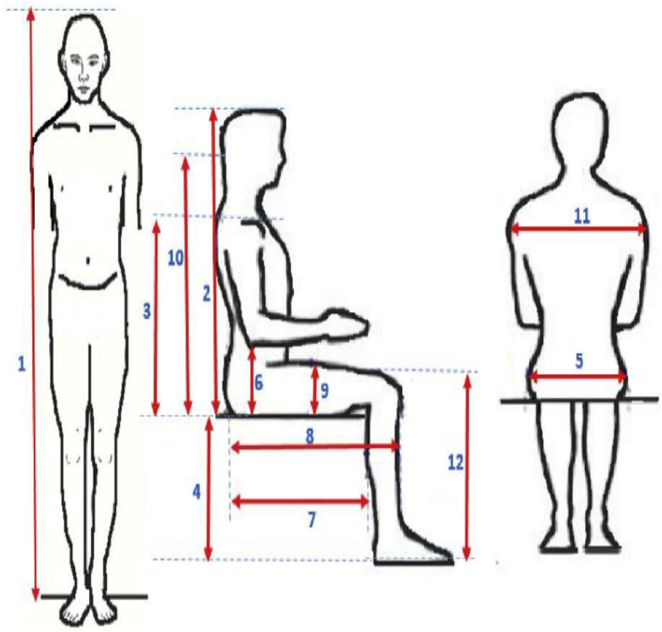

Figure 1.3 Anthropometric Measured Position

Table -1.1: Selection of Body Measurement for Chair Design

Sl./No.	Body Dimensions	Description
1	Stature(body height)	Top of the head, standing in erect stretched posture
2	Sitting height (erect)	Top of the head sitting in a normal relaxed posture

3	Shoulder height, sitting	Height of upper most point on the middle level of the shoulder
4	Popliteal height	Height of the underside of the thigh immediately behind the knee
5	Hip breadth, sitting	Maximum horizontal distance across the hips
6	Elbow height, sitting	Distance between seat and lower most part of the elbow
7	Buttock-popliteal length (seat depth)	Horizontal distance from the most posterior point on uncompressed buttock to the back of the lower leg at the knee
8	Buttock-knee length	Horizontal distance from the most posterior point on uncompressed buttock to most anterior point on the knee
9	Thigh clearance	The vertical distance from seat surface to the maximum bulge on the anterior surface of the thigh was measured with a shorted anthropometer
10	Eye height, sitting	Height of inner corner of the eye sitting in normal relaxed posture
11	Shoulder (bideltoid) breadth	Maximum horizontal distance across the shoulder
12	Knee height	Height of uppermost point on the knee
13	Body mass (weight)	Total mass(weight of the body) with minimum clothes and without shoes

Table -1.2: The combined body dimensions of male & female:

S/No.	Body dimensions	min	max	percentiles					mean	SD
				5th	25th	50th	75th	95th		
1	Stature (body height) (mm)	1288	1950	1465	1555	1619	1673	1171	1614	87
2	Sitting height (erect) (mm)	650	929	715	768	805	836	886	803	50
3	Shoulder height, sitting (mm)	426	657	475	509	541	566	603	540	40
4	Lower leg length (popliteal height) (mm)	305	540	374	399	419	439	466	399	39
5	(mm)	209	550	269	304	326	353	406	331	45
6	Elbow height, sitting (mm)	102	335	150	188	210	234	268	211	36
7	Buttock-popliteal length (seat depth) (mm)	340	595	394	429	451	474	509	453	35
8	Buttock-knee length (mm)	400	861	479	520	549	575	613	549	44
9	Thigh clearance (mm)	65	220	89	109	124	137	158	125	22
10	Eye height, sitting (mm)	515	867	623	686	723	751	796	716	54
11	Shoulder (bideltoid) breadth (mm)	276	672	349	393	417	443	479	418	41
12	Knee height (mm)	438	612	456	489	509	534	563	511	33
13	Body mass (weight) (kg)	30	118	40	47	53	60	74	55.2	11.3

2.2 Human Digital Model (HDM)

The human digital model is a virtual human which is used in the case of human-cantered design problems in the workplace before it physically exists. For Biomechanics Single Action Analysis and RULA analysis an HDM is required of human size. The size and shape of the human vary with gender, geographical region, race and age group. The HMD has been created in sitting and standing posture in CATIA V5 software as shown in Figure 1.4 & Figure 1.5. Figure 1.6 shows the HDM based on Indian Anthropometric Data in standing and sitting posture.

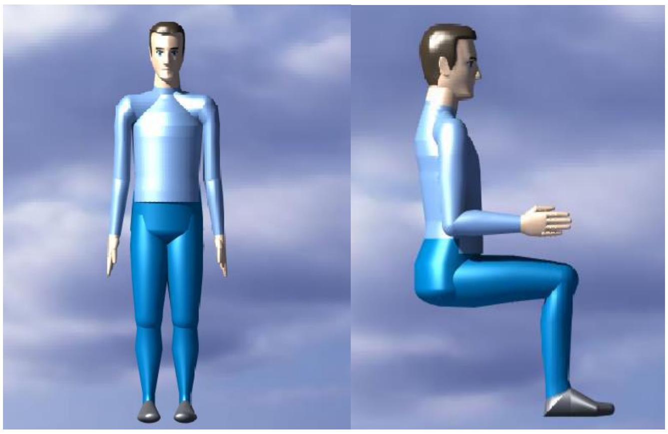

Figure 1.4: Human Digital Model of Male in Standing and Sitting Posture

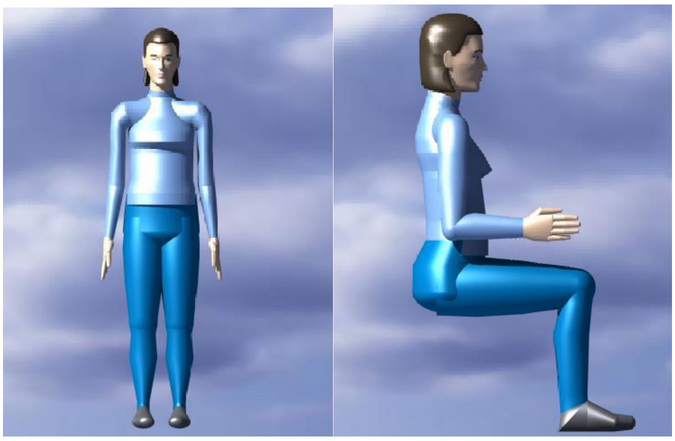

Figure 1.5: Human Digital Model of Female in Standing and Sitting Posture

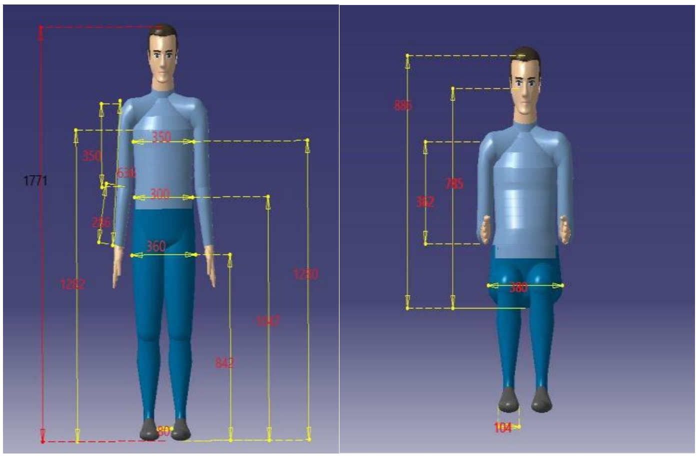

Figure 1.6: Human Digital Model in Standing and Sitting Posture with Indian anthropometric dimensions

3. RESULTS AND DISCUSSIONS:

Biomechanics Single Action Analysis of the chair in Figure 1.7 shows the compression limit and joint shear limit of 524 N and 102 N respectively which indicates that they are well below their maximum standard limit of 3400 N and 500 N respectively. This shows that the sitting posture of the human digital model is an ergonomic posture.

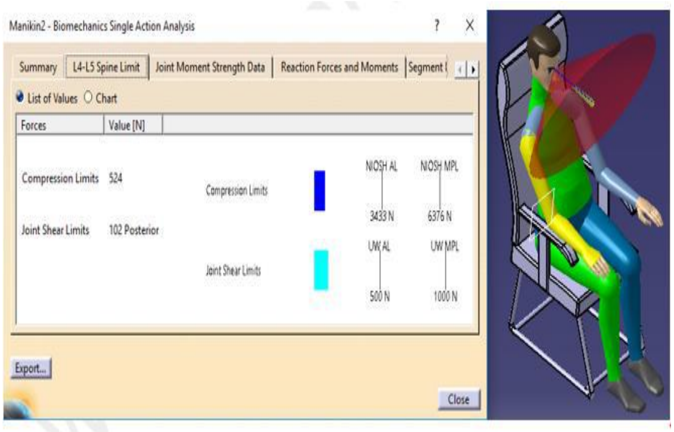

Figure 1.7: Biomechanics Single Action Analysis of the chair

The result of the RULA analysis of the chair shown in Figure 1.8. Most of the human body has a lower score between 0 and 2. Also, the colour shown is green indicating the posture is at a lower risk. The posture was set to be intermittent with the arm supported. The final score is 2 and the posture is considered as acceptable. Figure 1.9 shows the left and right side of Human digital model at the RUAL score of 2 showing green colour.

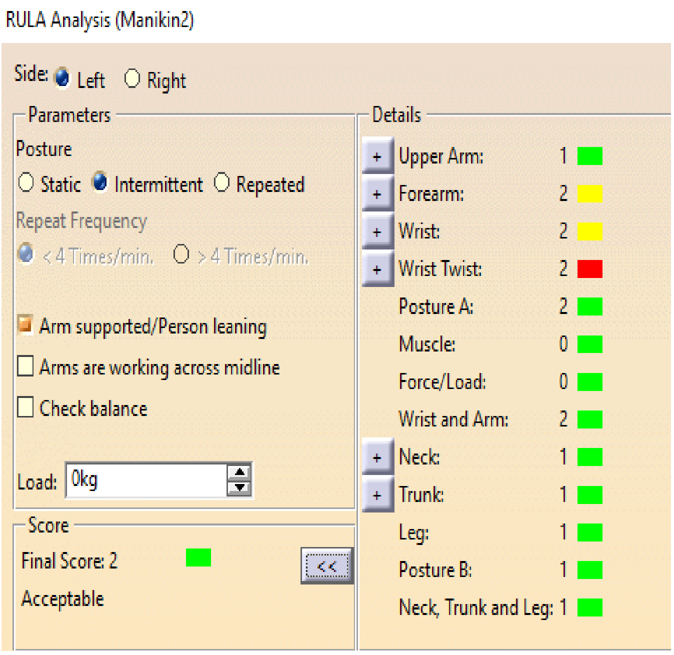

Figure 1.8: Result of RULA Analysis of HDM

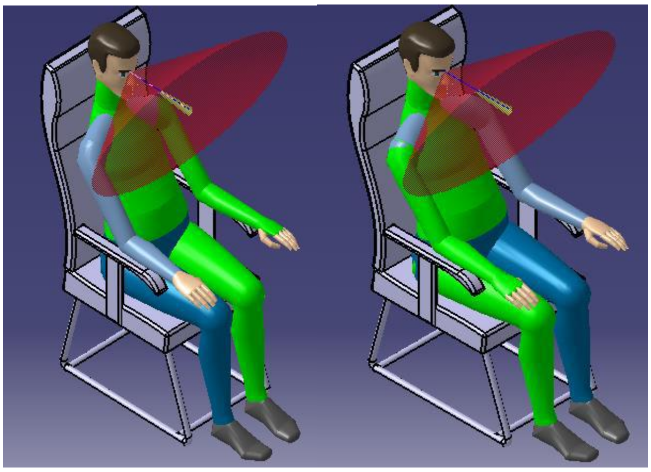

Figure 1.9: Result of RULA analysis of HDM in both left and right side of HDM in Sitting Posture

4. CONCLUSIONS:

In biomechanics single action analysis the compression limit and joint shear limit is found to be 524 N and 102 N respectively, which indicates that the posture of HDM is ergonomically fit posture and further can be used by computer users.

In RULA analysis the score 2 and colour green has come on intermittent and arm supported condition in both left and right side of HDM which implies that the posture of HDM with respect to the modelled chair is acceptable and ergonomically fit for computer users.

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