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Evaluation of Office Chairs to Enhance Comfort and Reduce Musculoskeletal Risk in Sedentary Work Environments

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ABSTRACT

This study evaluates the effectiveness of an ergonomically redesigned office chair, tailored to accommodate the anthropometric measurements of employees. The research addresses common issues associated with prolonged sitting, including musculoskeletal discomfort and fatigue, which are prevalent in sedentary work environments. The redesigned chair incorporates key dimensional modifications—such as seat height, seat depth, and backrest height—based on anthropometric data from prior studies. To assess the ergonomic impact, the Rapid Office Strain Assessment (ROSA) tool was used to evaluate postural alignment and ergonomic risk for both the original and redesigned chairs. The results indicate a statistically significant reduction in ergonomic strain, with the average ROSA score decreasing from 7.03 (old model) to 5.19 (new model), representing a 1.84-point improvement. A paired sample t-test further confirmed this enhancement, yielding a T-value of -9.98 and a P-value of 0.000, demonstrating that the new design significantly help reduces musculoskeletal risk. These findings highlight the critical role of ergonomic interventions in workplace furniture design, emphasizing the need for adaptability to diverse body types to mitigate occupational health risks associated with prolonged sitting.

Keywords: Anthropometry, ROSA (Rapid Office Strain Assessment), ergonomic design, musculoskeletal disorders, office furniture

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ABSTRAK

Penelitian ini mengevaluasi efektivitas kursi kantor yang telah didesain ulang secara ergonomis untuk menyesuaikan dengan data antropometri pegawai. Studi ini berfokus pada permasalahan umum akibat duduk dalam waktu lama, seperti ketidaknyamanan muskuloskeletal dan kelelahan, yang sering terjadi di lingkungan kerja sedentary. Kursi yang didesain ulang mengadopsi perubahan dimensi utama—tinggi dudukan, kedalaman dudukan, dan tinggi sandaran—berdasarkan data antropometri dari penelitian sebelumnya. Untuk menilai dampak ergonomisnya, dilakukan Rapid Office Strain Assessment (ROSA) guna mengevaluasi postur dan risiko ergonomi pada kursi lama dan baru. Hasil penelitian menunjukkan adanya penurunan signifikan dalam tingkat tekanan fisik, dengan skor ROSA rata-rata turun dari 7,03 (kursi lama) menjadi 5,19 (kursi baru), mencerminkan peningkatan sebesar 1,84 poin. Uji paired sample t-test lebih lanjut mengonfirmasi hasil ini, dengan T-value sebesar -9,98 dan P-value sebesar 0,000, yang menunjukkan bahwa desain baru secara signifikan dapat membantu mengurangi risiko muskuloskeletal. Temuan ini menegaskan pentingnya intervensi ergonomis dalam desain furnitur kantor, terutama dalam menyesuaikan kursi kerja dengan beragam jenis tubuh untuk mengurangi risiko kesehatan akibat duduk berkepanjangan.

Kata kunci: Anthropometri, ROSA (Rapid Office Strain Assessment), desain ergonomis, musculoskeletal disorders, furnitur kantor

INTRODUCTION

In modern work environments, prolonged sitting and inadequate seating design have been widely recognized as key contributors to physical discomfort and musculoskeletal disorders (MSDs). Office employees, particularly those in sedentary roles, frequently experience fatigue, lower back pain, neck strain, and muscle stiffness—symptoms that not only affect personal well-being but also decrease productivity and job satisfaction. Studies by Kautsar and Dewi [1] highlight that poorly designed office chairs exacerbate postural misalignment, restrict circulation, and increase the risk of long-term health issues. Improper support in seating often compels employees to adopt static or awkward postures, leading to chronic muscle strain, ergonomic stress, and even workplace injuries [2]. Given that MSDs are now one of the leading occupational health concerns worldwide, the need for ergonomically optimized office furniture has become increasingly urgent.

Despite the existence of ergonomic guidelines, research suggests that furniture design must be tailored to specific user demographics rather than relying on generic industry standards. Bai et al. [2] conducted a systematic review of ergonomic seating studies across multiple countries, demonstrating how anthropometric variations influence chair effectiveness. Their findings emphasize that while anthropometric measurements provide objective insights, subjective user feedback remains equally essential for evaluating long-term comfort and usability. Similarly, Cetin et al. [3] explored workplace seating satisfaction in Turkey, revealing that gender, body weight, and sitting duration significantly affect user comfort, reinforcing the necessity of customizable seating solutions to accommodate a diverse workforce.

At Politeknik Industri Furnitur dan Pengolahan Kayu Kendal, employees spend 5 to 7 hours per day seated, underscoring the critical role of ergonomic support in preventing musculoskeletal strain. Observations and preliminary user feedback indicate that the existing chairs, while generally aligned with ergonomic standards, fail to meet the anthropometric needs of many employees. Common discomforts include improper seat height, excessive seat depth, and inadequate lumbar support, which can force users into unnatural postures and increase muscle fatigue. Similar findings by Arora and Khatri [4] demonstrate that adjustable seating features—such as seat height modification and backrest customization—lead to significantly improved ergonomic outcomes.

To address these concerns, this study evaluates the ergonomic suitability of the existing office chairs at Politeknik Industri Furnitur dan Pengolahan Kayu Kendal and examines the impact of a redesigned chair based on workforce-specific anthropometric data. By utilizing quantitative and qualitative methods, including Rapid Office Strain Assessment (ROSA), user questionnaires, and structured interviews, the research aims to determine the extent of ergonomic mismatch between the current office chairs and employee anthropometry. We also want to assess whether a redesigned chair incorporating precise anthropometric measurements improves user comfort and postural alignment. And at the end, we hope that this study could measure reductions in ergonomic risk and musculoskeletal strain following the implementation of the redesigned chair.

By integrating scientifically validated ergonomic principles with user-centered design, this study seeks to contribute to workplace furniture innovations that enhance employee well-being, reduce MSD risk, and improve overall work efficiency.

METHODS

This study employed a multi-step approach to evaluate the comfort and ergonomic suitability of a redesigned employee chair, specifically tailored using previously collected anthropometric data from the target employee population. The study involved the following three key stages:

Redesign of the Employee Chair Using Anthropometric Data

The first phase of this study focused on evaluating and modifying the existing employee chair, which was originally adapted from a garden chair (kursi santai) design. While this chair was repurposed for office use, it was never intended for prolonged working hours, resulting in postural discomfort and ergonomic inefficiencies. Employees were required to work using a chair that prioritized aesthetics and relaxation over functional support, leading to poor lumbar support, improper seat height, and inadequate backrest alignment. Recognizing these issues, we initiated a dimension-focused redesign to determine whether modifying the chair's fundamental

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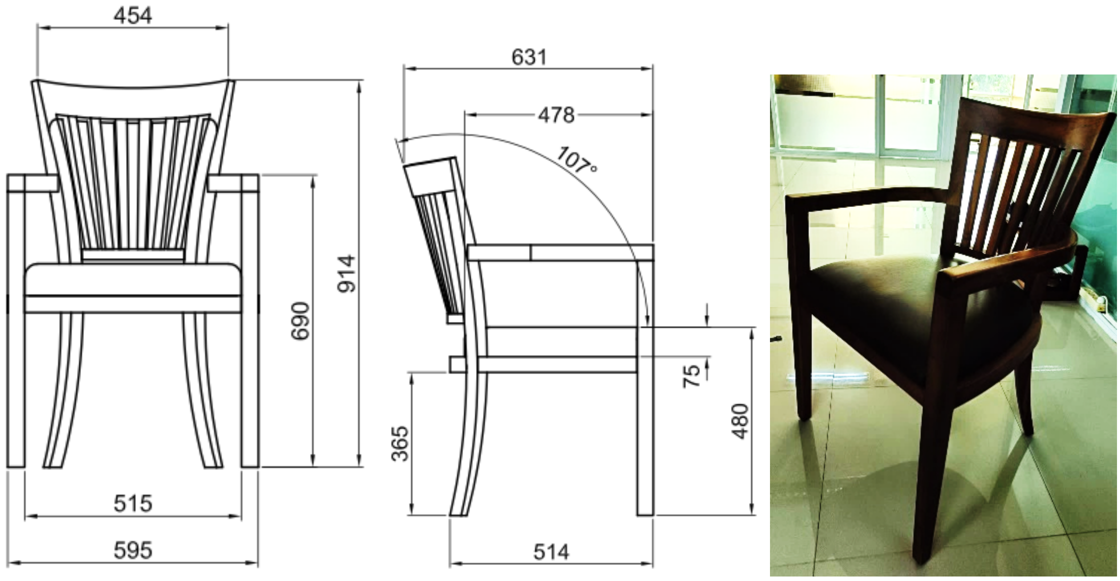
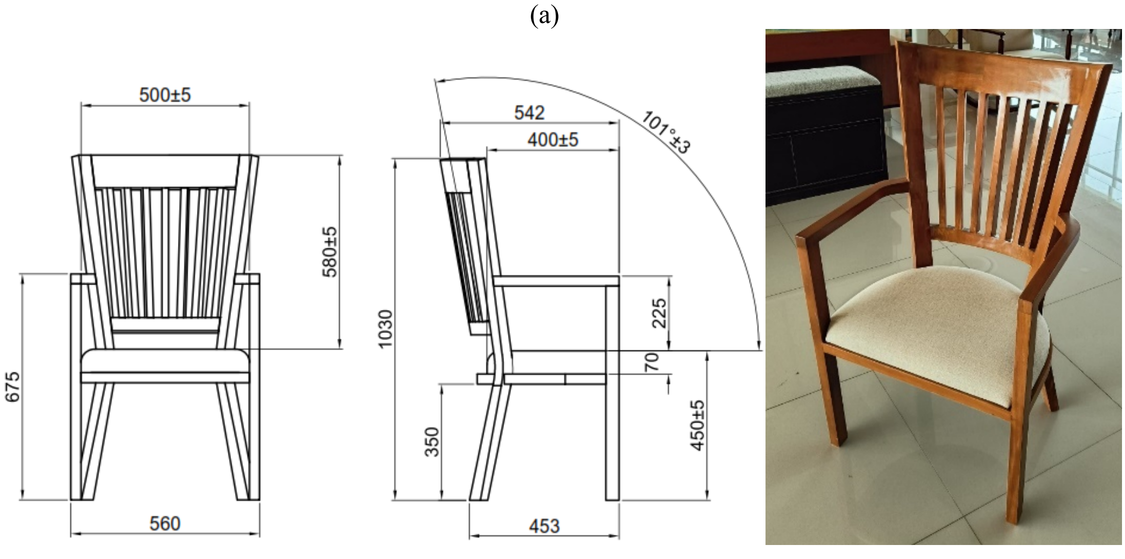
measurements—seat height, seat depth, and backrest height—could enhance comfort and accommodate employees' physical profiles more effectively.

Unlike traditional ergonomic chairs that incorporate adjustable mechanisms or additional support features, our redesign intentionally retained a fixed structure to isolate the impact of dimension changes alone on user comfort and posture. This approach aligns with established ergonomic research, which emphasizes that an appropriately scaled chair can significantly reduce discomfort, even without advanced adjustability features [2],[3]. By modifying the chair's dimensions while maintaining its core structure, this study sought to determine whether a simple dimensional adjustment would be sufficient to meet ergonomic needs or whether a more comprehensive design overhaul would be necessary. The redesigned chair is illustrated in Figure 1.



(a)



(b)

Figure 1. Chair design images (a) existing employee chairs (b) employee chairs after redesign

Source : Private Documentation, 2024

The development of the redesigned chair is based on anthropometric measurements collected from our workforce in a prior study, which aimed to ensure a better fit between employee body dimensions and seating ergonomics. Previous research has emphasized the importance of aligning furniture design with user-specific measurements to minimize discomfort and musculoskeletal strain [5]. Studies have shown that a mismatch between furniture dimensions and user anthropometry can lead to poor posture, increased muscle fatigue, and long-term health risks [6],[7].

Our prior study, although not yet published, systematically measured key anthropometric parameters such as seat height, seat depth, backrest height, and armrest positioning, ensuring that the new chair dimensions directly reflect the physical characteristics of our employees. Similar methodologies have been employed in other ergonomic furniture research, where anthropometric data serves as a basis for improving workplace seating comfort [8]. By applying these principles, the redesigned chair incorporates scientifically backed modifications that address the ergonomic deficiencies of the previous model, aiming to enhance user comfort, support proper posture, and reduce musculoskeletal strain over prolonged sitting durations.

The redesigned chair incorporates several dimensional changes aimed at enhancing user comfort and ergonomic support, based on anthropometric data. Each dimension was specifically chosen to address the physical requirements of employees, helping reduce strain and improve posture during long working hours. Details of the changes made are presented in Table 1.

Table 1. Modifications to the new employee chair

Component	Existing	Re-design	Justification
Seat width	515 mm	500 ±5 mm	Based on hip width measurements, which vary between individuals
Chair height	690 mm	675 mm	Based on popliteal height measurements, i.e. the distance from the floor to the bottom of the knee when sitting
Backrest height	590 mm	580.5 mm	Based on the measurement of shoulder height when sitting and lumbar height
Backrest angle	107°	101°	Based on the angle of the torso when sitting, which varies based on the user's preferences and comfort
Seat depth	478 mm	453 mm	Based on the measurement of thigh length, specifically the distance from behind the knee to the back of the buttocks
Armrest height	690 mm	675 mm	Based on elbow height measurements while sitting
Chair width	595 mm	560 mm	Based on shoulder and hip width measurements
Seat height	480 mm	450 mm	Based on popliteal height measurement

These dimensional changes improve the overall ergonomic performance of the chair by adapting to the users' body dimensions, offering increased comfort and support. By focusing on specific measurements, such as popliteal height for seat height and shoulder height for backrest, we ensure that each chair component meets a functional purpose in reducing strain and promoting healthy posture for prolonged use.

Posture Assessment Using Rapid Office Strain Assessment (ROSA)

The data collection process involved polytechnic employees who typically work 5 to 7 hours per day using the existing office chairs. The primary objective was to gather comprehensive feedback on the comfort and effectiveness of the chairs in a real work environment.

The study began with direct observation of employees while they were seated in their current chairs. This allowed the research team to identify visible signs of discomfort, poor posture, and other ergonomic issues related to the chair's design. These observations provided valuable insights into the user experience, highlighting specific areas where the existing chair failed to meet ergonomic standards.

The chair evaluation was conducted by requiring employees to use both the existing and redesigned chairs. Body posture and ergonomic suitability were assessed using the Rapid Office Strain Assessment (ROSA) method, a testing form designed to measure physical strain levels and potential musculoskeletal risks associated with office seating.

The Rapid Office Strain Assessment (ROSA) method was selected for this study due to its well-documented reliability and effectiveness in evaluating ergonomic risks in office environments. ROSA is a validated observational tool specifically designed to assess postural strain and musculoskeletal risk factors associated with prolonged sitting in workplace settings. It provides a structured approach to identifying ergonomic deficiencies by systematically scoring key components of office seating and workstation design, including seat dimensions, lumbar support, armrests, and workstation height [9].

One of the key advantages of ROSA is its ability to quantify ergonomic risk levels based on standardized scoring criteria. The tool assigns a risk score between 1 and 10, where higher scores indicate an increased likelihood of musculoskeletal strain and discomfort. Research has shown that ROSA effectively correlates with discomfort reports among office workers, making it a suitable method for assessing the ergonomic impact of different chair designs [10]. By using ROSA, this study aims to obtain an objective measurement of ergonomic risk, reducing the reliance on purely subjective feedback, which can sometimes be inconsistent.

ROSA scores range from 1 to 10, where higher scores indicate greater ergonomic risk and strain. Evaluators observed and recorded employees' seated postures based on various components, including back and neck alignment, lumbar support, seat height, and overall postural stability. The ROSA assessment was selected due to its effectiveness in identifying musculoskeletal strain and its proven reliability in office work environments [4].

To calculate ROSA scores, observational data were combined with employee feedback to generate a composite score for each participant. This score provided a quantitative measure of the strain experienced while using both the existing and redesigned chairs. The ROSA scores were then analyzed to determine whether the new chair design resulted in a statistically significant reduction in physical strain compared to the previous model.

To evaluate the effectiveness of the new chair design in reducing ergonomic risk, we conducted a paired-sample t-test to compare ROSA scores between the existing and redesigned chairs. The paired-sample t-test was used to quantitatively assess the relationship between employees' physical characteristics and their satisfaction with the new chair. This method was chosen because it is suitable for evaluating whether there is a statistically significant difference in mean ROSA scores for each respondent before and after using the redesigned chair [9],[11],[12].

RESULT AND DISCUSSION

In this study, we examined the ergonomic improvements in a redesigned office chair, using demographic data and ROSA (Rapid Office Strain Assessment) scores to assess the impact on user comfort and safety. By analyzing the demographic characteristics of our participants, and applying ROSA to evaluate ergonomic risk, we aimed to determine how well the redesigned chair accommodates diverse physical requirements and mitigates the risk of musculoskeletal strain.

Demographic Analysis of Respondents

The demographic analysis of respondents provides a clear picture of the physical diversity among users and helps establish the requirements for the chair’s ergonomic design. The data collected includes gender, age, height, weight, and BMI categories of each respondent. Among the 32 respondents, 60% were women and 40% were men, illustrating a fairly balanced user base. The age range spanned from 17 to 61 years, encompassing permanent employees, contract employees, and interns. Each respondent typically spends 5 to 7 hours seated per day, a duration that significantly heightens the risk of discomfort and musculoskeletal strain if their posture is not properly supported by ergonomic features [10].

To assess the impact of chair design on user comfort and posture, we asked each participant to uniformly test both the existing and redesigned chairs for a minimum of 30 minutes per session. This controlled trial period allowed respondents to experience the chair’s support and ergonomics firsthand, while also providing the research team with sufficient time to observe their seated posture, spinal alignment, and overall comfort levels. Through this approach, we aimed to capture both objective ergonomic assessments and subjective user feedback, ensuring a comprehensive evaluation of the redesign’s effectiveness.

Respondents’ heights ranged from 155 cm to 185 cm, with an average height of 170 cm, and weights ranged from 40 kg to 100 kg, averaging 64.5 kg. BMI data revealed that 13% of respondents were underweight, 38% were of normal weight, 34% were overweight, and 15% were obese. The distribution of body types reinforces the need for a flexible chair design that supports a broad range of body sizes and shapes, thus reducing strain for all users [13]. This demographic information is crucial in assessing the chair's capability to accommodate a diverse workforce and reduce ergonomic risk, as variations in body dimensions impact the need for adjustable features to support proper sitting posture [12].

ROSA (Rapid Office Strain Assessment) Analysis

The ROSA analysis is a standardized tool used to evaluate ergonomic risks associated with prolonged office seating, focusing on aspects such as armrest and back support, seat pan height and depth, and peripheral usage like monitors and keyboards. Higher ROSA scores indicate greater ergonomic risk. In this study, we applied ROSA to both the existing and new chair designs to measure improvements in ergonomics.

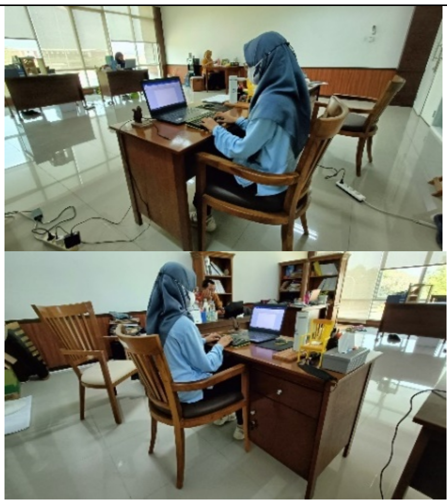
The ROSA scores indicated a significant improvement with the new chair design, as shown in Table 2. Most users experienced a decrease in ROSA scores, reflecting reduced risk of musculoskeletal strain and discomfort associated with prolonged sitting. For some users, the improvement was as substantial as a 4-point reduction, suggesting that the redesigned chair better supports a healthy seated posture. This positive change demonstrates the effectiveness of the new design in addressing ergonomic issues, as lower ROSA scores correlate with reduced strain and a lower likelihood of injury [10].

To statistically validate the ergonomic benefits of the new chair, we conducted a hypothesis test using Minitab software. The paired t-test, chosen due to the pre- and post-intervention data for the same group of respondents, tested whether there was a statistically significant difference in ROSA scores between the existing and new chair designs. The calculation result is shown at Table 3.

The hypothesis test yielded the following results:

- Null Hypothesis (H_0): The redesigned chair does not result in a significant reduction in MSD risk, as indicated by the mean ROSA scores remaining statistically unchanged between the old and new chair models ($\mu_1 - \mu_2 = 0$).
- Alternative Hypothesis (H_1): The redesigned chair (Kursi X) leads to a significant reduction in MSD risk, as indicated by a statistically significant decrease in mean ROSA scores between the old and new chair models ($\mu_1 - \mu_2 \neq 0$).

Table 2. Calculating ROSA Score (Existing Model vs New Model)

Section	Existing Model – Employee Chair	New Model – Employee Chair
Respondent X Height = 150 cm Weight = 40 kg		
Chair Height	No. Foot contact on ground (3) Non – adjustable (+1)	Kness at 90° (1) Non – adjustable (+1)
Pan Depth	Too Long – less than 3” (2) Non – Adjustable (+1)	Approximately 3”of space between knees and edge of seat (1) Non – adjustable (+1)
Armrests	Elbows Supported in line with shoulder, shoulders relaxed (1) Hard/damaged surface (+1) Non – Adjustable (+1)	Elbows Supported in line with shoulder, shoulders relaxed (1) Hard/damaged surface (+1) Non – Adjustable (+1))
Back Support	No back support (2) Back rest non – adjustable (+1) Duration > 4 hours (+1)	Adequate lumbar support, chair reclained between 95°-110° (1) Back rest non – adjustable (+1) Duration > 4 hours (+1)

Section	Existing Model – Employee Chair	New Model – Employee Chair
Score Section A	**8**	**5**
Monitor	Screen is not at eye level < 30° (2)	Screen at eye level (1)
	Documents – No. holder (+1)	Documents – No. holder (+1)
	Duration < 4 hours (+0)	Duration < 4 hours (+0)
Telephone	One hand on phone (1)	One hand on phone (1)
	Duration < 1 hour (-1)	Duration < 1 hour (-1)
Score Section B	**1**	**1**
Mouse	Mouse in line with shoulder (1)	Mouse in line with shoulder (1)
	Duration < 4 hours (+0)	Duration < 4 hours (+0)
Keyboard	Wrists traight, shoulders relaxed (1)	Wrists traight, shoulders relaxed (1)
	Duration < 4 hours (+0)	Duration < 4 hours (+0)
Score Section C	**1**	**1**
Score ROSA	**8**	**5**

Table 3. Two-Sample T-Test

Descriptive Statistics

Sample	N	Mean	StDev	SE Mean
Final Score	32	5.188	0.471	0.083
Final Score Before Redesign	32	7.031	0.933	0.16

Test

Null hypothesis	H_0: $\mu_1 - \mu_2 = 0$
Alternative hypothesis	H_1: $\mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-9.98	45	0.000

The statistical analysis using a paired-sample t-test yielded a T-Value of -9.98 and a P-Value of 0.000, indicating a statistically significant reduction in ROSA scores after the implementation of the redesigned chair. Given that the p-value is below the standard significance level of 0.05, we reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1), confirming that the new chair design significantly lowers ergonomic risks compared to the previous model.

The results of the paired sample t-test indicate a significant reduction in ROSA scores after the implementation of the redesigned chair. The mean ROSA score for the old chair was 7.03, while the new chair showed an average score of 5.19, resulting in a mean difference of 1.84 points. The standard deviation of the differences was 1.02, and the 95% confidence interval (CI) for the mean difference ranged from 1.48 to 2.21.

These findings provide strong statistical evidence that the redesigned chair improves ergonomic support and reduces the risk of musculoskeletal disorders. By optimizing key ergonomic factors—such as back support, seat height, and seat depth—the redesign aligns better with the anthropometric needs of employees, ensuring a more supportive and comfortable seating experience. The application of ROSA as an evaluation tool highlights the importance of objective ergonomic assessments in workplace furniture design, ensuring adaptability for diverse user populations while minimizing health risks associated with prolonged sitting.

CONCLUSIONS

The findings of this study demonstrate that the redesigned employee chair successfully improves user comfort by incorporating anthropometric measurements specific to the workforce. Key modifications, including adjustments to seat height, seat width, seat depth, and backrest dimensions, have resulted in a more ergonomic and user-friendly design. Additionally, the new model features a lighter structure, enhancing mobility without compromising durability. This reduction in weight is particularly beneficial in minimizing physical strain when employees need to reposition or move the chair, thereby improving overall usability.

Testing conducted with 32 respondents confirmed the effectiveness of the redesign, as most participants reported improved comfort and support. The ROSA (Rapid Office Strain Assessment) scores showed a statistically significant reduction in ergonomic risk, with the new chair model achieving an average ROSA score of 5.19, compared to 7.03 for the old model. This 1.84-point reduction indicates that the redesigned chair effectively minimizes postural strain and musculoskeletal stress, reducing the likelihood of long-term injury associated with prolonged sitting. The paired sample t-test further validated this improvement, with a T-value of -9.98 and a P-value of 0.000, confirming that the difference is statistically significant.

However, while modifying chair dimensions plays a crucial role in improving comfort, this study highlights that dimensional adjustments alone are not sufficient to meet the diverse ergonomic needs of users. Comfort and posture support are also influenced by structural and functional design elements, such as seat tilt, backrest shape, and lumbar support. Future research should explore incorporating adjustable features, including a flexible backrest, adjustable seat height, and enhanced padding, to allow for a more adaptable seating solution. By integrating these improvements, future designs can better accommodate a wider range of body types and postural preferences, further enhancing workplace comfort and productivity.

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