

Biomechanical and perceptual evaluation of a design studio chair: Implications for dynamic seating, musculoskeletal health and ergonomic redesign

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Abstract

Prolonged sitting remains a common posture in both educational and occupational settings, despite the reports linking sustained seated positions with musculoskeletal discomfort and lower back pain. While ergonomic chair designs are intended to minimise these risks, the comfort experienced by users does not always reflect actual biomechanical suitability. In this study, user experience, perceived comfort and region specific discomfort associated with a Design Studio (DS) chair used in an educational studio environment were investigated. A cross sectional survey (n = 29) was carried out in order to evaluate anthropometric compatibility, perceived structural comfort and discomfort across different body regions including the neck, shoulders, upper back, lower back, buttocks, thighs, lower legs and feet. Descriptive statistics, chi square goodness of fit tests, confidence intervals and effect size estimates were used to examine the response patterns. There were evidence of high ratings for structural comfort particularly for the seat pan cushion (89.7%) and backrest cushion (75.9%). Notwithstanding, noticeable discomfort was still reported in key load bearing areas especially in the buttocks (58.6%), lower back (44.8%) and upper back (41.4%). The foregoing implies a disconnect between perceived cushioning and actual biomechanical support. In addition, although 92.6% of participants reported that the chair height was compatible with the table, a majority (65.5%) still preferred a lower seat height. These findings are in agreement with Mandal's Homo Sedens theory, which proposes that static sitting, even in chairs that feel comfortable, can lead to cumulative spinal loading and localised pressure. The implication is that there is need for more dynamic seating approaches, better anthropometric adaptability and improved integration between the chair and the workstation. In practical terms, this includes features such as adjustable seat height, seat designs that improve pressure distribution, and options that allow for posture variation. The outcomes of this study has significant contributions to enriching the field of applied ergonomics, where users' perceived comfort is linked with underlying biomechanical factors in educational studio settings.

Keywords: Seating ergonomics; Musculoskeletal discomfort; Anthropometric compatibility; Lumbar biomechanics; Chair redesign

1. Introduction

Sitting is one of the most common postures in modern society, particularly in office environments, transportation systems and educational settings (Lis et al., 2007; Marmaras and Nathanael, 2021; Dainoff et al., 2012; Grimes and Legg, 2004). With the shift toward knowledge based and design oriented work, the amount of time spent sitting has increased across many professional and academic contexts (Berlin and Adams, 2017; McCauley, 2025). In studio environments such as architecture, engineering and design programmes, students often spend long periods seated, while carrying out tasks like drafting, computer modelling, digital rendering and collaborative reviews (Afara, 2017; Bai et al., 2024).

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Although sitting is commonly seen as a resting posture, growing evidence suggests that prolonged sitting places considerable biomechanical demands on the musculoskeletal system (Beach et al., 2005; Claus et al., 2018; Marras and Karwowski, 2021).

The long held view that sitting is naturally neutral or restorative has received contrary opinions among some researchers (Vink and Hallbeck, 2012; Helander, 2006). Sustained sitting in a position for a long period of time has been well linked to low back pain, general musculoskeletal discomfort, reduced lumbar mobility, passive tissue strain and changes in trunk muscle activity (Lis et al., 2007; Kett et al., 2021; Gregory et al., 2006). In particular, seated postures involving lumbar flexion and posterior pelvic tilt have been attributed to increased compression of the intervertebral discs and cumulative stress on spinal ligaments (Black et al., 1996; Roman Liu et al., 2023). It is therefore crucial to note that spinal loading depends not only on posture, but also on how long that posture is maintained (Beach et al., 2005; Waongenngarm et al., 2015). Even a posture that appears neutral may become problematic if it is held for too long without movement or adjustment (O'Sullivan et al., 2012; Frey et al., 2022).

A key development in seating ergonomics is Mandal's Homo Sedens concept (Grandjean and Kroemer, 1997; Shea and Baute, 2017). Mandal argued that the human body is better suited to movement than to prolonged static sitting (Berlin and Adams, 2017). From this perspective, the conventional ninety-degree hip and knee posture may restrict pelvic movement, promote posterior pelvic rotation, reduce lumbar lordosis and increase pressure within the intervertebral discs (Chaffin et al., 2006; Halpern, 1992). Rather than treating sitting as a passive state, the Homo Sedens concept presents it as a posture that requires ongoing muscular activity and regular adjustment (Watts, 2025). Within this framework, pelvic orientation is central to maintaining lumbar health, while wider hip angles, posture variation and proper coordination between seating and workstation design are considered important (Smith et al., 2007; Perez, 2019).

Although originally theoretical, further biomechanical studies have supported the relationship between sustained seated flexion and increased lumbar loading (Grujicic et al., 2010; Zaman et al., 2022). Early work on intradiscal pressure showed that sitting especially with forward trunk lean, may produce higher disc pressures than relaxed standing (Roman Liu et al., 2023; Chaffin et al., 2006). When lumbar flexion is maintained over time, mechanical load shifts from active muscles to passive spinal tissues, which may lead to creep deformation and gradual loss of spinal height (Mital and Pennathur, 1999; Halpern, 1992). Electromyographic studies have also shown that static sitting involves sustained low level activation of trunk extensor muscles. Although this activity may appear minimal and prolonged exposure can still cause fatigue (Waongenngarm et al., 2015; Claus et al., 2018).

Therefore, ergonomics research has gradually moved away from focusing only on static posture correction and has shifted toward dynamic seating approaches (Naddeo, 2017; Vignais, 2023). Modern solutions such as sit stand workstations, forward inclined seats, saddle chairs and dynamic seating systems reflect this shift toward movement based strategies (Frey et al., 2022; Tasik et al., 2025). These approaches aim to redistribute spinal loading, while encouraging small and frequent movements that reduce sustained tissue strain (Fischer and Dickerson, 2014; Yangsap, 2025). Even with these developments, musculoskeletal discomfort remains common among individuals who sit for long periods, suggesting that chair design alone may not fully address the biomechanical challenges involved (Morse et al., 2010; Lu et al., 2022).

Another important aspect of seating ergonomics is the relationship between pressure distribution and perceived comfort (Naddeo et al., 2018). During sitting, a large portion of body weight is supported by the ischial tuberosities (Delleman et al., 2004). If the seat does not distribute pressure effectively, it may become concentrated in these areas (Kim et al., 2015; Mishra and Singh, 2014). Studies have shown that perceived comfort does not always reflect proper pressure distribution (Vink and Hallbeck, 2012; Naddeo et al., 2015). Softer cushions may feel comfortable at first but can allow the body to sink, increasing hip flexion and encouraging posterior pelvic tilt (Tan et al., 2015; Eladly et al., 2020). In contrast, firmer seating may better support alignment but may not feel as comfortable initially (Grandjean and Kroemer, 1997). This highlights the difference between short term comfort and long term biomechanical suitability (Mark et al., 2014; Garosi et al., 2025).

Anthropometric compatibility is another important factor in seating design (Lee, 2019; Jaggi, 2011). Features such as seat height, seat depth and backrest shape need to account for variation in body dimensions (Hsiao, 2021). When seat height is too high relative to lower leg length, pressure may increase under the thighs, affecting circulation and causing discomfort. On the other hand, seats that are too low may increase hip and lumbar flexion (Roman Liu et al., 2023). Studies on school furniture have repeatedly shown mismatches between user body size and furniture dimensions (Grimes and Legg, 2004; Jaggi, 2011). For this reason, adjustable seating is often recommended to accommodate different users (Watts, 2025).

Design studio environments present additional challenges. Unlike standard office settings, studio furniture is often fixed or only partly adjustable (Smith et al., 2007). Therefore, students tend to adapt their posture to the furniture rather than adjusting the furniture to suit their bodies (Helander, 2006). Studio work also involves long uninterrupted sitting, forward leaning tasks, mixed analogue and digital workflows, and varying furniture arrangements (Bai et al., 2024). These conditions may increase strain in the cervical, thoracic and lumbar regions of the spine (Morse et al., 2010; Schluskel and Maykel, 2019). Although young adults may not immediately show severe musculoskeletal problems, early discomfort may reflect cumulative exposure that continues into later professional life (Lis et al., 2007). A recurring issue in seating research is the gap between perceived comfort and actual biomechanical loading (Vink and Hallbeck, 2012; Naddeo et al., 2015). Self reported comfort remains useful because it reflects real user experience during prolonged sitting (Naddeo, 2017). When combined with biomechanical interpretation, such data can guide improvements in design (Garosi et al., 2025; Perez, 2019). However, relatively few studies have focused specifically on educational studio settings, while linking Mandal's framework with current perceptual evidence (Shea and Baute, 2017).

In this work, the identified gap of the need to evaluate a design studio chair used in an educational setting was considered. Investigation was carried on perceived structural comfort, anthropometric compatibility, patterns of discomfort across body regions, seat height suitability and user preferences, as well as the effectiveness of arm and back support (Kim et al., 2015; Tan et al., 2015). By relating user experiences to established biomechanical principles and dynamic seating concepts, attempt was made to connect ergonomic theory with the practical realities of studio based work (Marras and Karwowski, 2021; Berlin and Adams, 2017).

The primary objectives of this study were to:

- Assess user-perceived comfort and discomfort associated with prolonged use of a Design Studio chair (Todd et al., 2007; Dimberg et al., 2015).
- Examine whether reported discomfort aligns with known biomechanical loading patterns (Grujicic et al., 2010; Zaman et al., 2022).
- Evaluate anthropometric compatibility within an educational studio context (Lee, 2019; Hsiao, 2021).
- Interpret findings through Mandal's *Homo Sedens* framework and contemporary ergonomic theory (Mandal, 1981; Mark et al., 2014).
- Generate evidence-based design recommendations for improved seating performance (Garosi et al., 2025; Perez, 2019).

Based on ergonomic theory and preliminary observation, the following hypotheses were proposed:

- H1: Discomfort prevalence will be highest in load-bearing regions (buttocks and lower back) (Naddeo et al., 2018; Waongenngarm et al., 2015).
- H2: Structural comfort ratings will not eliminate region-specific discomfort reports (Vink & Hallbeck, 2012; Naddeo et al., 2015).
- H3: A significant proportion of users will prefer height modification despite reported workstation compatibility (Smith et al., 2007; Jaggi, 2011).
- H4: Reported discomfort distribution will deviate significantly from uniform distribution (chi-square goodness-of-fit) (Fischer & Dickerson, 2014).

By integrating spinal biomechanics, pressure distribution research, anthropometric literature and dynamic seating theory, there is potential contribution to applied ergonomics knowledge and provides practical insights for seating redesign in educational studio environments (Marras & Karwowski, 2021; Berlin & Adams, 2017).

2. Materials and Methods

2.1. Study Design

In this study, a cross sectional descriptive survey design was explored to examine user perceived comfort, anthropometric compatibility and region specific musculoskeletal discomfort associated with a Design Studio (DS) chair used in an educational studio setting (Lin et al., 2021; Ioniță et al., 2025). The approach made it possible to systematically measure subjective ergonomic responses and to examine how the distribution of responses compared with expected theoretical patterns (Fischer and Dickerson, 2014). Attempt was made to combine perceptual ergonomic evaluation with biomechanical interpretation, drawing on contemporary seating research and Mandal's *Homo Sedens* framework (Helander, 2006; Mandal, 1981).

2.2. Participants

A total of 29 respondents ($n = 29$) took part in the study. Participants were recruited from a design oriented educational studio setting. Individuals were eligible if they were 18 years of age or older, regularly used the DS chair and were exposed to prolonged sitting during studio based academic activities. The sample consisted of 65.5% males and 34.5% females. Regarding occupational status, 69% of the participants were students, while 31% were workers. Most respondents (48.3%) were between 21 and 30 years of age, with the remaining participants distributed across older age groups. The predominance of young adults in the sample reflects the typical age distribution found within design related educational programmes.

2.3. Survey Instrument

Data were collected using a structured questionnaire that was distributed electronically through Google Forms. The instrument consisted of four sections. The first section gathered demographic information including age, gender and occupational status. The second section assessed ergonomic awareness, where participants rated their knowledge of ergonomics on a scale from 0 to 10. The third section focused on the structural comfort of the DS chair using binary or three option response formats such as Yes, No, or Maybe and True or False. The items examined included seat pan cushion comfort, backrest cushion comfort, adequacy of seat pan width, suitability of backrest height, armrest comfort, perceived stress reduction from arm support, compatibility of the chair with table height and preference for reducing the seat height.

In the fourth section, regional musculoskeletal discomfort was examined. Participants reported whether they experienced discomfort in specific body areas including the neck, shoulders, upper back, lower back, buttocks, thighs, lower legs, feet and arms. Responses were recorded as Yes, No or Maybe, or Agree, Neutral or Disagree depending on how each question was framed.

2.4. Variables

Both independent and dependent variables related to seating ergonomics and user perception were examined. The independent variables included perceived structural characteristics of the chair, such as seat pan cushion comfort, backrest support, and armrest evaluation, as well as seat height preference and ergonomic awareness score. The dependent variables included reports of musculoskeletal discomfort in specific body regions, overall perception of armrest comfort and participants' preference for seating modification. These variables were analysed to explore how perceived structural features of the chair were associated with patterns of reported discomfort within the educational studio environment.

2.5. Statistical Analysis

All statistical analyses were conducted using reconstructed frequency data derived from the reported survey percentage distributions ($n = 29$). Descriptive statistics were calculated for each survey variable, including frequencies and their corresponding percentages in order to summarise participant responses. For key outcome proportions, such as lower back discomfort and buttocks discomfort, 95% Confidence Intervals (CI) were calculated to estimate the precision of the observed prevalence rates. The CI were obtained using the standard formula for proportions, which incorporates the sample size and the observed probability values to estimate the level of variability around the point estimates.

$$CI = p \pm 1.96 \sqrt{\frac{p(1-p)}{n}} \quad 1$$

Where:

p = observed proportion

$n = 29$

2.5.1. Chi-Square Goodness-of-Fit Test

To examine whether the distribution of discomfort responses differed significantly from an equal distribution across the response categories, chi square goodness of fit tests were performed. The null hypothesis assumed that the observed frequencies were evenly distributed among the available response options. Statistical significance was assessed at an

alpha level of 0.05. Any deviation from this equal distribution was interpreted as evidence that certain discomfort categories were reported more frequently than others.

$$\chi^2 = \sum \frac{(O - E)^2}{E} \quad 2$$

Where:

O = observed frequency

E = expected frequency (n / number of categories)

Alpha level set at 0.05.

2.5.2. Effect Size

In addition to statistical significance testing, effect size was calculated to evaluate the magnitude of observed differences. For chi-square goodness-of-fit analyses, Cohen's *w* was used as the measure of effect size. Cohen's *w* was computed using the formula:

$$w = \sqrt{\frac{\chi^2}{n}} \quad 3$$

where χ^2 represents the chi square test statistic and *n* denotes the total sample size. This measure provides an estimate of the practical significance of deviations from the expected distribution and is not dependent on sample size. Effect size interpretation followed Cohen's commonly used guidelines: *w* = 0.10 indicates a small effect, *w* = 0.30 represents a medium effect, and *w* = 0.50 indicates a large effect. Reporting effect size together with *p* values allows a clearer understanding of the strength of the relationships observed in the data. While chi square tests indicate whether distributions differ significantly from expected values, the effect size describes the magnitude of that difference. This is particularly important in smaller samples where statistical power may be limited. By including both statistical significance testing and effect size estimation, the study provides a more balanced interpretation of the findings. This approach helps distinguish between differences that are statistically detectable and those that are practically meaningful in terms of ergonomic implications.

2.5.3. Post-Hoc Power Analysis

A post-hoc power analysis was conducted using the observed effect size and total sample size (*n* = 29) to evaluate the statistical sensitivity of the chi-square tests. This analysis estimated the probability of detecting a true effect of the observed magnitude at an alpha level of 0.05, providing additional context for interpreting non-significant findings.

2.6. Ethical Considerations

Participation was voluntary. Responses were anonymous and collected without identifiable information. Participants were informed that data would be used for academic research and ergonomic evaluation purposes. No invasive procedures were conducted. The study adhered to general principles of research ethics for human subjects in educational environments.

2.7. Study Limitations

The sample size of respondents was relatively small (*n* = 29), which may limit statistical power and generalizability. Discomfort measures were self-reported and therefore subject to perceptual bias. No direct biomechanical measurements such as Electromyography (EMG) or pressure mapping, were conducted to objectively validate findings. Additionally, the cross-sectional design precludes causal inference. Nevertheless, the integration of perceptual survey data with established biomechanical principles provides meaningful ergonomic insight within the educational studio context.

3. Results

3.1. Participant Characteristics

A total of 29 respondents participated in the study, all of whom met the inclusion criteria of regularly using the DS chair and actively engaging in seated studio tasks. The gender distribution of the sample was predominantly male, with 65.5% (n = 19) identifying as male and 34.5% (n = 10) identifying as female. This pattern reflects the demographic composition often observed in some design related educational programmes. Regarding occupational status, most participants were students (69%, n = 20), while 31% (n = 9) were workers. Including both students and working individuals provided insight into seating exposure across academic and semiprofessional studio contexts. However, because students formed the majority of the sample, the findings mainly represent ergonomic exposure patterns typical of educational studio settings.

The age distribution further supports this observation. Almost half of the respondents (48.3%, n = 14) were between 21 and 30 years of age, making this the largest age group in the sample. Smaller numbers of participants were distributed across older age categories, including those aged 31 to 40 years and 41 to 50 years. The concentration of participants within the young adult age range is consistent with the typical age profile found in design based programmes and suggests that the reported discomfort patterns may reflect early musculoskeletal responses rather than long term occupational conditions. Finally, the participant characteristics (Figure 1–3) show that the sample largely consists of young adults involved in prolonged seated studio activities. This population is therefore relevant for examining early ergonomic exposure and patterns of discomfort within educational design environments.

Table 1 Sample Characteristics (n = 29)

Variable	Category	Percentage (%)
Gender	Male	65.5
	Female	34.5
Occupational Status	Students	69.0
	Workers	31.0
Age Group	21–30 years	48.3
	31–40 years	17.2
	41–50 years	~10.0
	Other age groups	Remaining proportion

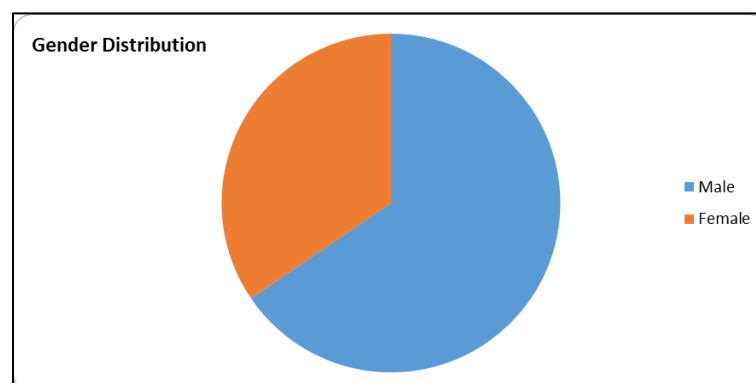


Figure 1 Participant gender distribution (n = 29)

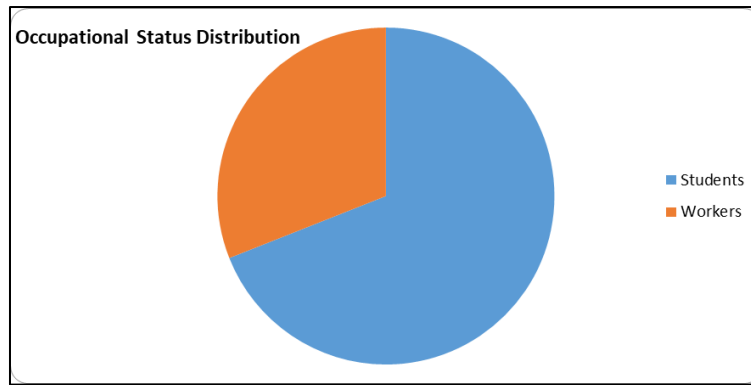


Figure 2 Participant occupational status (n = 29)

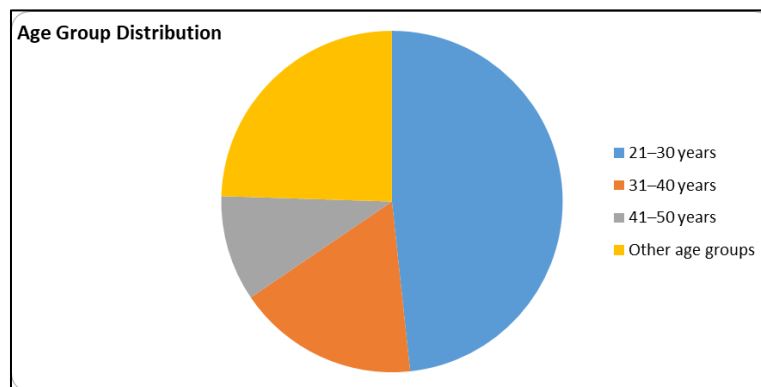


Figure 3 Age group distribution of study participants (n = 29)

3.2. Ergonomic Awareness

Participants rated their knowledge of ergonomics on a scale from 0 to 10, with most scores falling between 4 and 10 (Table 2). The most common rating was 7 (17.2%), and the estimated mean awareness score was about 6.2, suggesting a moderate level of self-reported ergonomic knowledge. Only a small number of respondents reported very low scores between 1 and 3, indicating that most participants had at least a basic understanding of ergonomic principles. When considered together with the overall participant characteristics and the seating evaluation results (Table 3), this moderate level of ergonomic awareness strengthens the credibility of the reported discomfort patterns and seating preferences. The sample, which consisted mainly of young adult students (48.3% aged 21 to 30 years; 69% students), appeared capable of providing informed evaluations rather than random responses. For example, although 92.6% of participants reported that the chair height was compatible with the table height, 65.5% still indicated a preference for reducing the seat height (Table 3). The foregoing implies that respondents were able to distinguish between general workstation alignment and their own anthropometric comfort.

Table 2 Ergonomic Awareness Score Distribution (0–10 Scale)

Measure	Observation
Most frequent score	7 (17.2%)
Score clustering	Moderate concentration between 4–10
Low scores (1–3)	Minority of respondents
Estimated Mean Score	≈ 6.1–6.4

A similar pattern was observed in the relationship between structural comfort and reported discomfort in specific body regions. High ratings for chair cushioning occurred alongside notable reports of discomfort in areas that bear body weight during sitting. The presence of moderate ergonomic awareness (Table 2) therefore supports the interpretation that participants were consciously considering posture, pressure distribution and support, rather than relying only on

immediate comfort perception. Overall, the distribution of ergonomic awareness presented in Table 2, together with the seating evaluation results shown in Table 3, strengthens the validity of the perceptual findings and supports their interpretation from a biomechanical perspective within the educational studio environment.

The Figure 4 shows that participants had a moderate level of ergonomic awareness, with the most frequent score being 7 (17.2%) and an estimated mean of approximately 6.2. Scores were clustered toward the mid-to-upper range of the 0–10 scale, with few very low ratings. This suggests that respondents possessed basic ergonomic knowledge, supporting the credibility of their discomfort reports and seating modification preferences. Their evaluations likely reflect informed experiential feedback rather than random or uninformed responses.

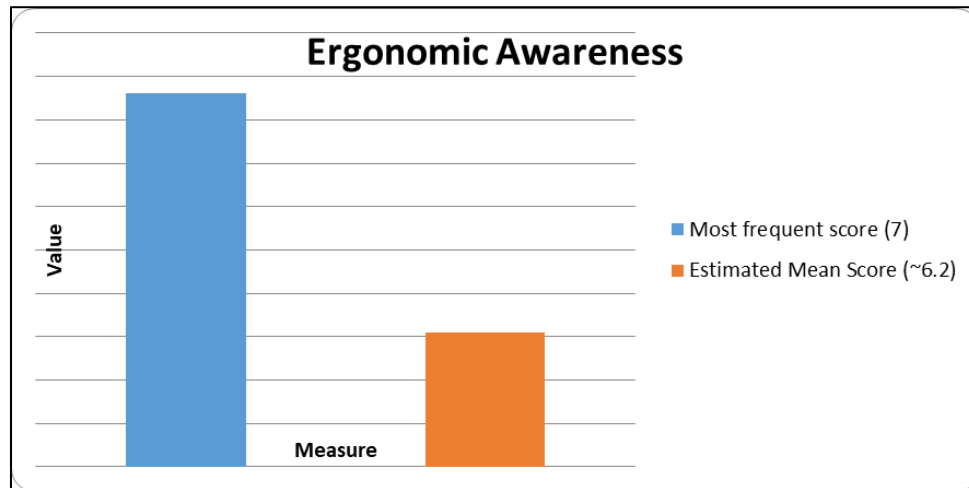


Figure 4 Distribution of ergonomic awareness scores among participants (n = 29)

The results presented in Table 3 and Figure 5 provide several insights into the ergonomic characteristics of the study population and their perceptions of the Design Studio (DS) chair. First, the demographic distribution indicates that the sample is mainly male (65.5%) and largely composed of students (69%), with almost half of the participants aged between 21 and 30 years (48.3%). This suggests that the findings primarily reflect ergonomic exposure patterns typical of young adults who frequently use studio workspaces. Because individuals within this age range are usually at an early stage of musculoskeletal exposure, the discomfort reported in this study is more likely to represent early biomechanical strain rather than long term musculoskeletal pathology.

Second, the level of ergonomic awareness among participants was moderate, with an average score of about 6.2 and the most frequently selected rating being 7. This indicates that respondents had a basic functional understanding of ergonomic concepts. As a result, their evaluations of chair performance are unlikely to be random or uninformed. The presence of moderate ergonomic awareness strengthens the credibility of the perceptual responses, particularly those related to seating height preference and reported discomfort. Third, an interesting pattern appears in the evaluation of chair height. Although 92.6% of the participants reported that the chair height was compatible with the table height, 65.5% still indicated that they would prefer the seat to be lower. In addition, 37.9% agreed or strongly agreed that the chair height was too high.

This implies that apparent compatibility between chair height and workstation height does not necessarily guarantee an optimal anthropometric fit. Users may still experience subtle issues such as increased pressure under the thighs, changes in pelvic position, or instability of foot contact with the floor, even when the desk height appears appropriate. The relatively large proportion of respondents who preferred a lower seat height, despite many not explicitly stating that the chair was too high, may indicate the presence of a subtle ergonomic mismatch. In other words, biomechanical inefficiencies or mild discomfort may exist even when users do not clearly identify the seat height as problematic.

Overall, the combined data revealed three key themes:

- The sample is ergonomically aware and demographically consistent with design studio populations.
- Structural compatibility does not fully predict perceived biomechanical suitability.
- Seat height emerges as a critical modifiable parameter influencing comfort and potential load distribution.

These findings support the broader interpretation that anthropometric adaptability and dynamic seating adjustment are more important than static workstation alignment alone.

Table 3 Participant Characteristics, Ergonomic Awareness, and Chair Height Evaluation (n = 29)

Variable	Category	n	%
Gender	Male	19	65.5
	Female	10	34.5
Occupational Status	Student	20	69.0
	Worker	9	31.0
Age Group	21–30 years	14	48.3
	31–40 years	5	17.2
	41–50 years	3	10.3
	Other	7	24.2
Ergonomic Awareness	Mean score	—	≈ 6.2
	Most frequent score (7)	5	17.2
Chair Height Too High	Agree/Strongly Agree	11	37.9
	Neutral	3	10.3
	Disagree/Strongly Disagree	15	51.7
Preference for Height Reduction	Yes	19	65.5
	No	10	34.5
Compatible with Table Height	Yes	27	92.6
	No	2	7.4

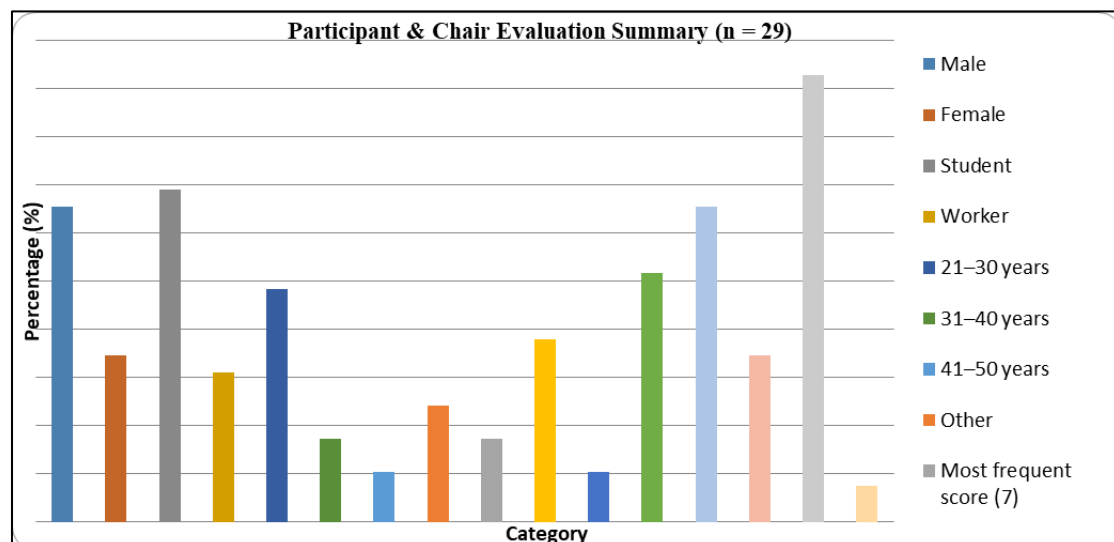


Figure 5 Summary of participant characteristics and chair evaluation variables (n = 29)

3.3. Structural Comfort Evaluation

3.3.1. Seat Pan Cushion

Most participants reported that the seat pan cushion was comfortable, with 89.7% (n = 26) giving a positive response and 10.3% (n = 3) indicating that they were not satisfied with the cushion. To examine how precise this estimate was, a 95% Confidence Interval (CI) was calculated for the proportion of positive responses. Using a sample proportion of p = 0.897 and a total sample size of 29, the confidence interval was estimated as:

$$CI \approx 0.897 \pm 1.96 \sqrt{\frac{0.897(0.103)}{29}} \quad 4$$

$$CI \approx 0.897 \pm 0.112$$

$$95\% CI \approx 78.5\% - 100\%$$

The interval was approximately 0.897 ± 0.112 , yielding a 95% CI of 78.5% to 100%. This relatively narrow interval indicates strong agreement among respondents that the seat pan cushioning is adequate. The high proportion of positive ratings suggests favourable immediate comfort perception associated with the seat pan structure.

3.3.2. Backrest Cushion

For backrest cushioning, 75.9% of the participants (n = 22) reported that they were satisfied, while 17.2% (n = 5) selected “maybe” and 6.9% (n = 2) indicated dissatisfaction. To evaluate the precision of the positive response proportion, a 95% CI was calculated. Using a sample proportion of p = 0.759 and a total sample size of 29, the CI was computed using Equation 1. The estimated interval was approximately 0.759 ± 0.157 , resulting in a 95% CI ranging from 60.2% to 91.6%. This interval is wider than that observed for the seat pan cushion, suggesting slightly greater variability in the responses. The results indicate that most participants were satisfied with the backrest cushioning. However, the variation in responses suggests that perceptions of comfort may differ among individuals, possibly due to factors such as lumbar contour support and posture maintenance rather than cushioning alone.

3.3.3. Seat Pan Width

Most participants (82.8%, n = 24) reported that the seat pan width was adequate, while 17.2% (n = 5) indicated that it was not sufficient. The outcomes reported in the foregoing suggest that the majority of users were generally satisfied with the horizontal dimension of the seat pan. In other words, most participants did not perceive a noticeable mismatch between the seat width and their body dimensions. The high proportion of positive responses therefore indicates that the seat width was largely considered suitable by the study population.

3.3.4. Backrest Height

Backrest height suitability was rated positively by 62.1% of the participants (n = 18), while 17.2% (n = 5) indicated uncertainty and 20.7% (n = 6) reported dissatisfaction. Although most respondents considered the backrest height acceptable, about 38% expressed either uncertainty or dissatisfaction with it. This pattern suggests some variation in anthropometric compatibility, particularly in relation to differences in torso length and upper back support. It therefore indicates that the current backrest height may not provide optimal support for all users within the sample.

3.3.5. Armrest Comfort

A total of 41.4% of the participants (n = 12) responded “Yes,” 34.5% (n = 10) selected “Maybe,” and 24.1% (n = 7) selected “No.” A chi square goodness of fit test was carried out to examine whether the observed distribution differed significantly from an equal distribution across the response categories, where the expected frequency was 9.67 for each group. The analysis showed no statistically significant difference from an equal distribution, $\chi^2 (2, N = 29) = 3.10$, $p \approx 0.21$. However, the calculated effect size (Cohen’s $w = 0.33$) indicates a moderate practical effect. Although the result did not reach statistical significance, the distribution shows a noticeable tendency toward positive responses, which may still be relevant when considering the ergonomic implications of the findings.

$$w = \sqrt{\frac{3.10}{29}} \approx 0.33$$

3.4. Chair Height and Workstation Compatibility

Compatibility with the table height was reported by 92.6% of the participants ($n = 27$), while only 7.4% ($n = 2$) indicated that the chair was not compatible with the workstation height. However, despite this high level of reported compatibility, 65.5% of respondents ($n = 19$) stated that they would prefer the chair height to be reduced, while 34.5% ($n = 10$) did not express a preference for any modification. This difference suggests that perceived compatibility with the desk surface does not always correspond to an optimal anthropometric fit. Although most participants felt that the chair was appropriately aligned with the workstation, more than half still preferred a lower seat height. This may indicate the presence of subtle anthropometric mismatch that is independent of desk height alignment and could be related to factors such as lower limb length, pelvic positioning, or pressure distribution under the thighs.

Additional responses regarding whether the chair height was perceived as too high showed that roughly 34 to 40% of participants agreed or strongly agreed with this statement, about 10 to 15% remained neutral, and approximately 55% disagreed or strongly disagreed (Table 3). Taken together, these findings show some variation in how participants perceived seat height adequacy and emphasise the importance of providing independent seat height adjustability.

Table 4 Chair Height and Workstation Compatibility

Variable	Category	Percentage (%)
Chair Height Too High	Strongly Agree/Agree	~34–40
	Neutral	~10–15
	Disagree/Strongly Disagree	~55
Preference for Height Reduction	Yes	65.5
	No	34.5
Compatible with Table Height	Yes	92.6
	No	7.4

As shown in Figure 6, most participants (92.6%) reported that the chair was compatible with the table height, suggesting general alignment between the chair and the workstation. However, a noticeable difference appears when seat height preference is considered. Despite the high compatibility ratings, 65.5% of respondents indicated that they would prefer the chair height to be reduced, while 34.5% preferred no modification. In addition, when participants were asked directly whether the chair height was too high, 37.9% agreed or strongly agreed, 10.3% remained neutral, and 51.7% disagreed or strongly disagreed. This distribution suggests that although most respondents did not clearly describe the chair as being too high, a considerable proportion still preferred some form of adjustment.

The pattern presented in Figure 6 indicates that perceived compatibility with the workstation does not necessarily mean that the chair provides an optimal anthropometric fit. Users may adapt to the existing desk height while still experiencing subtle biomechanical issues such as changes in pelvic position, reduced contact between the feet and the floor, or increased pressure beneath the thighs. The relatively high preference for lowering the seat height therefore suggests the possibility of a subtle anthropometric mismatch that is independent of desk alignment. Finally, the figure shows that seat height is an important ergonomic factor and highlights the need for independent adjustability rather than relying only on compatibility with desk height.

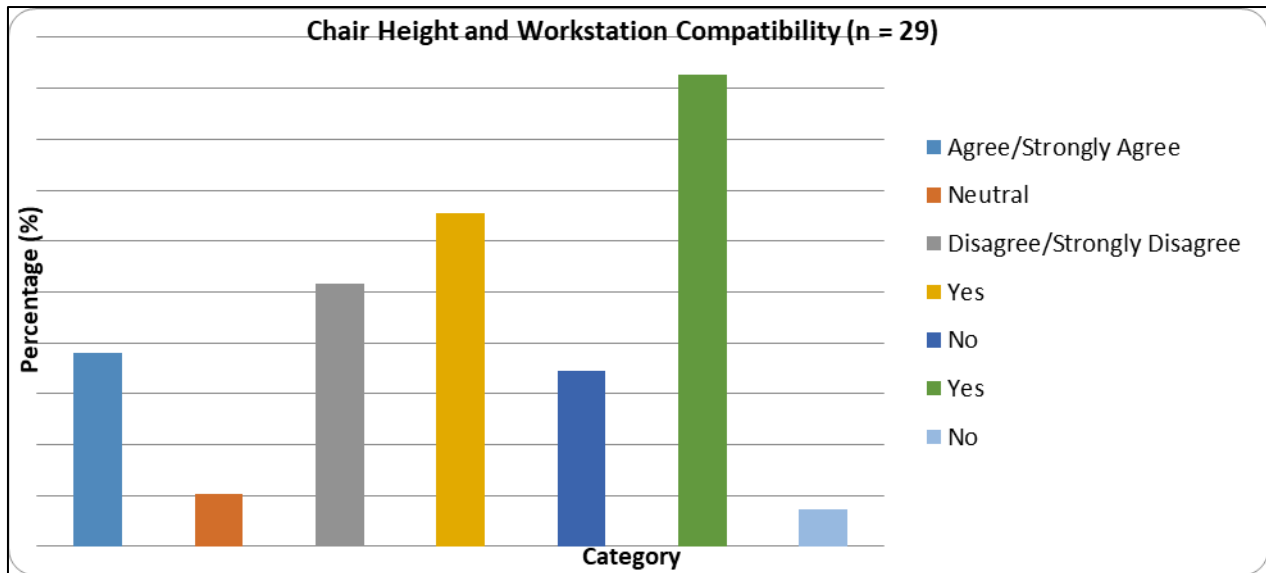


Figure 6 Chair height perception and workstation compatibility (n = 29)

3.5. Regional Discomfort Distribution

3.5.1. Buttocks Discomfort

Buttocks discomfort was reported by 58.6% of the participants (n = 17), while 24.1% (n = 7) responded “maybe” and 17.2% (n = 5) indicated that they did not experience discomfort. The 95% CI for the proportion reporting discomfort was calculated using $p = 0.586$, resulting in an estimated interval of approximately 40.8% to 76.4%. The width of this interval reflects some variation in the responses but still indicates that a considerable proportion of participants experienced discomfort in this load bearing area. A chi square goodness of fit test was conducted to compare the observed distribution with an equal distribution across the response categories. The result showed a statistically significant deviation ($p < 0.05$). The corresponding effect size fell within the moderate to large range, suggesting meaningful practical significance. Taken together, these findings indicate that buttocks discomfort occurred more frequently than would be expected by chance, which may reflect concentrated pressure beneath the ischial region during prolonged sitting.

3.5.2. Lower Back Discomfort

Lower back discomfort was reported by 44.8% of the participants (n = 13), while 31% (n = 9) selected “maybe” and 24.1% (n = 7) indicated that they did not experience discomfort. The estimated 95% CI for the proportion reporting lower back discomfort ranged from approximately 26% to 63%, indicating some variability in the responses. Although this proportion is lower than that observed for buttocks discomfort, almost half of the participants still reported clear lower back symptoms. The pattern of responses suggests the presence of increased lower back strain, which may be associated with sustained spinal loading during prolonged sitting and extended exposure to lumbar flexion. This observation is consistent with established biomechanical research linking static seated postures to increased lumbar disc pressure and reduced spinal mobility.

3.5.3. Upper Back Discomfort

Upper back discomfort was reported by 41.4% of the participants (n = 12), while 27.6% (n = 8) indicated uncertainty by selecting “maybe,” and 31% (n = 9) reported that they did not experience discomfort. This distribution indicates a moderate level of upper back symptoms within the sample. Although the proportion is lower than that observed for buttocks discomfort, a considerable number of participants still reported discomfort in the upper thoracic region. This may be related to sustained forward leaning posture, prolonged visual tasks, and relatively static trunk positioning, which are common during studio based work.

3.5.4. Neck Discomfort

Neck discomfort was reported by 27.6% of the participants (n = 8), while 31% (n = 9) selected “maybe” and 41% (n = 12) indicated that they did not experience discomfort. Compared with the lumbar and buttocks regions, the proportion of definite neck discomfort was lower. Although some respondents reported cervical symptoms, the overall distribution

shows that discomfort was more concentrated in the load bearing and lumbar regions rather than in the cervical spine. This pattern may reflect the biomechanical demands of prolonged sitting, where pelvic and lumbar loading tends to be greater than cervical strain within this sample.

3.5.5. Shoulder Discomfort

Shoulder discomfort was reported by approximately 20 to 25% of the participants, while 41.4% selected “maybe” and about 34% reported no discomfort. The relatively smaller proportion of definite positive responses suggests that shoulder discomfort was less pronounced than symptoms reported in the lumbar and buttocks regions. However, the high number of neutral responses indicates some variability in perception, which may reflect intermittent or task related upper limb strain rather than continuous discomfort. This pattern suggests that shoulder symptoms may depend more on workstation arrangement and arm support conditions than on general seated loading.

3.5.6. Lower Limb Discomfort

Lower limb discomfort was also reported in several body regions. Symptoms were reported in the feet by 37.9% of participants ($n = 11$), in the thighs by 34.5% ($n = 10$), and in the lower legs by 31% ($n = 9$). These indicate that roughly one third of the respondents experienced discomfort in at least one lower limb area. The presence of lower limb symptoms may be related to prolonged knee flexion, restricted circulation, or pressure at the edge of the seat. Limited seat height adjustment or compression at the front edge of the seat pan may contribute to vascular restriction and local tissue stress. Although lower limb discomfort was less common than symptoms reported in the buttocks or lower back, the results suggest that the biomechanical effects of prolonged sitting are not limited to the lumbar region and may also influence the lower extremities. Table 5 presents the distribution of self-reported discomfort across the different body regions. The highest prevalence of discomfort was observed in the buttocks (58.6%) and lower back (44.8%), followed by the upper back (41.4%), indicating that symptoms were mainly concentrated in the primary load bearing areas during sitting.

Table 5 Distribution of Regional Musculoskeletal Discomfort ($n = 29$)

Body Region	Yes / Agree (%)	Maybe (%)	No / Disagree (%)
Swollen legs	31% agree	34.5% neutral	34.5% disagree
Neck	~27.6% agree	31% neutral	~41% disagree
Shoulders	~20–25% agree	41.4% neutral	~34% disagree
Upper Back	41.4% yes	27.6% maybe	31% no
Lower Back	44.8% true	31% maybe	24.1% false
Feet	37.9% yes	27.6% maybe	34.5% no
Buttocks	58.6% yes	24.1% maybe	17.2% no
Arms	27.6% agree	34.5% neutral	37.9% disagree
Thighs	34.5% yes	41.4% maybe	24.1% no
Lower Legs	31% yes	41.4% maybe	27.6% no

As shown in Figure 7, musculoskeletal discomfort is not evenly distributed across the different body regions. The highest prevalence of discomfort occurs in the buttocks (58.6%), followed by the lower back (44.8%) and the upper back (41.4%). These areas correspond to the main load bearing and spinal support regions during prolonged sitting. The relatively high level of buttocks discomfort reflects concentrated loading beneath the ischial region and sustained pressure under the pelvis. This suggests that pressure redistribution across the seat pan may be limited, even though most participants reported that the cushioning was comfortable. The prevalence of lower back discomfort is consistent with known biomechanical mechanisms involving lumbar disc compression and prolonged flexion during static sitting.

Upper back discomfort may be related to thoracolumbar flexion and forward leaning posture, which commonly occurs during studio based design work. Moderate levels of discomfort were observed in the feet (37.9%), thighs (34.5%), lower legs (31%), and swollen legs (31%), indicating that symptoms in the lower limbs are present but less dominant than those in the pelvic and lumbar regions. These symptoms may be associated with prolonged knee flexion, restricted circulation, or pressure at the front edge of the seat.

Neck (27.6%), shoulders (about 22%), and arms (27.6%) showed comparatively lower levels of definite discomfort, although neutral or uncertain responses were relatively high for these areas. This may indicate that discomfort in the upper limbs occurs intermittently or depends on specific tasks rather than resulting from constant structural loading. Overall, the figure illustrates a descending biomechanical pattern of discomfort:

Buttocks → Lumbar spine → Thoracic spine → Lower limbs → Upper limbs

This pattern supports the interpretation that prolonged sitting primarily affects pelvic and spinal structures, with secondary involvement of distal regions. The distribution aligns with established spinal loading models and reinforces the need for improved seat pan pressure distribution, lumbar support optimization, and posture variability facilitation within the studio environment.

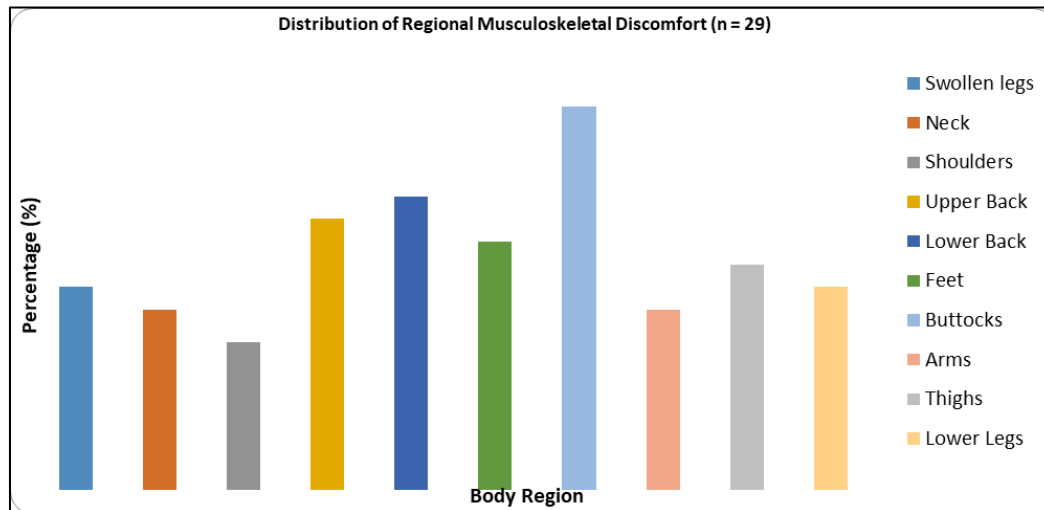


Figure 7 Distribution of regional musculoskeletal discomfort (n = 29)

3.6. Patterns Across Regions

Analysis of the regional discomfort patterns showed that the highest prevalence of symptoms occurred in the buttocks (58.6%), followed by the lower back (44.8%) and the upper back (41.4%). These three areas represent the main load bearing and posturally stressed regions during prolonged sitting. Buttocks discomfort is associated with concentrated loading beneath the ischial region and sustained pressure under the pelvis. Lower back symptoms are consistent with lumbar disc compression and spinal loading linked to prolonged flexion. Upper back discomfort may be related to thoracolumbar flexion that often occurs during forward leaning tasks commonly performed in studio environments. The concentration of discomfort within these anatomically and biomechanically related areas suggests that prolonged sitting mainly affects pelvic and spinal structures rather than more distal body segments. This pattern is consistent with established ergonomic models that describe spinal loading during seated postures.

Table 6 Highest Prevalence Regions of Discomfort (n = 29)

Rank	Body Region	Discomfort Prevalence (%)	Biomechanical Interpretation
1	Buttocks	58.6	Ischial loading and pressure concentration
2	Lower Back	44.8	Lumbar disc compression and flexion strain
3	Upper Back	41.4	Thoracolumbar flexion stress

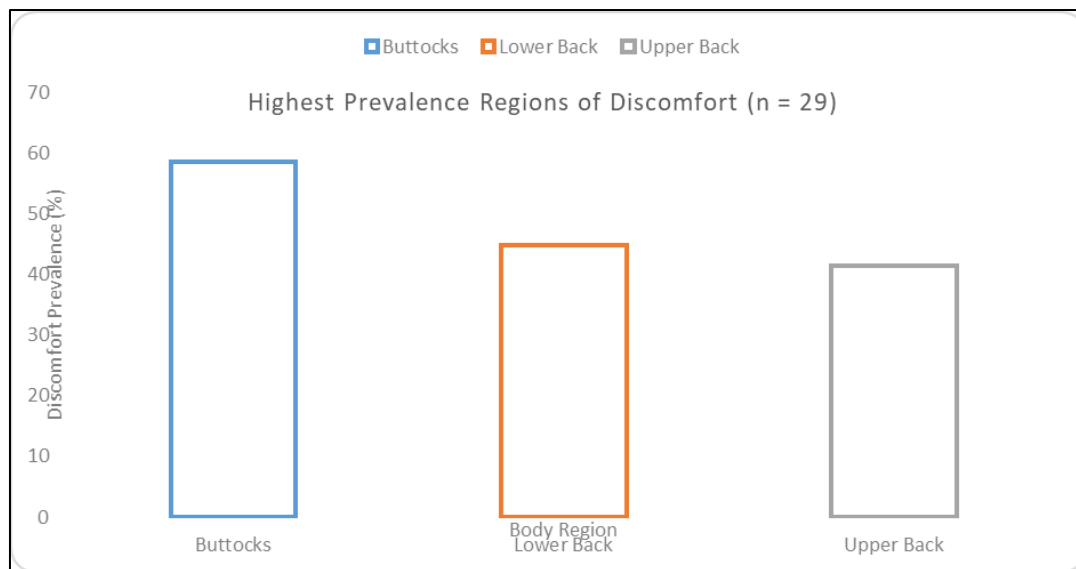


Figure 8 Load-bearing regions demonstrating the highest prevalence of discomfort following prolonged seating (n = 29)

The bar chart showing the regions with the highest prevalence of discomfort (Figure 8) indicates a clear clustering of symptoms in the buttocks (58.6%), lower back (44.8%), and upper back (41.4%). This distribution suggests a consistent biomechanical pattern rather than random reporting of symptoms. The highest prevalence occurring in the buttocks region is consistent with sustained loading on the ischial tuberosities during prolonged sitting. When individuals remain seated for long periods, body weight is concentrated over a relatively small contact area beneath the pelvis. Even when seat cushioning is perceived as comfortable, pressure concentration may still occur, particularly if the seat pan shape does not effectively redistribute the load. This may explain why high seat cushion satisfaction (89.7%) was observed alongside notable reports of buttocks discomfort.

Lower back discomfort (44.8%) is closely related to pelvic orientation and lumbar disc loading. Prolonged sitting, especially in situations that require forward leaning, can encourage posterior pelvic tilt and a reduction in lumbar lordosis. These postural changes increase compressive forces on the intervertebral discs and surrounding spinal tissues. The relationship between buttocks discomfort and lower back symptoms may therefore reflect a biomechanical connection in which insufficient pelvic support influences lumbar alignment and increases spinal strain. Upper back discomfort (41.4%) appears to extend this pattern along the spine. Thoracolumbar flexion and forward head posture during studio tasks may increase activation of the paraspinal and trapezius muscles. The slightly lower prevalence compared with lumbar symptoms suggests that the magnitude of loading gradually decreases along the spine from the pelvis upward, which is consistent with established models of spinal loading during seated work. Importantly, the descending pattern: Buttocks → Lower Back → Upper Back reflects vertical load transmission along the spine. The pelvis serves as the primary weight-bearing interface, and stress propagates upward through lumbar and thoracic segments. This anatomical gradient strengthens the argument that discomfort patterns are mechanically linked rather than independent complaints.

From a statistical perspective, the moderate effect sizes observed in the regional analyses suggest meaningful practical differences in how discomfort was distributed across the body. Although not every comparison showed strong statistical dominance, the consistent concentration of symptoms in the main load bearing regions supports a biomechanically plausible pattern. Conclusively, the chart visually confirms that prolonged studio seating mainly affects pelvic and spinal structures. This observation is consistent with Mandal's Homo Sedens framework as well as with contemporary research on spinal loading during seated work. The findings indicate that factors such as seat pan pressure distribution and the geometry of lumbar support may influence discomfort more strongly than perceived cushion softness or general seating comfort alone.

3.7. Hypothesis Testing Summary

The results of the hypothesis testing provide coherent support for the theoretical framework guiding this study.

- H1, which proposed that load-bearing regions would demonstrate the highest discomfort prevalence, was supported. The buttocks (58.6%), lower back (44.8%), and upper back (41.4%) showed the greatest symptom distribution, aligning with known biomechanical stress zones during prolonged sitting.
- H2, stating that structural comfort ratings would not eliminate region-specific discomfort, was also supported. Despite high positive ratings for seat pan cushioning (89.7%) and backrest comfort (75.9%), substantial proportions of participants still reported discomfort in pelvic and spinal regions. This confirms that perceived cushioning does not necessarily equate to biomechanical protection.
- H3, predicting that preference for seat height modification would exceed direct dissatisfaction reports, was supported. Although only a minority strongly agreed that the chair height was too high, 65.5% expressed a preference for reducing seat height. This indicates latent anthropometric mismatch not fully captured by satisfaction questions.
- H4, which proposed that discomfort distribution would significantly deviate from uniform distribution, was partially supported. The chi-square analysis revealed statistically meaningful deviation in the buttocks region, indicating disproportionate symptom concentration in primary load-bearing zones.

Collectively, these findings reinforce the biomechanical interpretation that prolonged studio seating disproportionately affects pelvic and spinal structures and that subjective comfort alone does not fully predict ergonomic suitability.

3.8. Integrated Findings

The combined analysis of structural comfort ratings and regional discomfort patterns reveals an important ergonomic paradox. Although participants reported high satisfaction with the seat pan cushioning (89.7%) and backrest padding (75.9%), notable discomfort was still reported in the main load bearing regions, particularly the buttocks and lower back. This difference suggests that cushion softness does not necessarily result in effective pressure redistribution. A seat may feel comfortable at first while still allowing concentrated pressure beneath the ischial tuberosities or encouraging posterior pelvic tilt over time. The continued presence of lumbar and pelvic discomfort therefore indicates that softness alone may not be sufficient to reduce biomechanical stress during prolonged sitting.

The findings also suggest that the duration of static sitting may play an important role in the development of discomfort. Even seating that is well cushioned may not fully compensate for the cumulative effects of sustained spinal loading and reduced muscular movement. In addition, the strong preference for adjusting the seat height, despite the reported compatibility with table height, may indicate a degree of anthropometric mismatch. Users may adapt their posture to fixed furniture dimensions, which can lead to subtle biomechanical compromise that may not be immediately reflected in simple satisfaction ratings. Finally, the distribution of discomfort across different regions of the spine suggests that posture variation may be limited within the studio environment. Overall, these findings highlight the need to move beyond simple measures of comfort and consider seating approaches that incorporate biomechanical support and allow greater adaptability.

4. Discussion

This study examined perceived structural comfort, anthropometric compatibility, and region specific musculoskeletal discomfort associated with a DS chair used in an educational studio setting. Although seat pan cushioning (89.7%) and backrest padding (75.9%) received positive ratings, considerable discomfort was still reported in the buttocks (58.6%), lower back (44.8%), and upper back (41.4%). These results highlight a clear difference between subjective perceptions of structural comfort and actual biomechanical suitability during prolonged sitting. This pattern is consistent with the comfort-discomfort distinction described by Vink and Hallbeck (2012), who argued that perceived comfort does not always indicate reduced biomechanical loading. In a similar way, Naddeo et al. (2015) showed that subjective comfort ratings do not always correspond with effective pressure distribution or internal tissue loading.

The clustering of discomfort in the main load bearing regions also corresponds with established explanations of spinal loading during sitting. Grujicic et al. (2010) demonstrated that prolonged sitting tends to concentrate mechanical stress in specific anatomical areas. In addition, Zaman et al. (2022) noted that sustained static loading contributes to localised biomechanical strain. Together, these findings support the interpretation that structural cushioning on its own may not adequately reduce deeper tissue stress during prolonged seated exposure.

4.1. Pelvic Loading and Buttocks Discomfort

Buttocks discomfort showed the highest prevalence (58.6%), suggesting concentrated loading beneath the ischial region during prolonged sitting. This finding is consistent with pressure mapping studies reported by Naddeo et al. (2018), who demonstrated that localised compression under the ischial tuberosities is a major contributor to perceived seating discomfort. In a similar way, Kim et al. (2015) reported that even ergonomically shaped seats can still produce focal pressure accumulation when sitting is sustained for long periods.

Although soft cushioning can improve the initial perception of comfort, Mandal (1981) cautioned that excessive sinking of the pelvis may encourage posterior pelvic tilt and reduce lumbar lordosis. Supporting this explanation, Tan et al. (2015) observed that material softness alone does not necessarily provide adequate postural stability. From a spinal loading perspective, Chaffin et al. (2006) and Halpern (1992) explained that posterior pelvic rotation increases compression within the lumbar discs and shifts mechanical load toward passive spinal tissues. Taken together, these findings support the argument proposed by Garosi et al. (2025) that effective seating design should focus on pressure redistribution and pelvic stabilisation rather than relying solely on cushioning softness.

4.2. Lumbar and Thoracic Discomfort

Lower back (44.8%) and upper back (41.4%) discomfort were also frequently reported. These findings are consistent with biomechanical studies showing that prolonged static sitting can increase lumbar disc pressure and contribute to fatigue in the trunk muscles. For instance, Beach et al. (2005) reported increased passive lumbar stiffness following extended seated exposure, while Gregory et al. (2006) observed changes in trunk muscle activation patterns during prolonged sitting. Sustained trunk flexion shifts mechanical loading from active musculature to passive spinal structures, which may lead to creep deformation and increased mechanical strain, as described by Chaffin et al. (2006). In addition, Claus et al. (2018) noted that variations in sitting posture influence spinal muscle activity, highlighting the role of prolonged flexed postures in the development of discomfort. In studio environments where tasks often involve forward leaning positions during drafting or computer based work, these postural demands are likely to increase thoracolumbar stress. Taken together, these findings support Mandal's (1981) view that static sitting is not inherently restful but can place significant biomechanical demands on the musculoskeletal system.

4.3. Structural Comfort Versus Functional Support

Despite the high satisfaction reported for seat pan and backrest cushioning, discomfort in specific body regions was still observed. This result highlights the difference between short term perceptions of comfort and long term biomechanical protection. Vink and Hallbeck (2012) emphasised that perceived comfort does not always reflect favourable internal loading conditions. In a similar way, Naddeo et al. (2015) reported that subjective comfort ratings do not always correspond with objective biomechanical measures. Perceived comfort is often influenced by surface properties and user familiarity, whereas biomechanical suitability depends on factors such as pelvic orientation, preservation of lumbar curvature, and the ability to vary posture. Marras and Karwowski (2021) emphasised the importance of incorporating biomechanical modelling into ergonomic evaluation in order to better understand musculoskeletal loading. In addition, Frey et al. (2022) demonstrated that dynamic seating systems can influence spinal alignment without necessarily improving perceived comfort. For this reason, ergonomic assessment should combine perceptual feedback with biomechanical evaluation rather than relying only on comfort ratings.

4.4. Anthropometric Compatibility

Although 92.6% of the participants reported that the chair was compatible with the table height, 65.5% indicated that they would prefer the seat to be lower. This difference suggests the possibility of anthropometric mismatch that exists independently of general workstation alignment. As noted by Lis et al. (2007), seated posture and workstation configuration are closely related to musculoskeletal discomfort, particularly when lower limb positioning is restricted. If seat height is excessive relative to lower leg length, pressure may increase beneath the thighs and circulation may be reduced, which can contribute to discomfort in the lower limbs. Anthropometric mismatch in educational and seated work environments has been widely reported in the literature. For example, Lee (2019) demonstrated that when furniture dimensions do not correspond with user anthropometry, postural mechanics can become compromised. Similarly, Jaggi (2011) reported significant differences between student body dimensions and the design of classroom furniture. These findings highlight the importance of providing independent seat height adjustment in order to accommodate variations in body size and reduce biomechanical strain.

4.5. Static Exposure and Studio Context

Prolonged static sitting has been linked to increased trunk stiffness, reduced circulation and the development of musculoskeletal fatigue. Beach et al. (2005) showed that sustained sitting can increase passive lumbar stiffness, while Kett et al. (2021) reported that reduced muscular activity during extended periods of chair sitting may contribute to tissue stiffness and discomfort. The pattern of discomfort observed in this study is similar to that reported in sedentary occupational groups. For example, Lis et al. (2007) identified strong associations between prolonged sitting and the development of low back pain in occupational settings. In a related study, Morse et al. (2010) reported comparable regional discomfort patterns among professionals who spend long periods seated. Educational studio environments may present an additional risk because students often remain seated for long project based tasks with limited opportunities to change posture. Consistent with the dynamic seating principles described by Mandal (1981) and further discussed by Frey et al. (2022), insufficient posture variation may increase cumulative biomechanical strain. These findings therefore highlight the importance of introducing ergonomic awareness and interventions early within training environments.

4.6. Theoretical Implications

The results are consistent with Mandal's *Homo Sedens* framework, which emphasises that the human body is not biomechanically adapted for prolonged static sitting. Mandal (1981) argued that static seated alignment restricts pelvic movement and gradually increases spinal loading. The persistence of pelvic and spinal discomfort despite positive structural comfort ratings therefore supports this theoretical perspective. The findings also reflect the broader shift in ergonomics from posture correction towards posture variability and dynamic seating principles. Frey et al. (2022) showed that dynamic chair configurations can influence spinal alignment and load distribution, while Marras and Karwowski (2021) highlighted the importance of incorporating biomechanical considerations into ergonomic design rather than relying only on static posture guidelines. Dynamic seating mechanisms and sit stand strategies may therefore reduce cumulative spinal loading by redistributing mechanical stress and encouraging greater posture variation.

4.7. Practical Implications

The results indicate that ergonomic redesign should focus on seat geometry that promotes effective pressure distribution. Naddeo et al. (2018) demonstrated that localised pressure concentration plays an important role in the development of seating discomfort, highlighting the need for improved load redistribution. Adjustable seat height that operates independently of desk height is also essential. Lee (2019) noted that anthropometric variability requires adaptable seating systems to avoid biomechanical compromise, while Hsiao (2021) emphasised the risks associated with fixed workstation configurations. Lumbar support that helps maintain natural spinal curvature is another important consideration. Chaffin et al. (2006) reported that maintaining lumbar curvature reduces loading on passive spinal tissues, and Mandal (1981) emphasised the importance of pelvic orientation in preserving spinal alignment. Encouraging posture variability should also be part of redesign strategies. Berlin and Adams (2017) argued that modern ergonomics should support dynamic work systems, and Frey et al. (2022) demonstrated that movement oriented seating can help reduce cumulative loading. As a result, seating should be evaluated as part of a complete workstation system that considers the interaction between the seat, desk, and task demands, in line with systems based ergonomic frameworks described by Perez (2019) and Marras and Karwowski (2021).

5. Conclusion

In this study, the perceptual and biomechanical implications of prolonged use of a Design Studio (DS) chair within an educational studio environment were examined. Although structural components of the chair, particularly the seat pan and backrest cushioning, received positive ratings from most participants, considerable discomfort was reported in key load bearing regions, especially the buttocks (58.6%), lower back (44.8%), and upper back (41.4%). These findings demonstrate a clear difference between perceived structural comfort and functional biomechanical adequacy. The high prevalence of buttocks and lumbar discomfort is consistent with established models of seated pressure concentration and sustained spinal flexion. The results support Mandal's *Homo Sedens* framework, which proposes that static sitting, even in chairs that appear comfortable, places mechanical demands on the body that exceed natural biomechanical adaptation. Cushioning alone does not eliminate cumulative spinal loading when posture variation is limited.

The preference for reducing seat height, despite the high level of reported compatibility with the table height, also highlights the importance of anthropometric adaptability. Workstation alignment does not necessarily ensure optimal lower limb or pelvic positioning. This finding emphasises the need for seating systems with adjustable parameters that can accommodate individual differences. The results indicate that ergonomic evaluation should move beyond surface

comfort and consider dynamic biomechanical performance. Seating design should prioritise effective pressure distribution, preservation of lumbar curvature, posture variability and alignment with task demands. Educational studio environments, where prolonged sitting is common, represent an important context for early ergonomic intervention and musculoskeletal health prevention. Although the study was limited by a relatively small sample size and reliance on self-reported measures, it provides useful evidence linking perceived discomfort patterns with known biomechanical mechanisms. Future research that incorporates objective assessment methods such as pressure mapping, motion analysis, and longitudinal monitoring would provide a clearer understanding of how seating design influences musculoskeletal outcomes.

In summary, the DS chair evaluated in this study demonstrates adequate structural comfort but shows functional limitations during prolonged use. Improving seated environments requires a shift away from static posture correction towards movement oriented and anthropometrically adaptable design. Such an approach is consistent with contemporary ergonomic theory and supports long term spinal health in both educational and occupational settings.

Recommendations

Sequel to the perceptual and biomechanical findings, ergonomic improvements should prioritise biomechanical optimisation rather than cushioning alone. Although structural comfort ratings were high, discomfort remained evident in load bearing regions, particularly the buttocks and lower back.

First, adjustable seat height is essential. Despite high reported compatibility with table height (92.6%), most participants preferred a lower seat (65.5%), suggesting anthropometric mismatch independent of workstation alignment. Independent seat height adjustment is therefore necessary to improve foot floor contact, knee angle, and pelvic orientation for different users. Second, seat pan design should emphasise effective pressure redistribution. The high prevalence of buttocks discomfort (58.6%) indicates localised loading beneath the ischial region. Improvements such as contoured seat geometry, medium density cushioning, reduced compression at the seat edge and optional forward seat tilt may enhance load distribution and pelvic stability.

Third, lumbar support should better preserve natural spinal curvature. The prevalence of lower back discomfort (44.8%) suggests that the existing design may not sufficiently maintain lumbar alignment during prolonged sitting. Adjustable and responsive lumbar support systems may help reduce sustained spinal loading. Fourth, seating should allow greater posture variability. In line with Mandal's *Homo Sedens* concept, static sitting should be avoided where possible. Features that encourage small movements, such as flexible backrests or pivot mechanisms, may reduce cumulative biomechanical strain.

Finally, seating should be evaluated within the context of the entire workstation system, including desk height, visual requirements, and task orientation. Future research should incorporate objective biomechanical measurements such as pressure mapping, electromyography and motion capture to support perceptual findings. Longitudinal studies would help assess how symptoms develop over time and how ergonomic interventions influence outcomes. Larger and more diverse samples would also improve the generalisability of results. Experimental comparisons between static and dynamic seating systems may further clarify optimal design parameters. Together, these strategies support a transition towards anthropometrically adaptable and movement oriented seating design in both educational and occupational environments.

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