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ENHANCING THERMAL COMFORT AND POSTURAL SUPPORT IN DESK WORKERS THROUGH ERGONOMIC HEATED BACKREST DESIGN

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Abstract: The increasing prevalence of prolonged sitting and sedentary work culture has contributed significantly to the rise of musculoskeletal discomfort, particularly lower back pain and posture-related problems among desk workers. Inadequate seating support, static posture, and extended working hours are major contributors to spinal strain, muscle fatigue, and discomfort during prolonged sitting. Although existing ergonomic backrests provide a certain degree of lumbar support, many products primarily focus on posture correction and fail to address muscle stiffness and thermal comfort simultaneously. This highlights the need for more comprehensive ergonomic solutions that combine structural support with therapeutic relief. The present study aimed to analyse posture-related discomfort among desk workers and develop an improved ergonomic heated backrest, "Ergo-Warm," designed to enhance lumbar support and provide controlled thermal comfort during prolonged sitting. A mixed-method research design was adopted involving 160 participants engaged in desk-based occupations requiring extended sitting durations. Quantitative data were collected using structured questionnaires and the Cornell Modified Discomfort Questionnaire (CMDQ), while qualitative insights were gathered through semi-structured interviews. The study examined participants' sitting behaviour, discomfort patterns, awareness of ergonomic products, and preferences regarding lumbar support, adjustability, material, and heating features. The findings revealed that static posture, prolonged working hours, and lack of lumbar support were the most common causes of discomfort among participants. A majority of respondents reported experiencing lower back discomfort after sitting continuously for 6–8 hours daily. Participants also expressed strong preference for adjustable lumbar support, memory foam cushioning, and integrated heating features that could provide relaxation and reduce muscle stiffness. The study further highlighted growing interest in ergonomic products that combine comfort, posture correction, and therapeutic benefits. The research concludes that integrating ergonomic design with heat therapy can improve sitting comfort, reduce musculoskeletal strain, and support better posture among desk workers. The proposed Ergo-Warm design offers a user-centred approach toward enhancing occupational comfort and well-being in modern sedentary work environments.

Keywords: Ergonomics, Heated Backrest, Lumbar Support, Thermal Comfort, Posture, Musculoskeletal Discomfort, Desk Workers.

I. INTRODUCTION

The rapid shift toward sedentary, desk-based work has led to a marked rise in musculoskeletal complaints, particularly among office workers in urban and emerging economies. Prolonged sitting, often exceeding 6–8 hours per day, is strongly associated with lower back pain, spinal discomfort, and joint stiffness. These issues are not merely discomfort-related but can evolve into chronic musculoskeletal disorders that impair productivity and long-term health. Research consistently identifies sustained seated postures, especially when combined with poor ergonomic conditions—as a significant risk factor for low back pain and related

disorders (Waongenngarm, 2018). Inadequate lumbar support and improper spinal alignment during sitting contribute to increased mechanical stress on the vertebral column, leading to fatigue and injury over time.

Ergonomics plays a critical role in designing workstations that align with human anatomical and physiological capabilities, thereby minimizing strain during prolonged tasks (Rao, 2018). Poor ergonomic practices during extended sitting hours can exacerbate spinal loading and muscle imbalance, significantly increasing the risk of chronic back pain among desk workers (Rao, 2024). Ergonomic interventions have traditionally focused on optimizing seating design to maintain the natural curvature of the spine. Backrests with appropriate lumbar support play a critical role in distributing pressure evenly and reducing strain on the lower back. According to Bridger, effective lumbar support facilitates neutral spinal posture and significantly reduces the risk of developing chronic low back pain (Bridger, 2018). Contemporary designs such as memory foam cushions, adjustable lumbar supports, and mesh-backed chairs provide varying degrees of structural support. However, these solutions primarily address biomechanical alignment and often overlook the physiological aspects of muscle fatigue and stiffness that accompany prolonged sitting (Waghmare & Rao, 2022).

An emerging body of evidence highlights the benefits of adjunct therapeutic interventions, particularly heat therapy, in managing musculoskeletal discomfort. Superficial heat application has been shown to enhance blood circulation, reduce muscle stiffness, and alleviate pain in individuals with low back conditions (Nadler, 2004). Despite its proven benefits, heat therapy is rarely integrated into ergonomic seating solutions, resulting in a missed opportunity to provide a comprehensive intervention that addresses both structural and muscular factors (Pereira & & Rao, 2022).

This study aims to bridge this gap by evaluating existing ergonomic backrest designs and developing an innovative solution “Ergo-Warm”—that integrates ergonomic support with controlled heat therapy. The proposed design seeks to enhance thermal comfort while maintaining optimal spinal alignment, thereby offering a dual-function approach to improving workplace well-being. By combining principles of ergonomics with therapeutic heat application, this research contributes to the development of holistic interventions for reducing musculoskeletal strain and enhancing comfort among desk workers.

II. Review of Literature

Many studies underscore the relationship between prolonged sitting, inadequate seating design, and the development of musculoskeletal disorders (MSDs), particularly in desk-based occupations. Contemporary research has increasingly focused on understanding how ergonomic interventions, especially backrest design and lumbar support—can mitigate discomfort and improve postural outcomes.

Recent experimental work by De Carvalho and Callaghan (De Carvalho, 2023)examined how variations in chair design influence lumbar posture, muscle activation, and perceived discomfort during extended sitting. Their findings indicate that chairs with adjustable lumbar support and adaptive features significantly improve spinal alignment and reduce muscular strain. Notably, a substantial proportion of participants reported increased discomfort during prolonged sitting in non-ergonomic conditions, reinforcing the importance of dynamic and customizable seating solutions. This aligns with earlier findings that emphasize the biomechanical burden placed on the lumbar spine when seated without adequate support.

A comprehensive review of ergonomic furniture studies spanning a decade (2012–2022), concluding that poorly designed seating—particularly those lacking lumbar support, contributes significantly to spinal misalignment, muscle fatigue, and long-term discomfort (Bai, 2024). Their analysis highlights that ergonomic interventions must go beyond static design and incorporate adjustability and user-specific customization to be effective. The absence of such features has been consistently identified as a key risk factor for work-related MSDs.

In addition to lumbar support, the role of overall seating configuration has been explored in biomechanical studies. Another study demonstrated that appropriate backrests and armrests reduce neck flexion angles, shoulder muscle activity, and overall physical strain during seated tasks (Straker, 2018). Their findings suggest that comprehensive ergonomic support systems can redistribute mechanical load across the musculoskeletal system, thereby improving comfort and reducing fatigue during prolonged sitting.

Beyond structural ergonomics, recent literature has begun to explore adjunct therapeutic interventions. Heat therapy, for instance, has been shown to provide significant relief from musculoskeletal discomfort by increasing blood flow, reducing muscle stiffness, and enhancing tissue flexibility (Nadler, 2004). Continuous low-level heat application has demonstrated superior outcomes in pain reduction compared to standard pharmacological interventions in certain cases. Despite its efficacy, integration of heat therapy into everyday ergonomic products remains limited.

More recent workplace health studies also emphasize the importance of combining passive ergonomic support with active or therapeutic elements. For example, studies on sedentary behaviour suggest that static

ergonomic solutions alone may not fully address the multifactorial nature of discomfort, which includes both biomechanical and physiological components (Waongenngarm, 2018). This indicates a need for hybrid solutions that simultaneously address posture and muscle relaxation.

Thus, the literature reveals a clear trend: while ergonomic backrests with lumbar support are essential for maintaining spinal alignment, they are insufficient in isolation. There exists a critical gap in integrating therapeutic modalities such as heat into ergonomic design. Addressing this gap could lead to more holistic solutions that enhance both structural support and physiological recovery, thereby improving comfort, reducing MSD risk, and promoting sustained productivity among desk workers.

III. AIM & OBJECTIVES

This study aims to explore how existing ergonomic backrest designs support posture during prolonged sitting and to develop an improved backrest model that combines effective lumbar support with integrated heat therapy to enhance comfort and reduce musculoskeletal discomfort. The specific objectives being, to: (i) understand how common back discomfort and posture-related issues are among individuals who spend long hours sitting at a desk; (ii) critically review and compare currently available ergonomic backrest solutions in terms of their design, functionality, and effectiveness; (iii) design an improved ergonomic backrest that not only supports the natural curvature of the spine but also incorporates a heating element to relieve muscle stiffness and fatigue; (iv) assess user expectations and preferences regarding features such as lumbar support, adjustability, and thermal comfort in backrest products.

IV. RESEARCH METHODOLOGY

This study adopts a mixed-methods experimental approach, combining both quantitative and qualitative techniques to develop a comprehensive understanding of back discomfort among desk workers and to inform the design of an improved ergonomic backrest. The intention was not only to measure discomfort objectively but also to understand how individuals experience it in their daily work environments and what they expect from a supportive seating solution.

160 desk-based workers were included in the study. Participants were selected using random sampling while ensuring they met predefined inclusion criteria. Individuals engaged in occupations that require prolonged sitting, typically more than 5–6 hours a day, were considered eligible. Additionally, participants who reported mild to moderate back discomfort during working hours were included, as they represent the primary target group for ergonomic interventions. On the other hand, individuals with a history of severe spinal injury, diagnosed postural disorders, or recent back or spinal surgery were excluded to avoid confounding clinical conditions that may influence the findings.

Ethical considerations were given due importance throughout the research process. All participants were informed about the purpose and scope of the study before data collection began. Informed consent was obtained, and participants were assured that their responses would remain confidential and used solely for academic purposes. Participation was entirely voluntary, and individuals were free to withdraw at any stage.

Data collection was carried out using multiple tools to ensure depth and reliability. A structured questionnaire was administered to gather quantitative data related to sitting duration, posture habits, perceived comfort levels, and the frequency and intensity of back pain during work hours. This provided a measurable overview of patterns and trends across the sample population. To complement this, semi-structured interviews were conducted with selected participants to gain qualitative insights into their personal experiences with prolonged sitting, challenges faced with existing seating arrangements, and expectations from ergonomic back support. These interactions added context to the numerical data and helped identify user-centric design requirements.

An additional standardized assessment tool, the Cornell Modified Discomfort Questionnaire (CMDQ), was used to evaluate the location and severity of musculoskeletal discomfort. The CMDQ enabled a more detailed mapping of discomfort across different body regions, with particular emphasis on the lumbar and lower back areas, which were found to be the most affected.

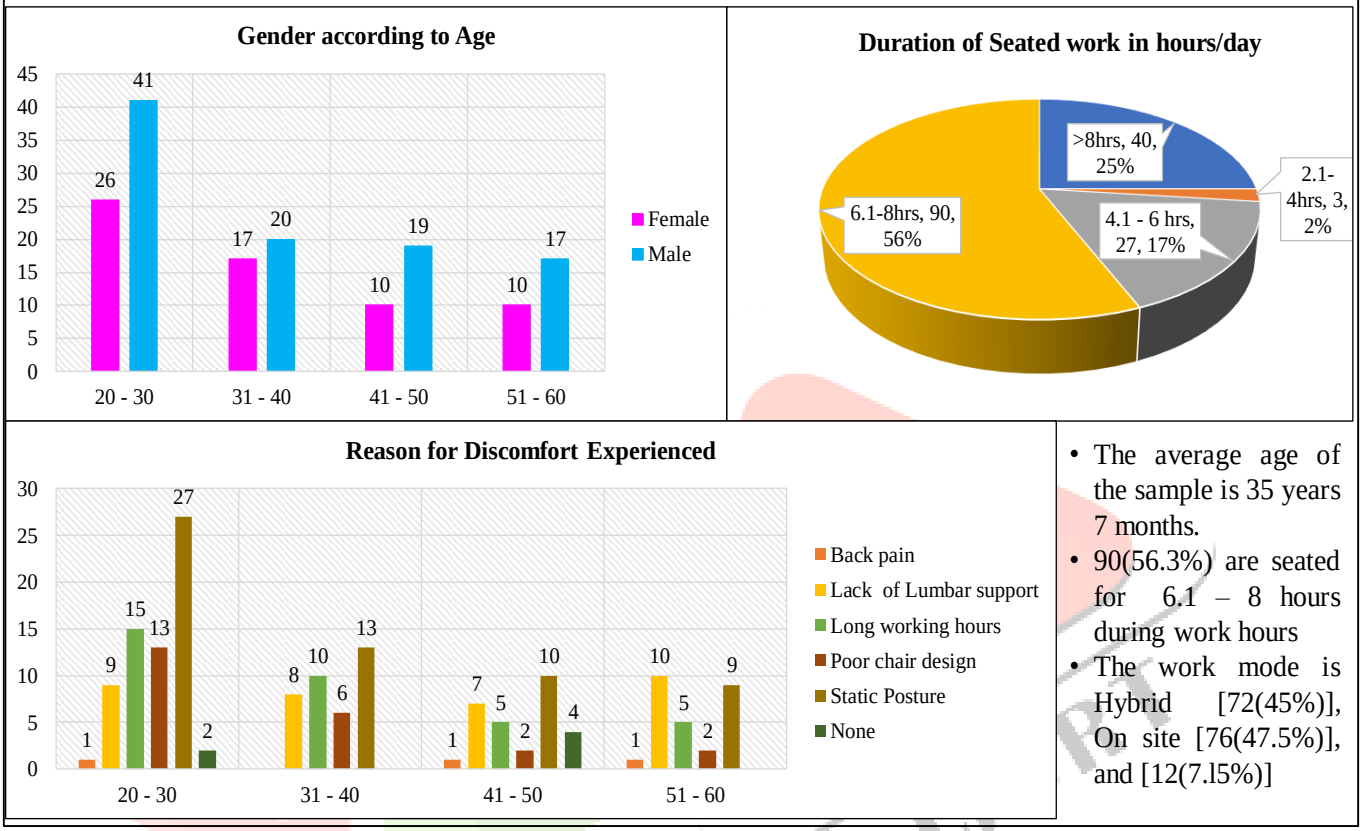
Following data collection, the quantitative data from questionnaires and CMDQ responses were analysed using descriptive statistics such as frequency distributions and percentages. Qualitative data from interviews were thematically analysed to identify recurring patterns and user needs. The combined analysis helped establish relationships between prolonged sitting, posture, and discomfort, and provided a strong evidence base for the design of the proposed ergonomic heated backrest.

V. RESULTS AND DISCUSSION

Demographic Profile: The demographic profile of the participants was analysed based on age, gender, occupation, work mode, and daily sitting duration to assess the suitability of the sample in relation to the aim and objectives of the study. 160 participants were included in the research, all of whom were primarily engaged in desk-based or sedentary occupations. The participants represented a diverse range of professions such as accountants, managers, office staff, graphic designers, students, and other individuals whose daily activities required prolonged sitting and screen-based work. This occupational diversity enhanced the representativeness of the sample while maintaining direct relevance to the study's focus on prolonged seated work and ergonomic intervention.

The age distribution revealed that the majority of respondents [67(41.9%)] belonged to the 20–30 years age group, followed by participants in the 31–40 years category. This demographic trend is particularly

Fig. 1: Demographic Profile



- The average age of the sample is 35 years 7 months.
- 90(56.3%) are seated for 6.1 – 8 hours during work hours
- The work mode is Hybrid [72(45%)], On site [76(47.5%)], and [12(7.l5%)]

significant because younger and middle-aged adults form a substantial portion of today's desk-working population. The findings suggest that musculoskeletal discomfort associated with prolonged sitting is increasingly becoming a lifestyle-related concern rather than an issue limited to older age groups. The dominance of younger adults within the sample highlights the growing early onset risk of posture-related problems and lower back discomfort due to prolonged sedentary work habits, poor sitting posture, and inadequate ergonomic support.

The sitting-duration data further validated the appropriateness of the sample for the present research. A majority of the participants [90(56.3%)] reported sitting continuously for approximately 6–8 hours per day, while several respondents indicated sitting durations extending beyond 8 hours. Such prolonged exposure to static seated posture directly aligns with the study objective of examining posture-related discomfort and evaluating the need for improved ergonomic support systems. Since the present study aims to design an ergonomic heated backrest intended for prolonged sitting conditions, selecting participants with high daily sitting exposure strengthened both the relevance and applicability of the findings.

The sample also included both male and female participants, allowing the research to capture a broader spectrum of user experiences, comfort expectations, and ergonomic needs. This diversity improves the generalisability of the findings and ensures that the proposed ergonomic backrest design addresses the requirements of varied user groups instead of focusing on a limited demographic segment.

Another important observation from the demographic profile was the prevalence of hybrid and office-based work modes among participants. The increasing adoption of remote and hybrid work culture has resulted

in greater dependence on non-standard seating arrangements at homes, co-working spaces, and temporary workstations. Many individuals may not have access to ergonomically designed furniture, thereby increasing the risk of poor posture, muscle fatigue, and lower back discomfort. This trend further reinforces the importance of developing accessible, adaptable, and user-friendly ergonomic support solutions.

The demographic characteristics of the sample thus strongly support the aim and objectives of the study. The participants represent a population highly exposed to prolonged sitting, posture-related strain, and musculoskeletal discomfort, making them an appropriate and relevant target group for evaluating ergonomic backrest requirements and user expectations regarding lumbar support, adjustability, comfort, and integrated thermal therapy features.

Common Back Discomfort and Posture-Related Issues due to Long Sitting Hours: The analysis of discomfort-related responses revealed that prolonged sitting was strongly associated with multiple posture-related and musculoskeletal concerns among the participants. The findings obtained from the graphs indicate that static posture was the most commonly reported reason for discomfort, accounting for 59(36.9%) responses. This was followed by long working hours 35(21.9%) and lack of lumbar support 34(21.3%). Other notable causes included poor chair design 23(14.4%), while only a very small number of participants reported experiencing no discomfort during prolonged sitting.

The graph representing discomfort reasons across different sitting durations demonstrated a clear relationship between the number of sitting hours and the severity or frequency of discomfort. Participants who reported sitting for 6–8 hours daily showed the highest levels of discomfort across almost all categories, particularly static posture and lack of lumbar support. Similarly, respondents sitting for more than 8 hours also reported considerable discomfort, especially related to long working hours and static seated positions. These findings suggest that the risk of musculoskeletal strain increases significantly with prolonged uninterrupted sitting duration.

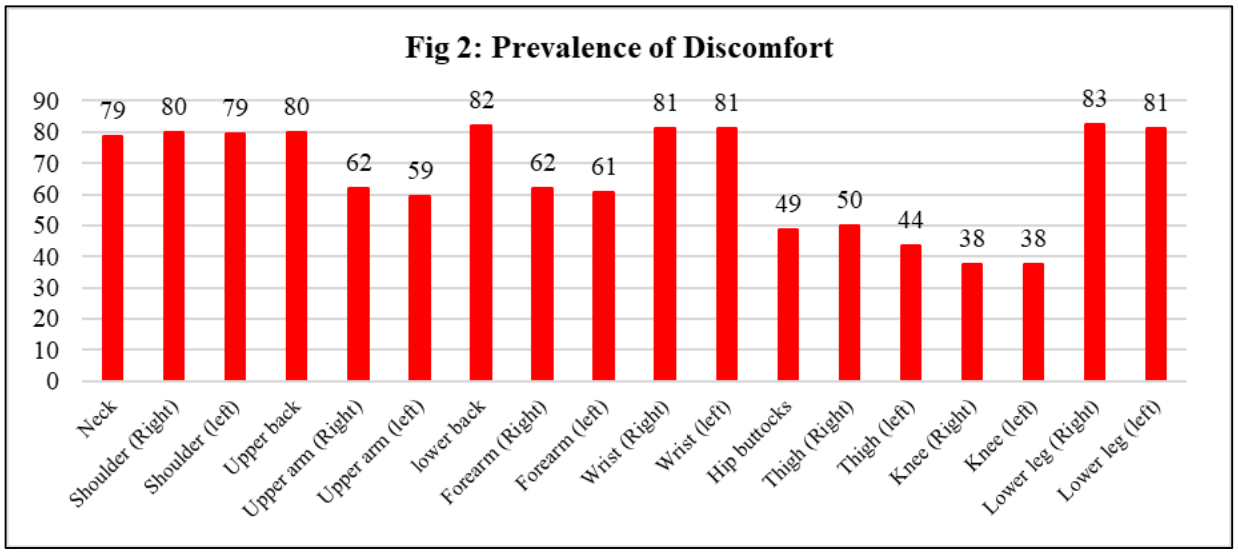
The gender-wise comparison of discomfort factors revealed that both male and female participants experienced posture-related issues, although the frequency was slightly higher among male respondents due to their larger representation within the sample. Static posture emerged as the most dominant issue for both genders, indicating that sustained seated positioning is a common ergonomic challenge irrespective of gender differences. Lack of lumbar support and long working hours were also consistently reported across both male and female participants, highlighting the widespread nature of these concerns in desk-based occupations.

The age-group analysis further provided important insights into the prevalence of discomfort among different demographic categories. Participants within the 20–30 years age group reported the highest levels of discomfort related to static posture, long working hours, and poor chair design. This trend is particularly significant because it indicates that posture-related discomfort is increasingly affecting younger adults at an early stage of their academic and professional lives. The findings challenge the traditional assumption that back discomfort is primarily associated with ageing and instead suggest that prolonged sedentary work habits and poor ergonomic conditions are major contributing factors.

Interestingly, discomfort associated with lack of lumbar support remained consistently high across all age groups, including participants aged 31–40, 41–50, and 51–60 years. This indicates that inadequate spinal support is a universal ergonomic issue that affects users regardless of age. Older participants, however, demonstrated relatively greater sensitivity to lumbar support deficiencies and prolonged sitting durations, possibly due to reduced musculoskeletal resilience with advancing age.

Fig 2, results of the discomfort questionnaire illustrates the prevalence of discomfort experienced by participants across different body regions during prolonged sitting and desk-based work. The findings indicate that discomfort was most commonly reported in the lower back [82(51.3%)], followed closely by the lower left leg [81(50.6%)], wrist (right) [81(50.6%)], and hip (left) [81(50.6%)]. High levels of discomfort were also observed in the shoulders [80(50%)], upper back [80(50%)], and neck region [79(49.4%)].

Moderate discomfort was reported in the upper arms [62(38.8%) and 59(36.9%)], forearms [62(38.8%) and 61(38.1%)], and thighs approximately 31%). Comparatively lower discomfort levels were observed in the knees [f = 44, 27.5% and f = 38, 23.8%] and feet [38(23.8%)].



The results clearly indicate that prolonged sitting predominantly affects the spinal and upper body regions, particularly the lower back, shoulders, neck, and upper limbs. This pattern suggests that static seated posture, repetitive desk-based movements, and inadequate lumbar support contribute significantly to muscular fatigue and postural strain. The high prevalence of lower back discomfort strongly supports the need for improved ergonomic interventions focusing on spinal alignment and lumbar support.

Additionally, the substantial discomfort reported in the wrists, shoulders, and upper back highlights the interconnected nature of poor sitting posture and workstation ergonomics. These findings suggest that prolonged sitting does not affect only a single body region but produces cumulative musculoskeletal stress across multiple areas of the body.

The findings clearly establish that prolonged sitting, static posture, poor chair design, and inadequate lumbar support are the major contributors to back discomfort among desk workers. The results strongly support the need for ergonomic interventions that not only improve posture alignment but also reduce muscle fatigue and discomfort during extended sitting hours. These observations directly align with the objective of designing an improved ergonomic heated backrest that combines structural support with enhanced comfort and therapeutic relief.

Backrest currently used: The findings of the study revealed varying levels of satisfaction among participants regarding currently available ergonomic backrest and chair solutions. Although a considerable number of respondents reported using chairs with basic ergonomic features, the majority indicated that these features were insufficient in effectively preventing discomfort during prolonged sitting. Participants commonly reported that existing backrests provided only partial support and often failed to maintain comfort during extended work hours.

One of the most significant concerns identified through the data was the lack of adjustability and personalisation in existing ergonomic backrest designs. A large proportion of participants expressed preference for adjustable backrests over fixed designs, indicating the importance of flexibility in accommodating different body types, sitting habits, and working postures. Users highlighted that many commercially available backrests offer generic lumbar contours that may not align properly with individual spinal curvature, thereby reducing their effectiveness over long durations of use.

Another major issue reported was inadequate lumbar support. Participants experiencing prolonged sitting discomfort frequently associated their pain with poor lumbar alignment and insufficient lower back support. The discomfort was especially evident among individuals sitting for 6–8 hours or longer per day. Several respondents also indicated that existing chairs tend to lose support quality over time due to poor cushioning materials or rigid design structures.

The study further identified a noticeable gap in the availability and awareness of advanced therapeutic ergonomic features. Although some participants had heard of heated or massage-enabled backrests, overall awareness and usage of such features remained relatively limited. At the same time, many respondents showed interest in the idea of controlled heating functions integrated into ergonomic backrests, particularly for relieving stiffness and fatigue during long sitting hours. This indicates an emerging user demand for ergonomic products that provide not only structural support but also physiological comfort.

Material preference data from the study revealed that memory foam was the most preferred cushioning material among participants due to its perceived comfort, pressure distribution, and adaptability to body contours. Participants also expressed preference for additional features such as breathable fabric, washable covers, portability, and adjustable temperature settings.

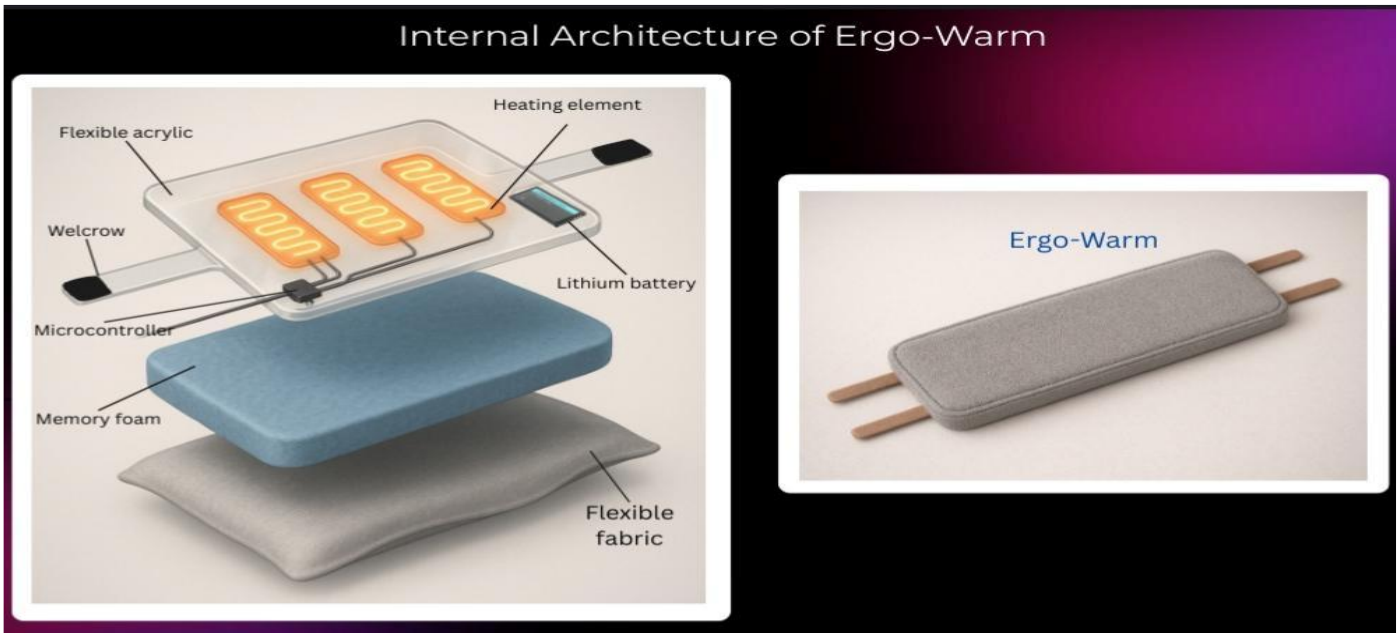
The findings suggest that existing ergonomic backrest solutions primarily focus on posture correction at a structural level while largely neglecting muscle relaxation and thermal comfort. As a result, users may achieve temporary postural support but continue to experience fatigue, stiffness, and discomfort during prolonged sitting. These findings strongly support the need for integrated ergonomic solutions such as the proposed "ErgoWarm" backrest, which combines lumbar support with thermal therapy to provide a more holistic sitting experience.

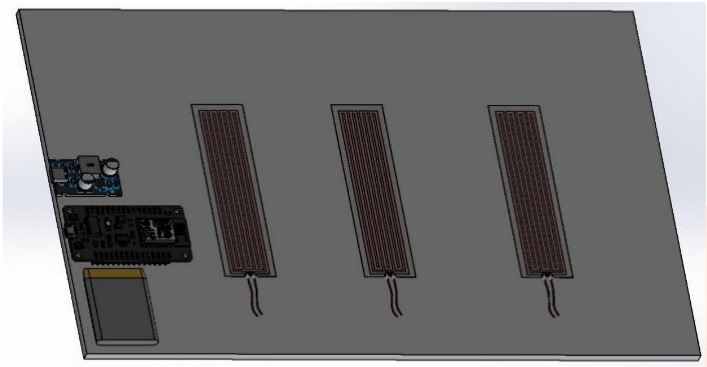
VI. DESIGN SUGGESTION, RECOMMENDATIONS, USERS EXPECTATIONS AND PREFERENCE FOR ERGONOMIC BACKREST

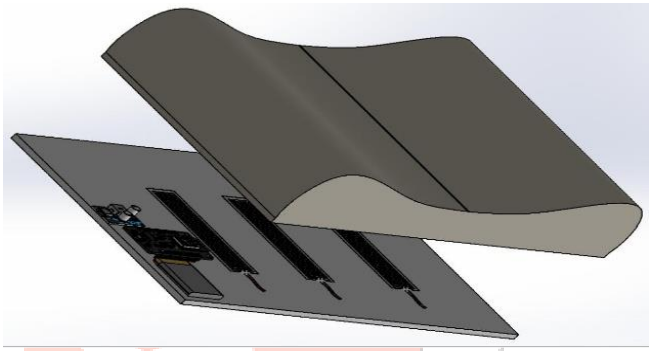
The findings of the study highlighted several important user expectations regarding the design and functionality of ergonomic backrests for prolonged sitting. Participants consistently emphasized the need for improved lumbar contouring, adjustable support systems, comfort-oriented materials, and lightweight portable designs. A large proportion of respondents expressed dissatisfaction with conventional seating arrangements, particularly due to inadequate lower back support and prolonged static posture during work. These responses indicate that users are seeking ergonomic solutions that provide both structural support and long-term sitting comfort.

The analysis of user preferences revealed that memory foam emerged as the most preferred material for backrest construction. Participants associated memory foam with improved pressure distribution, cushioning, and enhanced comfort during long working hours. Mesh and breathable materials were also preferred by several respondents due to their ventilation properties and ability to reduce heat accumulation during prolonged use. These findings suggest that material selection plays an equally important role as structural design in determining user comfort and satisfaction.

Another major observation from the study was the strong preference for adjustable backrests over fixed designs. Most participants indicated that adjustable lumbar support and customizable contouring were essential for maintaining proper posture and accommodating different body dimensions. This demonstrates that users no longer view ergonomic support as a one-size-fits-all solution but expect products to adapt according to individual comfort and posture needs.







The study also identified growing interest in therapeutic comfort features, particularly integrated heating systems. Many respondents expressed willingness to use a backrest with gentle and controlled heating to reduce stiffness, fatigue, and muscular discomfort caused by prolonged sitting. Safety-related features such as adjustable temperature settings, auto shut-off mechanisms, washable covers, and portable power options were also viewed positively by users.

From a discussion perspective, the findings indicate a shift from purely product-centric ergonomic designs toward more user-centric and multifunctional solutions. Participants were not simply demanding additional features but were seeking meaningful features that directly address discomfort and improve sitting experience. The results strongly support the integration of ergonomics with therapeutic interventions such as heat therapy. Furthermore, participants showed a favourable attitude toward adopting such products if they were reasonably priced and practically designed for daily use. These findings provide strong justification for the development of the proposed ergonomic heated backrest model, “Ergo-Warm,” which aims to combine posture correction, comfort enhancement, and therapeutic relief within a single integrated design.

Ergo Warm, is an evidence-based ergonomic backrest designed with anatomically contoured, adjustable lumbar support, dynamic flexibility, and integrated thermal comfort to reduce postural strain, enhance musculoskeletal health, and improve everyday sitting comfort during prolonged desk work.
The specifications of the product are:

- The heating pad runs on a rechargeable 3.7V battery, similar to a power bank lasts 3-4hrs.
- When switched on, the battery powers the internal heating plates, making them warm.
- An ESP32 chip works as the “brain,” controlling how the heating functions.
- It follows a 10-second ON and 5-second OFF cycle to save battery and maintain comfort.
- A temperature sensor continuously monitors the heat level.
- If the pad gets hotter than the safe limit, the system automatically shuts off the heaters.
- All components are covered with soft memory foam and stitched fabric for smooth, even warmth.
- The battery supplies power the heaters generate warmth and theESP32 ensures safety, Comfort, and proper functioning.

VII. SCOPE OF THE STUDY

The present study focuses on the conceptual development and evaluation of an ergonomic heated backrest cushion designed to improve postural support and enhance comfort among individuals engaged in prolonged sitting activities. The scope of the research includes understanding posture-related discomfort, analysing user needs, and developing a design solution that combines ergonomic lumbar support with integrated thermal therapy. The proposed design primarily aims to support the natural curvature of the spine, particularly the lumbar region, which is highly vulnerable to strain and discomfort during extended desk work and sedentary activities.

The study further examines important aspects such as ergonomic form, material selection, adjustability, user comfort, and the incorporation of a safe and controlled heating mechanism intended to reduce muscle stiffness and fatigue. Attention is also given to user expectations regarding portability, cushioning materials, and practical usability in modern work environments including offices, home workstations, and study settings.

The scope of the study extends beyond product design by addressing the growing health concerns associated with sedentary lifestyles and poor workplace ergonomics. With increasing dependence on desk-based work and hybrid working patterns, the study highlights the importance of preventive ergonomic solutions that can improve comfort, reduce musculoskeletal stress, and support overall well-being.

Although the research is limited to the conceptual design and user-based evaluation of the product, the findings may serve as a foundation for future studies involving prototype development, biomechanical testing, thermal performance assessment, and large-scale ergonomic product innovation.

VIII. LIMITATIONS OF THE STUDY

The present study is limited to the conceptual design and evaluation of an ergonomic heated backrest and does not include the development or testing of a functional physical prototype. As a result, the actual performance, durability, thermal efficiency, and long-term ergonomic effectiveness of the proposed design could not be experimentally validated. The study primarily focuses on the backrest component and does not examine the ergonomics of the complete seating system, including seat height, armrests, and workstation setup, which may also influence posture and comfort. In addition, the findings are based largely on self-reported responses, which may involve subjective bias. The study was also limited to a specific sample population of desk workers and may not fully represent all occupational groups or users with severe musculoskeletal disorders.

IX. AUTHOR STATEMENTS

- The author expresses sincere gratitude to the college and all participants for their valuable cooperation and support throughout the study. Their responses and insights significantly contributed to understanding user needs and developing the conceptual ergonomic heated backrest design.
- Ethical considerations were maintained throughout the research process. Informed consent was obtained from all participants prior to data collection, and they were informed about the purpose of the study.
- Participant confidentiality and privacy were strictly maintained, and all collected information was used solely for academic purposes.
- The study did not receive any external funding or financial assistance and was conducted independently as part of academic research. The author further declares that there are no conflicts of interest related to this study.

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