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Modelling of Office Chair for Laptop Users from Ergonomics Perspective

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Abstract

COVID-19 has gradually increased all the countries and has become a global pandemic. Due to quarantine and lockdown all over the globe, work from home has increased. As a result of this there is increase in the laptop users as well as the health hazards. The global market size of computer workstation chair is rapidly increasing and presently stand around USD 29.67 Billion. Ergonomic based design computer chairs are very important in increasing the productivity and reduce the lower back injuries. Researches have been carried all over the world for ergonomic based on desktop operators. Less work is carried out for ergonomic based design for Laptop users. Hence the objective of this work is to design an ergonomic office chair for lap top users considering Indian Anthropometric data. Inputs for the design of the workstation were based on the parameters of the workstation which are directly related to the human posture and the measurements of the human body. Design inputs are gathered from the standards of Indian Anthropometry based on the general human factors while using the laptop. CAD model of the sub components of the workstation is based on Indian anthropometric standard data using Solid Works. The time taken by the operator to complete the task for without strain on the muscular parts reduces unnecessary movements of the arm and the hand.

Keywords: Musculoskeletal disorders, Office Chair, Anthropometric data

1. Introduction

Computer is one of the important components at the workplace which is used to execute work for prolong durations i.e. for dynamic as well as static conditions. In the present world, computer workstation are used in all offices, industries, institutes, schools, colleges, universities etc. and people spent maximum time continuously and doing monotonous work on it[1]. From the past several years as COVID-19 has gradually increased in all countries and became a global pandemic. Due to quarantine and lockdown all over the globe, work from home has increased. As a result of this there is increase in the laptop users as well as the health hazards.

According to the international data Corp 2020 the sales of the computing machines has exceeded 302 million at 13 % increase from the past years. Improper design of the laptop workstation, improper sitting postures and excessive sitting in workstations hurt the health and affects the body metabolic rate that causes the disease like high blood pressure, depression, hypertension, obesity, dslipidaemia, low back pain, musculoskeletal disorders, and diabetes. These are responsible for the ergonomic problems in the industrially developing as well as developed countries. It further causes the reduction of efficiency of computer users, loss of productivity, and economic loss for sufferers, organizations and the society collectively reducing the manpower of the nation. As a result, many of the chairs advertised as ergonomic actually are not well designed [2].

The consequences of non-ergonomic computer laptop work station design in offices are manifested in the form of eyes pain, joints pain, shoulder pain, arm pain, back pain, neck pain and wrist pain. Researcher

suggested parameters while modeling ergonomics office chair [3]. Frequent pains were also reported by the IT employees in the neck, shoulder, upper back and lower back regions. Further Analysis indicated a high co-relation between the effected body parts and the chair design [4]. Twelve Anthropometric dimensions were considered in designing an ergonomic chair for Indian population in the age group of 20 to 50 years with an objective to reduce the reported musculoskeletal disorders [5]. An attempt has been made to design ergonomically fitted office chair considering anthropometric variables and human bio- mechanics for Bangladeshi people [6].

In India certain studies have focused on the importance of designing office chairs considering the anthropometric data, with an objective to reduce musculoskeletal disorders [2,5]. The anthropometric variables in Indian context to be considered in designing the static chair with an objective to reduce musculo-skeletal disorders have been identified[7]. However, these studies indicate that manufacturers in India are not considering anthropometric data for design [8]. Reachability of 95 percentile and Clearance dimension of five percent have been considered for Indian subjects in the design of sedentary workstation [9]. Proposed an innovative ergonomic chair design and engineering to satisfy all the basic needs of the students in the classroom environment [10,11].

This work focuses on the 3D CAD modelling of office chair for laptop users from ergonomics perspective using Solid works. Modelling of an ergonomically efficient computer workstation based on Indian standards data for Laptop users. In order to reduce the Low Back Pain (LBP) and Musculoskeletal Disorders (MSD) there by improving the performance of the laptop users.3D CAD workstation chair modelling is based on the adjustable parameters like keyboard tray, armrest height adjustment and seat pan etc.

Review of open literature [1-11] shows that a lot of research has been carried out for ergonomically computer workstation considering western anthropometric data but very few works has been done according to Indian anthropometric standard data for the laptop users. This work is focused on the laptop users for integration of both chair and the desk, where the laptop or the keyboard and the note pads are placed in the workstation. For the design of workstation, the armrest/keyboard height and the elbow position and the chair height to the knees id is greater than 90o and the best posture for the shoulder and arm resting makes an angle of 80-100 between upper arm and the lower arm. Multifunctional tilt mechanism focus on the backrest. The seat pan of the chair can be tilted separately, which helps the user to customize the necessary angle required for the seat pan and the backrest angle.

2. Materials and Methods

This research work focused on the ergonomics in design on Anthropometry Data for Design of laptop users, followed by the collection of data such selection of materials, dimension of the chair and loads to be applied etc. Firstly, the idea generation computer workstation chair drawings were drawn using solidworks3D CAD model.

2.1 Inputs for the Design

General inputs for the design of the workstation are based on the parameters of the workstation which are directly related to the human posture and the measurements of the human body [12]. Design inputs are gathered from the standards of Indian Anthropometry based on the general human factors like age, height, weight, grip reach, seat height adjustments and factors like minimizing the side and front reach while using the laptop.

2.1.1 Anthropometric data:

Anthropometric measurement for the sitting workstation is designed on the dimensions and design guidelines for ergonomically structured computer workstation [13]. The distance measured from sitting surface from seat pan and the floor is directly related in gathering of the dimensions. For the design of workstation, measurements are gathered when the user or the operator is seated in normal stretched erect position looking straight, with the parameters like elbow to elbow distance in relaxed and closed position, midthigh and elbow rest position in the sitting posture. The required standard dimension for the design of the workstation is generally taken from the Indian Anthropometric Dimensions [14, 15].

Table 2.1 shows the standard dimension for the Elbow rest for Indian users.

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Table 2.1: Elbow rest position dimensions

Parameters			Percentiles						
		Min	5th	25th	50th	75th	95th	Max	Mean
Elbow Rest	Male	112	158	192	213	236	270	335	215
	Female	102	124	170	194	218	265	290	195
	Combined	102	150	188	210	234	268	335	211

Elbow - Elbow (Closed Position): The distance between elbows with the upper arms in downward position touching side of trunk and forearm in front direction extended straightly shown in the Table 2.3.

Table 2.3: Elbow - Elbow dimension in closed position

Parameters			Percentiles						
		Min	5th	25th	50th	75th	95th	Max	Mean
Elbow to Elbow (Closed)	Male	296	346	375	409	435	489	746	411
	Female	257	282	325	364	399	435	510	363
	Combined	257	311	366	396	430	479	746	398

Elbow – Elbow in relaxed position: The distance between the elbows during the maximum relax position in sideways represented in the Table 2.4.

All the dimension is represented here are for male, female and the combined average from 5th percentile to the 95th percentile. The design dimension is generally considered for the 95th percentile of the combined parameters for the betterment in the proposing design of the workstation [16].

Table 2.4 : Elbow - Elbow dimension in relaxed position

Parameters			Percentiles						
Elbow to Elbow (Relaxed)		Min	5th	25th	50th	75th	95th	Max	Mean
	Male	330	424	464	505	549	644	821	514
	Female	340	352	395	439	474	572	587	444
	Combined	330	389	451	494	539	632	821	501

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2.2 Concept Drawing

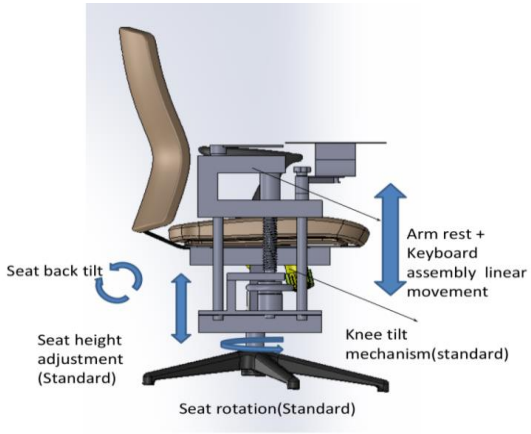

Fig 2.1: Concept Drawing of Laptop users and Functionalities

Fig 2.1 shows the concept drawing of the proposed laptop users with the parts and the functions.

The functionalities involved in the concept design are:

- Casters: These are generally used as an attachment for the objects which enables them to move in and around the surroundings.
- Chair base: The wide spider web like structure normally used for the stability of the entire load of the body and the weight of the upper portion of the chair.
- Chair Cylinder: Cylinder/Gas lift generally used for the adjustment of the chair providing upward and downward motion of the chair.
- Cylinder cover: It is the outer casing provided for the chair gas lift covering it from any sort of plastic material or rubber material for its functioning.

C Frame: Supports or holds the entire assembly of the keyboard and laptop tray, arm rest assembly and the height adjustment mechanism for the arm rest assembly based on Indian anthropometric dimensions and standards [17,18].

2.3 Laptop workstation assembly based on the part and views of the assembly

2.3.1 Laptop Workstation assembly of the Bottom Plate/Main support plate part:

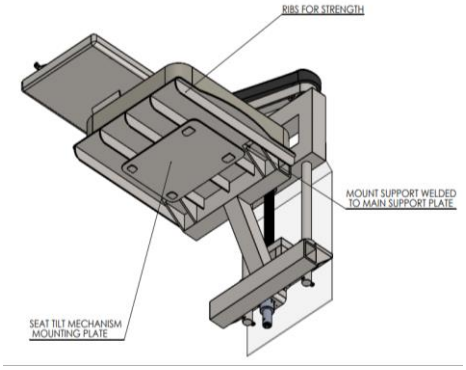

Fig. 2.2: Bottom plate/ Main support plate

Figure 2.2 shows the assembly of Bottom plate/ Main support plate

Bottom Plate: The main component compiled of parts like seat tilt mechanism mounting plate. Mounting plate to hold tilt mechanism plate and mount support with rib based design for holding the seat and withstand load firmly, Maximum loading is observed on the bottom plate due to occupant weight or the body weight of the user [19-21].

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2.3.2 Laptop Workstation parts representation from the side view

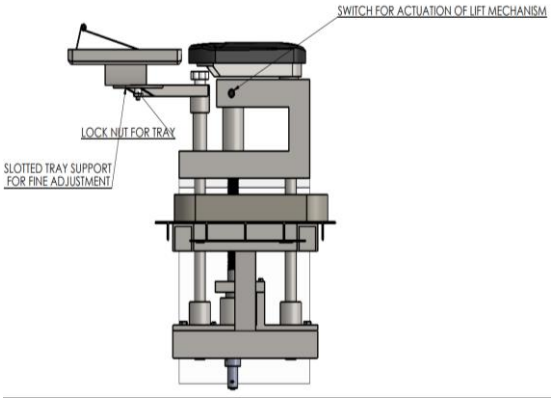

Fig 2.3: Side View Laptop Workstation parts

Fig 2.3 shows the side view comprises of the switch for actuation of the arm rest, Lock nut for holding the tray firmly for supporting the laptop tray and mouse tray assembly and slotted tray support for fine adjustment of the tray based on the user accessibility considering the ergonomic factors for the ease of use of the tray based on the accessibility. Switch is provided for the actuation of the lift mechanism to desired height of the arm rest based on the position of the easy accessibility of the Mouse, Keyboard and Books on the tray. Grip reach and the arm reach are easily achieved by the design and mechanism of the arm rest.

2.3.3 Top view of the Laptop workstation chair:

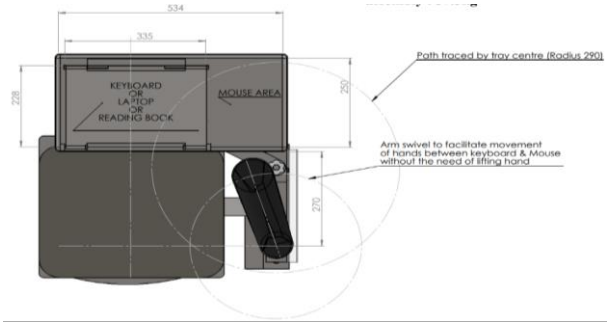

Fig 2.4: Top view of the laptop workstation chair

Fig 2.4 shows the trace or the movement of the tray based on usage by the user the tray can be used flexibly based on the requirements like reading, laptop usage and mouse usage and Arm swivel angle are desired in such a manner that they help to hold the tray or arm rest components at the desired place and the desired angle for the individual user based on their respective individual operator anthropometry. Swivel is to facilitate the movement of hands right and left between keyboard and mouse without the need of lifting hand. Swivel also helps in the movement of the tray based on the requirement of the user or the operator under desired conditions when used or not in use of the tray. Knob or the lock is used to hold the tray firmly based on the required angle by the operator at any position vertically or horizontally [22-24].

2.3.4 C Frame side view and Rear view:

Fig 2.5 shows C frame assembly and the tilt angle of the mouse tray width of the seat and Fig 2.6 shows the rear view of the seat with the mount clamp height, Max height of the seat pan to tray, distance between the arm rest to the seat, seat thickness, the distance between the screw rod assembly to the seat centre.

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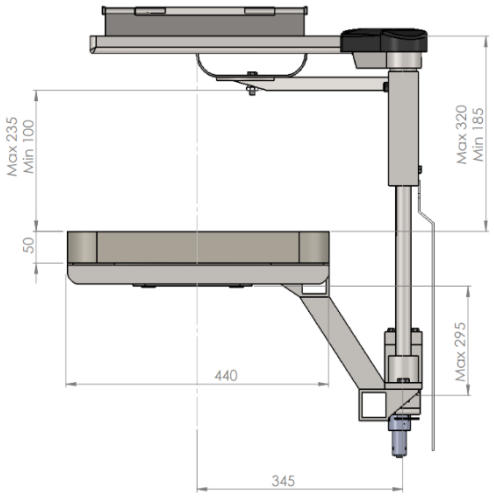

Fig 2.5: C-Frame side view

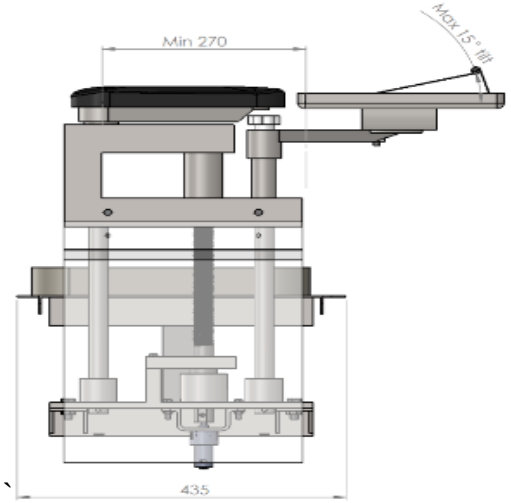

Fig 2.6: Rear View of the Seat

2.3.5 Assembly and Components of laptop workstation:

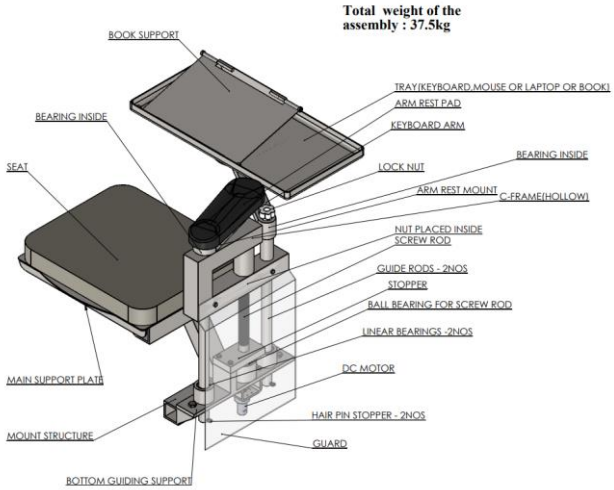

Fig 2.7: Laptop workstation assembly and components

Fig 2.7 shows the sub components of the laptop workstation designed based on the Indian Anthropometry comprising of book support for holding the book and laptop, bearing for the movement of the arm rest support, Seat for user to sit and work, main support plate to hold the tilt mechanism components or part firmly, mounting structure to hold the C Frame module assembly and seat pan firmly. Guard to protect the external material entering the C frame assembly, Hair pin stopper to stop the Seat height once it reach the maximum height as per the standard, DC motor to move the guide rod when the actuation switch is actuated for the height adjustment, Linear bearing to move the guide rod in the linear direction for the height adjustment, ball bearing for screw rod functioning, stopper resist the screw rod to stop the movement touching the bearing present downward. Nut placed in the screw rod to provide the movement for the screw rod, C frame for holding the Armrest, screw rod, hold the guide rods and tray assembly parts, Lock nut used for holding the tray firmly at any instance firmly, Tray used for holding Keyboard, mouse and laptop and additional tray to hold the fixture[25].

2.3.6 Chair assembly:

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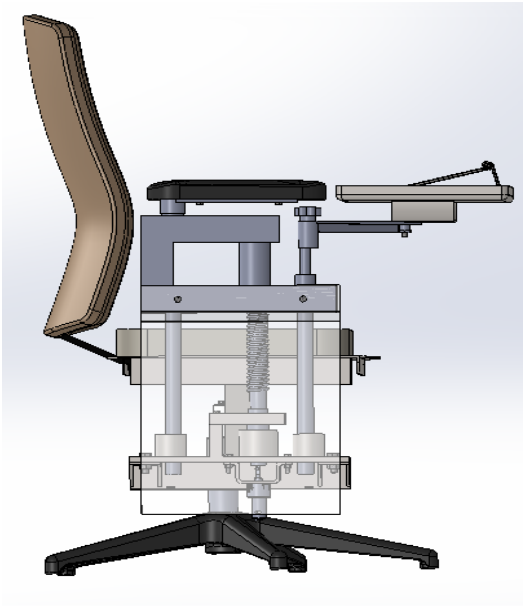

Fig 2.8: Assembly of the laptop workstation with chair

Fig 2.8 shows the C frame is mounted to the chair assembly for the complete workstation design. It comprises of the seat assembly, arm rest mechanism, Laptop or mouse tray and the gas lift mechanism features for the height adjustment of the seat from normal to desired height of the user based on the requirement of the user. Tilt mechanism is used to the seat tilt operation based on the contact of the lumbar support and the seat base.

2.3.7 Chair till mechanism:

Fig 2.9 shows the tilt mechanism of the seat. Tilt mechanism for the user is used to avoid the unnecessary strain and the muscular effort of the body parts while working for prolong period at the workstation. It shows the angle of tilt 30 degree of the seat at the actual condition and the seat at the tilt position while the user lean back for resting or relaxing position[26].

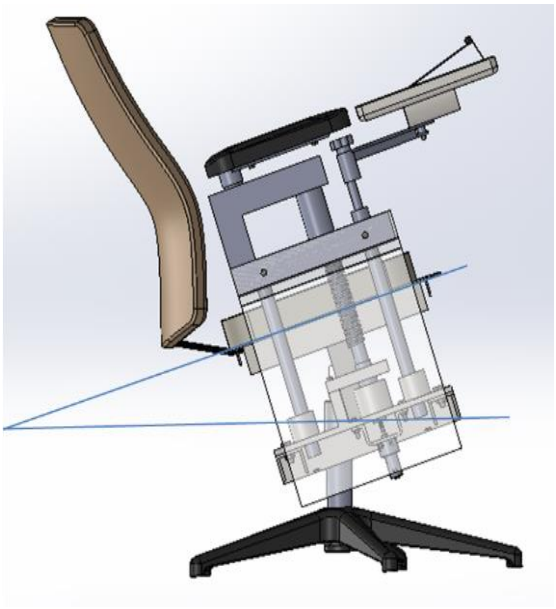

Fig 2.9: Tilt condition of the laptop workstation chair

3. Conclusions and Future Work

Workstation design is feasible for user or the operator ease of use in terms of adjustable features of arm rest at any instants by eliminating the rail system used in existing design. Modeling of chair offers the benefits of lean and tilt back actions. The Swivel angle of the laptop tray and the arm rest are having more movement along the axis. Seat with Lumbar support and curb area support for reducing the musculo skeletal disorders over a prolong usage of the workstation. Screw rod mechanism was used instead to obtain better height adjustment of the Armrest support. Reduces the operator to work for prolong period of time without strain on the muscular parts, reduces eye strain, unnecessary movements of the arm or the hand is reduced.

Anthropometry functions like grip reach, arm reach, eye height, mouse and keyboard tray height adjustment, tilt back and lean angle, arm support and height adjustment of the chair has been facilitated for the user. Work can be further extended in developing by fabricating the Indian Anthropometry standard based workstation to fit the Indian computer users. Development of zero gravity workstation can be taken in consideration for the users in India.

References

1. Parth Patel, Tejal Patel. “Ergonomic modification in study bench with validation through RULA method and EEA.” International Journal for Research & Development in Technology, Vol.5, Issue-5 (May-2016): 112-115.
2. Mahantesh M.Math, Dr. Rajeswara Rao K. V. S. and Jaydeep Mandal (2021) “Human digital modeling and RULA analysis for an office chair user in computer work environment – A case study in Indian context” AIP Conference Proceedings
3. Yusop, Md, Shafizal Mat, F. R. Ramli, A. R. Dullah, and Siti Nurhaida Khalil. "Design of welding armrest based on ergonomics analysis: Case study at educational institution in Johor Bahru, Malaysia." ARPN Journal of Engineering and Applied Sciences 13, 1 (2006): 309-313.
4. Noshin, L., H. Sen Gupta, and Md G. Kibria. "Office chair design: a systematic approach of ergonomic design based on the anthropometric measurement of Bangladeshi people. "International Journal of Research in Industrial Engineering, 7, 2 (2018):224-234.
5. Mahantesh M.Math, Dr. Rajeswara Rao K. V. S. and Kirthan L J (2019) “Analysis of Ergonomic Office Chair for Information Technology Work Environment-A case study in Indian context”, International Conference on Sustainable Computing in Science, Technology & Management (SUSCOM-2019) (SSRN Elsevier Proceedings).
6. Peteri, Virve. "Bad enough ergonomics: A case study of an office chair." SAGE Open 7, 1 (2017):2158244016685135.
7. Rizwan M. Farooqi, Dr. R. B. Shahu, Analysis of anthropometric dimensions for sitting posture and chair design: A Review, International Journal of Innovation in Engineering and Technology (IJIET), Vol. 6, Issue 3, (February 2016):221-224
8. Porchilamban, S., VK Bupesh Raja, S. Senthil Kumar, and S. Satish Kumar. "Review on scope and trends in ergonomic evaluation of work posture in dentistry." In Frontiers in Automobile and Mechanical Engineering-2010, pp. 261-264. IEEE, 2010.
9. Taifa, Ismail Wilson, and Darshak A. Desai. "Anthropometric measurements for ergonomic design of students’ furniture in India." Engineering science and technology, an international journal 20, 1 (2017):232-239.
10. E. H. C. Wooa, P. White and C. W. K. Lai. “Ergonomics standards and guidelines for computer workstation design and the impact on users’ health Department of Health Technology and Informatics, The Hong Kong Polytechnic University, Hong Kong, Special Administrative Region, China2015.
11. Suebsak Nanthavanij, “Body height-workstation settings matrix: A practical tool for ergonomic VDT workstation adjustment” 0169-8141/96/$15.00 Copyright © 1996 Elsevier Science B.V.

12. Michael J. Smith et.al “Do ergonomics improvements increase computer workers' productivity: an intervention study in a call centre” ERGONOMICS, 2003, VOL. 46.
13. R.A.R.C. Gopura et al “Design of an Ergonomically Efficient Chair” 14th eru symposium, 2008: Faculty of Engineering, University of Moratuw
14. Kemal Lale “Anthropometric Computer Workstation Design To Reduce Perceived Musculoskeletal Discomfort “Eastern Mediterranean University September 2013 Gazimağusa, North Cyprus
15. Avinash B, Praveen M P, Pradeep A “Design and Fabrication of Multi utility Chair,” International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 3 Issue 7, July - 2014
16. YE Yong-jun, ZHANG Zhong-feng, HE rui-lin, “Study on design of Chair shaping based on Kansei engineering,” International Journal of Scientific & Engineering Research, Volume 5, Issue 8, August-2014ISSN 2229-5518.
17. Pratibha Joshi, Indu Karki and Promila Sharma, “Computer Workstation Ergonomics: Knowledge Testing of State Agricultural Universities (SAU) Students” J Hum Ecol, 49(3): 335-339 (2015).
18. Ashraf A. Shikdar & Mahmoud A. Al-Kindi “Office Ergonomics: Deficiencies in Computer Workstation Design,” International Journal of Occupational Safety and Ergonomics (JOSE) 2007, Vol. 13, No. 2, 215–223.
19. Salami O. Ismaila “Design of Ergonomically Compliant Desks and Chairs for Primary Pupils in Ibadan, nigeria,” Journal of Engineering Science and Technology Vol. 10, No. 1 (2015) 35 - 46 School of Engineering, Taylor’s University.
20. Lennart Dimberg. “The Changing Face of Office Ergonomic” 1875-9343/15 The Ergonomics Open Journal, 2015, 8, 38-56.
21. A. McKinney, E. Kub and M.S. Hallbeck, “Ergonomic Evaluation of Student Computer Workstations,” Suny Binghamton on March 9, 2015.
22. Muhammad Atif Khan, “Ergonomic Assessment of Workstation among Computer Users of Karachi”, American Journal of Engineering Research (AJER) e-ISSN: 2320-0847, p-ISSN : 2320-0936
23. Nabila Chowdhury et.al, “Ergonomic assessment of working postures for the design of university computer workstations,” Occupational Ergonomics 13 (2017) S37–S46 S37 DOI 10.3233/OER-170252
24. Nasr Al-Hinai, “An Ergonomic Student Chair Design and Engineering for Classroom Environment,” International Journal of Mechanical Engineering and Robotics Research Vol. 7, No. 5, September 2018
25. Ibrahim H. Garbie, “An Experimental Study on Assembly Workstation Considering Ergonomically Issues,” Proceedings of the 41st International Conference on Computers & Industrial Engineering.
26. S M Raj Kumar et. al., “Design of Workstations for Computer Users: A Review” Oct 2017 | IRE Journals | Volume 1 Issue 4 | ISSN: 2456-8880.