DOI: 10.7860/JCDR/2024/65715.19086

Original Article

Physical Medicine and Rehabilitation Section

Ergonomic Evaluation of Static, Revolving, and Wooden Chairs using Cornell's Seating Evaluation v21 in Professionals with Prolonged Sitting: A Cross-sectional Study

SHRUSHTI NARESH ARORA[1], SUBHASH KHATRI[2]

BY-NC-ND

ABSTRACT

Introduction: In contemporary workplaces, individuals using sedentary workstations often remain seated for approximately two-thirds of their workday, with extended periods of sitting lasting at least 30 minutes uninterrupted. The widespread use of various types of chairs in professional settings and their significant impact on individual well-being necessitate this ergonomic study. Given that professionals spend a considerable portion of their day seated, it is imperative to understand the ergonomic characteristics of different chair types to promote a comfortable and supportive work environment. This study focuses on evaluating static, revolving, and wooden chairs to identify their strengths and weaknesses.

Aim: To compare the ergonomic features of static, revolving, and wooden chairs among in professionals with prolonged sitting using Cornell's Ergonomic Scale.

Materials and Methods: A cross-sectional study was conducted among professionals at a corporate company in Ahmedabad, Gujarat, India, from July 2021 to September 2022. Participants, regardless of gender, who had been using a laptop or desktop for at least four hours a day for a year were included. The study assessed three types of chairs: static, revolving, and wooden. The survey consisted of two sections: demographic and job-related information, and the Cornell Ergonomic Seating Evaluation v21 scale, which measured chair adjustment, seating comfort, ease of use, body support, and an overall ergonomic score. Data were analysed using Statistical Package for Social Sciences (SPSS) version 25.0, employing one-way ANOVA.

Results: A total of 217 participants were surveyed, including 182 males and 35 females. The overall Ergonomic Discomfort Score (EDS%) was 32.49±2.71% for static chairs, 66.3±3.56% for revolving chairs, and 25.26±3.27% for wooden chairs (p-value <0.001).

Conclusion: The application of practical ergonomic principles with tools such as the Cornell scale can effectively minimise employee discomfort and enhance both work capacity and job satisfaction.

Keywords: Chairs, Ergonomics, Musculoskeletal disease, Postures

INTRODUCTION

Since the mid-20th century, human life has transitioned from active to more sedentary work, resulting in reduced physical activity. This shift towards a sedentary lifestyle is due to social, economic, and environmental changes. Office workers make-up one of the largest occupational groups and often remain seated for about two-thirds of their working hours, with sitting periods typically lasting at least 30 minutes at a time [1]. Recent advancements in technology and the proliferation of smart devices have led to a significant increase in daily sitting time [2,3]. Professions that involve prolonged sitting include desk jobs, computer professionals, bankers, receptionists, chartered accountants, and many others [4,5], where individuals are required to maintain a static posture for extended periods.

Chairs are among the most ancient and widely used pieces of furniture. Yajnyadatta Dora's study described a chair as a piece of furniture designed for lying, sitting, or standing in a relaxed and casual manner. With evolving technology, there has been a progression in the types, structures, materials, comfort levels, and aesthetics of chairs. Properly designed chairs can reduce the risk of musculoskeletal disorders [6]. Over time, chairs have become more accessible and have been crafted from various materials, such as wood, metal, and plastic. In the 20th century, ergonomic considerations became integral to chair design, with the goal of creating chairs that are not only comfortable but also supportive of the back and body to minimise musculoskeletal disorder risks [6]. Today, there is an array of chairs available, including office chairs, gaming chairs, and those specifically designed for standing desk configurations.

The Cornell Seating Evaluation v21 is a practical tool designed to help professionals make informed decisions when evaluating different chair designs. It is used to assess the ergonomic qualities of chairs, identifying areas for potential improvement in terms of comfort, design, and material selection [7]. Although there are no articles specifically discussing the Cornell Seating Evaluation v21, it remains a useful tool for assessing the ergonomic design of chairs. The present study was conducted to compare the ergonomic aspects of static, revolving, and wooden chairs among in professionals with prolonged sitting using Cornell's Ergonomic Scale.

MATERIALS AND METHODS

A cross-sectional study was conducted with professionals working in a corporate company in Ahmedabad, Gujarat, India, from July 2021 to September 2022. The study commenced after obtaining clearance from the Institutional Ethical Committee (NCP/213C/2020) and permission from the corporate company's Human Resources team.

Inclusion criteria: Participants of any gender using a laptop or desktop for at least four hours a day for one year were included.

Exclusion criteria: Participants with a history of musculoskeletal injury, incomplete questionnaires, and pregnant women were excluded.

Sample size: The sample size was determined using the formula:

$$Z\,(1-\alpha)^2 \times p\,(1-p)/d^2$$

Here, Z $(1-\alpha)^2$ is the standard normal variate (1.96 for a 5% type I error ($p<0.05$) and 2.38 for a 1% type I error ($p<0.01$)); in this study, 1.96 was used. The 'p' represents the expected proportion of the population, and 'd' represents the absolute error or precision, which is determined by the researcher [8]. The sample size was calculated in reference to a previous study [9], taking 'p' as 85% and 'd' as 0.05. Consequently, the sample size was established at 217. A non-probability purposive sampling method was utilised for the survey.

Procedure

Study participants used three different types of chairs: revolving chairs, static chairs, and wooden chairs. A revolving chair is a chair with multiple adjustment features such as height, seat pan, backrest adjustments, and armrests with wheels. A static chair, while lacking adjustability, is characterised by cushioning, adequate back support, and a cushioned seat. The wooden chair is a standard seat with mid-back support made from wood. Participants were randomly selected based on their job designation, with chair assignments stratified according to job roles. Senior managers and above received fully adjustable revolving chairs, mid-level managers received normal static cushioned chairs without adjustability, and officers or trainees used wooden chairs. All participants had the common job requirement of working on computers for at least four hours a day. Employee selection was randomised after they completed the initial 90 minutes of computer work. Data were collected by assessors visiting each employee's workstation, where employees filled out the evaluation form on-site.

Survey questionnaire: The survey questionnaire comprised two sections: the first section collected demographic and job-related information, and the second section involved Cornell's Ergonomic Seating Evaluation v21 self-administered scale [7]. The scale uses a 10-centimeter linear rating scale with well-defined intervals. A score of 0 indicates an unacceptable rating, 10 indicates an outstanding rating, and 5 represents an average chair experience. A score of 0 is given when a chair lacks any notable features. The responses are subjective, focusing on chair usability and comfort. The scale includes five sections, assessing chair adjustments, seat comfort, ease of use, and body support, with an additional section for an overall comfort rating. Scores from each section are aggregated, leading to an overall percentage EDS. These sections allow for the comparison of different chairs on individual items, feature sections, overall subjective performance, or the total chair performance as indicated by the %EDS [7].

STATISTICAL ANALYSIS

Data were collected and entered into Microsoft Excel 2017 and analysed using IBM's Statistical Package for the Social Sciences (SPSS) Version 25. A one-way ANOVA was utilised to compare the different types of chairs across each parameter of the Cornell Ergonomic Seating Evaluation v21 scale and the percentage %EDS. The level of significance was set at $p<0.05$.

RESULTS

The survey included a total of 217 participants, comprising 182 males and 35 females. The majority of participants, numbering 102 (47%), were in the 31-40 age group. An analysis of average daily working hours revealed that 193 participants (89%) sat for approximately 8-10 hours each day [Table/Fig-1].

Criteria	Mean±SD
Age (years) (mean±SD)	36.85±7.35
Duration of work (hours)	10.24±7.60
Hours of sitting	9.10±0.83

[Table/Fig-1]: Demographic and occupational details.

Regarding chair usage, 103 individuals (47.5%) utilised static chairs, 67 (30.9%) used revolving chairs, and 47 (21.6%) sat on wooden chairs.

The study assessed three different types of chairs against specified criteria. The overall chair experience, which combined all criteria, resulted in mean±SD scores of 19.30±2.70 for static chairs, 24.48±2.63 for revolving chairs, and 16.51±2.54 for wooden chairs. These scores suggest that revolving chairs provided a superior overall experience [Table/Fig-2].

Ergonomic seating	Static chair (n=103) Mean±SD	Revolving chair (n=67) Mean±SD	Wooden chair (n=47) Mean±SD	p-value
Chair adjustment	0.57±3.34	22.19±3.99	0.57±3.94	**<0.001**
Seat comfort	21.50±2.84	31.48±3.41	13.26±4.09	**<0.001**
Ease of use	7.93±0,73	30.78±3.18	9.43±0.62	**<0.001**
Body support	18.92±2.27	29.73±3.33	13.28±3.18	**<0.001**
Overall chair experience	19.30±2.70	24.48±2.63	16.51±2.54	**<0.001**

[Table/Fig-2]: Cornell's Ergonomic seating evaluation v21 and its determinants. Test used: One-way ANOVA; Bold p-values are significant

The total EDS% for static chairs was 32.49±2.71%, for revolving chairs it was 66.3±3.56%, and for wooden chairs, it was 25.26±3.27% [Table/Fig-3]. The total EDS% is calculated as follows: ((A+B+C+D+E)/210)×100, where A represents the chair adjustment score, B is the seat comfort score, C is the ease of use score, D is the body support score, and E is the overall chair experience score.

Type of chair	Total N=217	Total EDS percentage (%)	p-value
Static chair	103	32.49±2.71	**<0.001**
Revolving chair	67	66.03±3.56	
Wooden chair	47	25.26±3.27	

[Table/Fig-3]: Percentage of Ergonomic Discomfort Scale (EDS) scores. ANOVA was used

DISCUSSION

The study involved 217 participants, comprising 182 males and 35 females, with a predominant age group of 31-40 years (47%). Significant disparities among chair types were revealed in the findings. Revolving chairs demonstrated superior performance in terms of chair adjustment, seat comfort, ease of use, body support, and overall chair experience compared to static and wooden counterparts. These results are in line with previous studies that emphasise the impact of chair design on ergonomic outcomes [10,11]. The %EDS score, a comprehensive measure of ergonomic performance, corroborated these individual findings, indicating that revolving chairs were markedly more ergonomic (66.03±3.56%) than static (32.49±2.71%) and wooden chairs (25.26±3.27%). These results substantiate the importance of considering ergonomic design in office chairs and echo the findings of previous research that advocates for workplace ergonomics as a key determinant of employee well-being and productivity [12,13]. Hence, the study underscores the pivotal role of revolving chairs in fostering a conducive and ergonomic work environment, thereby contributing to enhanced employee satisfaction and overall productivity.

Seating comfort is one of the most important factors affecting employees' performance in an office environment. Apart from its influence on posture and comfort, poor workplace ergonomics can also detrimentally affect health, leading to job dissatisfaction [14]. Zhang L et al., in their study, examined 21 ergonomic office chairs and found that while discomfort levels increased over time, there were no substantial correlations between discomfort and cognitive function [9]. Studies have found that back/neck pain is often associated with increasing levels of workplace sitting. Therefore, it is important to take breaks and adjust sitting posture to prevent discomfort during prolonged sitting [15,16].

Comfort and discomfort are self-determining factors (i.e., a decrease in discomfort does not necessarily lead to an increase in comfort).

Comfort has been associated with well-being, aesthetics, relaxation, and energy factors [17,18]. The ergonomic design of chairs has gained significant importance over the last 20 years. In fact, when the term 'ergonomics' is mentioned, many people immediately think of office and chair ergonomics [18].

Chairs must fit a user's anthropometrics (body measurements) to eliminate discomfort while sitting. There are five aspects of occupational ergonomics: safety, comfort, ease of use, productivity/performance, and aesthetics. Occupational ergonomics is a science concerned with the "fit" between people and their work. Ergonomic chairs are designed to optimise comfort and reduce work injuries [17].

The findings of the present study underscore the potential for enhancing the comfort features of office chairs through the exploration of diverse combinations of padding materials. This avenue for research aligns with previous studies that emphasise the importance of material choices in ergonomic design for optimal user satisfaction [19,20]. Additionally, incorporating practical ergonomics in office settings emerges as a promising strategy to mitigate employee discomfort and subsequently elevate their working capacity and job satisfaction. Previous research has demonstrated a positive correlation between ergonomic interventions in the workplace and improved employee well-being [10,11].

Furthermore, the study highlights the importance of prioritising comfort and ergonomics over aesthetic considerations. While aesthetics play a role in the overall design, their influence on satisfaction levels should be secondary to the fundamental aspects of comfort and ergonomic functionality. This finding is consistent with research that emphasises the primacy of ergonomic factors in chair design for an optimal user experience and satisfaction [12,21].

Limitation(s)

The scope of this study was confined to a single corporate company, which may limit the broader applicability of the findings. Expanding the research to encompass a larger and more diverse population could provide deeper insights into the scale's utility and its potential future implications. The use of purposive sampling further constrains the generalisability of the results. Additionally, the cross-sectional design of this study precludes the establishment of causation. To fully understand the efficacy of the Cornell Ergonomic Evaluation Scale v21, more research, particularly longitudinal studies, is necessary.

CONCLUSION(S)

This study not only identifies the most ergonomically suitable chair among the three types evaluated but also underscores the critical importance of incorporating proper ergonomics into our daily routines. The findings suggest that the application of ergonomic principles is an effective strategy for promoting health, comfort, and productivity. By emphasising ergonomic design in workplace furnishings, especially in chair selection, individuals can enhance their overall work experience and quality of life. Moreover, results of this study support the routine application of the Cornell Ergonomic Evaluation Scale as a valuable instrument for assessing employee comfort levels in the workplace.

REFERENCES

[1] Owen N, Healy GN, Matthews CE, Dunstan DW. Too much sitting: The population-health science of sedentary behavior. Exerc Sport Sci Rev. 2010;38(3):105-13.
[2] Church TS, Thomas DM, Tudor-Locke C, Katzmarzyk PT, Earnest CP, Rodarte RQ, et al. Trends over 5 decades in US occupation related physical activity and their associations with obesity. PLoS One. 2011;6(5):e19657.
[3] Daneshmandi H, Choobineh A, Ghaem H, Karimi M. Adverse effects of prolonged sitting behavior on the general health of office workers. J Lifestyle Med. 2017;7(2):69-75.
[4] Kwon Y, Kim JW, Heo JH, Jeon HM, Choi EB, Eom GM. The effect of sitting posture on the loads at cervico-thoracic and lumbosacral joints. Technol Health Care. 2018;26(S1):409-18.
[5] Thorp AA, Healy GN, Winkler E, Clark BK, Gardiner PA, Owen N, et al. Prolonged sedentary time and physical activity in workplace and non-work contexts: A cross-sectional study of office, customer service and call centre employees. Int J Behav Nutr Phys Act. 2012;9:128. https://ijbnpa.biomedcentral.com/articles/10.1186/1479-5868-9-128
[6] Farquhar SA, Wiggins N, Michael YL, Luhr G, Jordan J, Lopez A. "Sitting in different chairs:" roles of the community health workers in the Poder es Salud/Power for Health Project. Educ Health (Abingdon). 2008;21(2):39.
[7] Hedge A. Cornell's ergonomic seat evaluation v21. Cornell's University, 2007.
[8] Charan J, Biswas T. How to calculate sample size for different study designs in medical research? Indian J Psychol Med. 2013;35(2):121-26.
[9] Zhang L, Helander MG, Drury CG. Identifying factors of comfort and discomfort in sitting. Human Factors. 1996;38(3):377-89.
[10] Peteri V. Bad enough ergonomics: A case study of an office chair. SAGE Open. 2017;7(1):2158244016685135.
[11] Robertson MM, Amick III BC, DeRango K, Rooney T, Bazzani L, Harrist R, et al. The effects of an office ergonomics training and chair intervention on worker knowledge, behavior and musculoskeletal risk. Appl Ergon. 2009;40(1):124-35.
[12] Mansor R, Sheau-Ting L. Criteria for occupant well-being: A qualitative study of Malaysian office buildings. Building and environment. 2020;186:107364.
[13] Deouskar N. The impact of ergonomics on the productivity of people. Int J Mark Financ Manag. 2017;5(6):59-63.
[14] Çetin MS, Karabay G, Öztürk H, Kurumer G. Seating comfort satisfaction level of office workers and their expectations from an office chair. Mugla J Sci Technol. 2020;6(1):72-77.
[15] Kallings LV, Blom V, Ekblom B, Holmlund T, Eriksson JS, Andersson G, et al. Workplace sitting is associated with self-reported general health and back/neck pain: A cross-sectional analysis in 44,978 employees. BMC Public Health. 2021;21(1):875. Doi: 10.1186/s12889-021-10893-8.
[16] Baker R, Coenen P, Howie E, Williamson A, Straker L. The short term musculoskeletal and cognitive effects of prolonged sitting during office computer work. Int J Environ Res Public Health. 2018;15(8):1678.
[17] Alnaser MZ, Wughalter EH. Effect of chair design on ratings of discomfort. Work. 2009;34(2):223-34.
[18] Shackel B, Chidsey KD, Shipley P. The assessment of chair comfort. Ergonomics. 1969;12(2):269-306.
[19] Mohanty PP, Mahapatra SS. An integrated approach for designing office chair with ergonomic consideration. Int J Serv Oper Manag. 2014;17(2):194-220.
[20] Helander MG. Forget about ergonomics in chair design? Focus on aesthetics and comfort! Ergonomics. 2003;46(13-14):1306-19.
[21] Hakkarainen P, Ketola R, Nevala N. Reliability and usability of the ergonomic workplace method for assessing working environments. Theor Issues Ergon Sci. 2011;12(4):367-78.

PARTICULARS OF CONTRIBUTORS:
1. Scholar (PhD), Department of Physiotherapy, Sankalchand Patel University, Visnagar, Gujarat, India.
2. Principal, Department of Physiotherapy, Sankalchand Patel University, Visnagar, Gujarat, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Shrushti Naresh Arora,
Samta 25, Row House, Amba Township Pvt. Ltd., Behind Trimandir Adalaj,
Gandhinagar, Gujarat, India.
E-mail: shrushti068@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: May 30, 2023
- Manual Googling: Dec 09, 2023
- iThenticate Software: Dec 27, 2023 (5%)

ETYMOLOGY: Author Origin

EMENDATIONS: 9

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **May 30, 2023**
Date of Peer Review: **Aug 08, 2023**
Date of Acceptance: **Dec 29, 2023**
Date of Publishing: **Feb 01, 2024**