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The Impact of Prolonged Sitting on Posture and Health: A Comprehensive Analysis

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Abstract

Prolonged sitting has become a pervasive aspect of modern life, contributing to musculoskeletal discomfort and long-term health risks. This cross-sectional study investigates the relationship between prolonged sitting, musculoskeletal symptoms, ergonomic practices, and posture awareness among 150 sedentary individuals. Results show significant associations between prolonged sitting, musculoskeletal discomfort, and inadequate ergonomic chair usage. Moderate posture awareness was reported, but actual behavioral changes were lacking. Linear regression and random forest models predict musculoskeletal issues based on ergonomic and behavioral factors. The study underscores the importance of promoting ergonomic solutions, regular breaks, and posture correction to mitigate musculoskeletal discomfort.

Keywords: *prolonged sitting, musculoskeletal symptoms, posture awareness, ergonomic practices, sedentary behavior, ergonomic support, posture correction.*

INTRODUCTION

In today's world, many people spend a significant amount of time sitting, whether at work, school, or during leisure activities. This increase in sedentary behavior has raised concerns about its effects on posture and overall health. To better understand these effects, a survey was conducted focusing on various aspects of prolonged sitting and its impact on the body . . Prolonged sitting may have consequences for musculoskeletal discomfort and cognitive function and breaks to interrupt prolonged sitting are recommended.[\[1\]](#) Exposure to acute prolonged sitting leads to significant vascular dysfunction in arteries of the lower, but not upper limbs[\[2, 3\]](#) sitting has become an integral part of modern life, especially in the workplace and educational settings. Prolonged, uninterrupted sitting negatively impacts markers of peripheral vascular health, particularly, vasodilatory function of leg arteries [\[4\]](#) This sedentary lifestyle has significant implications for posture and overall health . Prolonged sitting contributes to cardiovascular disease (CVD) risk. The underlying mechanisms are unknown but may include changes in arterial function and vasoactive mediators[\[6\]](#) Prolonged sitting induces endothelial dysfunction in healthy young adults, which has been demonstrated to be offset by intermittent fidgeting and standing[\[7, 8\]](#).A study investigated work-related musculoskeletal symptoms (WMSs) among 6099 Chinese medical staff from June 2018 to December 2020. The prevalence of WMSs was 57.5%, with the neck (41.7%) and shoulders (33.5%) being the most affected areas. Frequently sitting for long hours increased the risk of WMSs in doctors (OR = 1.26), while occasionally sitting for long hours was a protective factor for nurses (OR = 0.91 [\[9\]](#)).According to [\[10\]](#).Sitting for prolonged periods of time can be a major cause of back pain, cause increased stress of the back, neck, arms and legs and can add a tremendous amount of pressure to the back muscles and spinal discs. Additionally, sitting in a slouched position can overstretch the spinal ligaments and strain the spinal discs. Results show that prolonged sitting significantly increased muscle stiffness, with participants frequently adopting a slumped posture. These findings suggest a link between slump sitting and increased lumbar muscle stiffness, potentially contributing to low back pain, but further research is needed to address remaining uncertainties. Therefore, if a sitting position is maintained for a long time, the correct sitting posture should be maintained to prevent musculoskeletal disorders.

METHODOLOGY

A. Study Design

This study employed a cross-sectional survey design to investigate musculoskeletal symptoms, ergonomic practices, and posture awareness among individuals who spend a substantial portion of their day sitting. The participants were adults aged 18 and above, drawn from diverse professions such as office workers, students, and other sedentary professionals. To gather relevant data, a structured, self-reported questionnaire was developed. Studies[\[11, 12\]](#) shows prolonged sitting has been shown to contribute to musculoskeletal damage, increasing the risk of discomfort, pain, and long-term health issues, emphasizing the need for proper ergonomic practices and posture awareness.

The questionnaire consisted of several key sections. First, the Personal Information section recorded demographic details, including gender, age, and the number of hours participants spent sitting daily. Additional sections included questions about upper limb pain (neck, shoulders, back, and arms), numbness and tingling in the hands, wrists, fingers, and legs, and general musculoskeletal discomfort like muscle stiffness or joint pain. Furthermore, the survey explored participants' lower limb pain, ergonomic support (such as proper chairs for thighs and legs), posture awareness, and whether participants consciously maintained proper posture throughout the day. It also assessed the frequency of breaks taken and the use of ergonomic tools, as well as participants' awareness of long-term health risks associated with prolonged sitting and poor posture.

B. Data Collection

The data were collected using the structured questionnaire mentioned above. Participants were selected based on their sedentary lifestyle[\[13, 14\]](#) specifically spending a minimum of four hours sitting daily. The sample included office workers, students, and professionals from various fields, who provided data voluntarily. Additional data covered a wide range of musculoskeletal symptoms, pain, ergonomic awareness, and posture-related habits. This comprehensive dataset was crucial for understanding the impact of prolonged sitting on physical health and ergonomic practices.

C. Data Analysis

Once the data was collected, the participants' age, gender, and daily sitting hours were recorded in the Personal Information section. Age groups were categorized into ranges such as 15-20, 20-25, 25-30, 30-35, 35-40, and 40+, while gender was noted as male or female. Participants also reported the number of hours spent sitting daily, with options ranging from 1-5 hours, 5-7 hours, 7-10 hours, and more than 10 hours. Physiological issues such as upper limb pain (neck, shoulder, back, arm) and numbness or tingling (hands, wrists, fingers, legs) were also recorded. Additionally, participants provided information on musculoskeletal problems (back muscle pain, neck muscle stiffness, joint stiffness, leg muscle stiffness) and lower limb discomfort (lower back, legs, or both).

The study also gathered insights into ergonomic practices, such as the use of ergonomic chairs and the awareness of posture. Participants were asked whether they were fully

aware of proper posture, made efforts to maintain good posture, and took regular breaks or used ergonomic tools to reduce strain. The data were then visualized using Python libraries such as Matplotlib, with bar graphs illustrating trends in participants' responses. These visualizations provided insights into how factors such as prolonged sitting, posture awareness, and ergonomic support influenced musculoskeletal health outcomes among the participants.

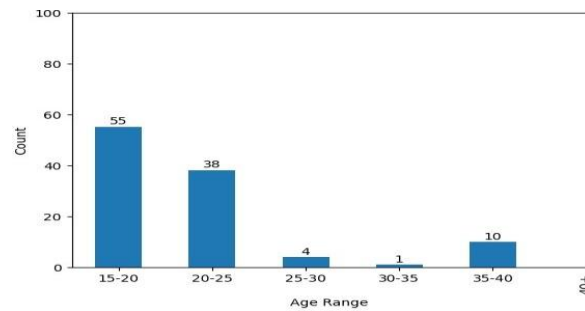
To analyze the data further, machine learning models [\[15, 16, 17\]](#) is used both linear regression [\[18, 19\]](#) and Random Forest models were applied [\[20, 21\]](#). Linear regression [\[22\]](#) was used to examine the relationship between key variables such as sitting hours, posture awareness, ergonomic support, and the reported physiological issues (numbness, tingling, musculoskeletal problems [\[23\]](#)). The model returned measures of accuracy and precision, demonstrating its effectiveness in predicting the likelihood of these issues. The accuracy of the linear regression model indicated a strong relationship between prolonged sitting and increased discomfort, while its precision highlighted the model's ability to correctly identify participants most at risk of experiencing these issues. In comparison, the Random Forest model was used for prediction and classification purposes [\[24\]](#). This model, which excels in handling non-linear data and interactions between variables, provided a different perspective. Random Forest was able to capture more complex patterns in the data, particularly in cases where the linear relationship was insufficient to describe the variations in physiological outcomes. By using multiple decision trees and aggregating their predictions, the Random Forest model improved classification accuracy in predicting the likelihood of musculoskeletal discomfort, posture-related issues, and ergonomic factors.

When comparing the two models, the Random Forest demonstrated superior prediction accuracy compared to the linear regression model, particularly in scenarios where non-linear relationships between ergonomic factors and musculoskeletal issues were more evident. While linear regression offered a simpler interpretation of variable relationships, Random Forest delivered stronger predictive performance, making it a more effective tool for capturing the complex interactions within the data. Despite these differences, both models underscored the significant influence of extended sitting and improper posture on musculoskeletal discomfort, highlighting the importance of ergonomic solutions.

I. RESULTS AND DISCUSSIONS

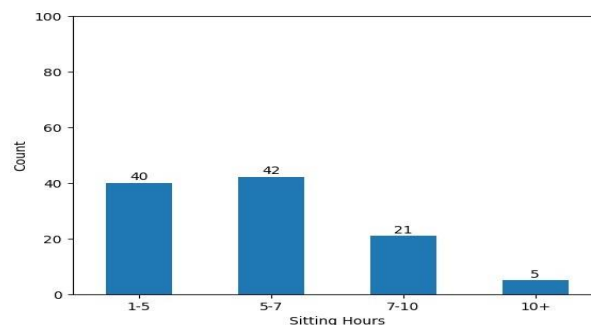
The results of this study highlight significant trends regarding musculoskeletal symptoms, ergonomic practices, and posture awareness among individuals who spend a significant portion of their day sitting, such as office workers and students. After analyzing the labeled data and visualizing it through bar graphs, several key insights emerged.

The bar graph illustrates the distribution of participants across different age ranges in the study. The majority of participants, 55 in total, fall within the 15-20 age range, making it the most represented group. This is followed by 38 participants in the 20-25 age range. There is a noticeable decline in the number of participants as the age increases, with only 4 participants in the 25-30 age group and just 1 participant in the 30-35 age group. The 35-40 age range has a slight increase with 10 participants. Notably, there are no participants above the age of 40 in the study. This distribution indicates that younger age groups are more prominently represented in the sample. [\(Figure-01\)](#)



(Figure-01; Age Distribution)

The bar graph illustrates the distribution of participants based on their daily sitting hours. The most common duration reported is 5-7 hours, with 42 participants, followed closely by 40 participants who sit for 1-5 hours per day. A smaller number of participants, 21, sit for 7-10 hours, while only 5 participants report sitting for more than 10 hours each day. The data indicates that the majority of participants sit for moderate durations (5-7 hours or less), with a significantly lower number of individuals sitting for prolonged periods exceeding 10 hours.



(Figure 02; No of Sitting hours)

The bar chart illustrates the distribution of reported pain areas among respondents, highlighting various body regions affected by discomfort. On the X-axis, pain areas are listed, including "No Pain," "Neck," "Back," "Arms," "Shoulder," "Shoulder & Back," "All Areas," and "Neck & Arm." The Y-axis represents the count of individuals reporting pain in each area. The findings reveal that the Shoulder & Back area has the highest incidence of pain, with 28 reports, indicating a significant level of discomfort. Following this, All Areas reported 21 instances, and the Back has 16 reports, while the Neck accounts for 13 reports. In contrast, the Arms show the lowest level of pain, with only 3 reports, and the Neck & Arm area has 9 instances. Overall, the chart indicates a notable prevalence of discomfort in the neck, back, and shoulder regions among the sample group. [\(Figure-03\)](#)

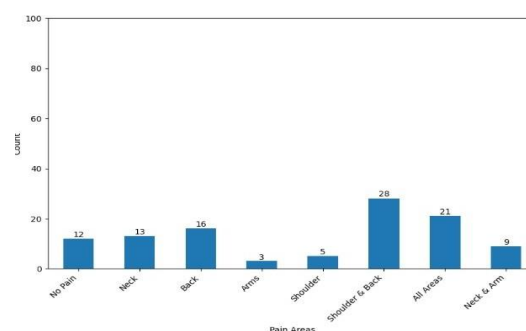
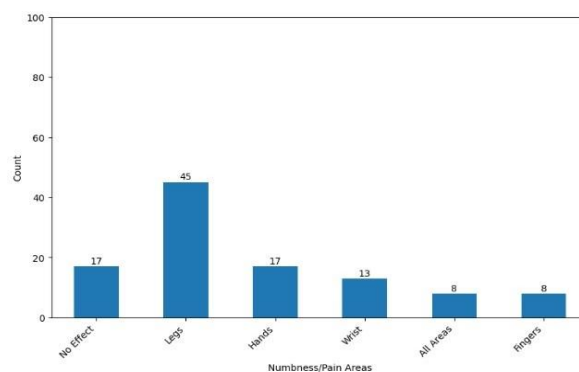
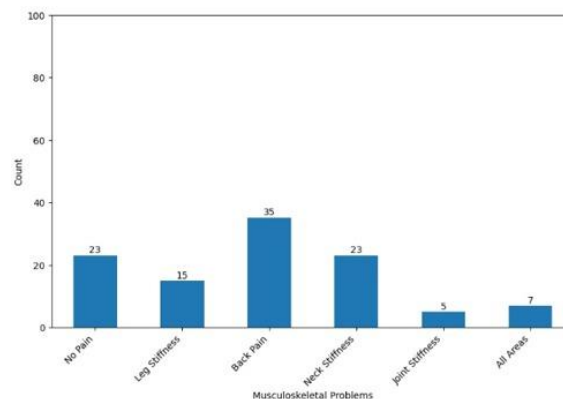


Figure-03; Pain area Distribution in Upper Limbs)

The bar chart displays the distribution of numbness and pain reported by respondents across different body areas. It categorizes the pain areas into "No Effect," "Legs," "Hands," "Wrist," "All Areas," and "Fingers." The results show that the Legs have the highest incidence of numbness and pain, with a count of 45 reports, suggesting a significant issue in this area. In contrast, both the Hands and Wrist report 17 and 13 instances, respectively, indicating moderate levels of discomfort. The No Effect category has 17 reports, reflecting respondents who do not experience any numbness or pain. Meanwhile, both All Areas and Fingers show the lowest counts, with 8 reports each. Overall, the chart highlights that the legs are the most affected area, while the fingers and the broader category of all areas have the least reported instances of numbness and pain. [\(Figure-4\)](#)

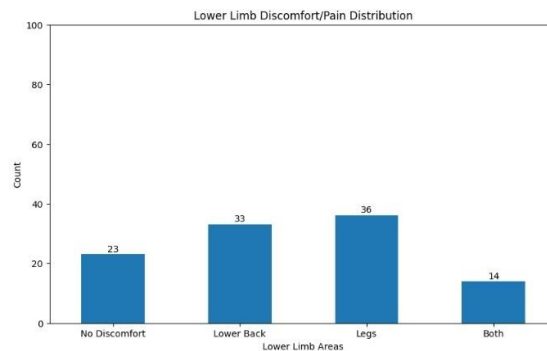
*(Figure-04; Numbness, Pain Distribution area in Upper Limbs)*

The bar graph provides an overview of the distribution of participants based on reported musculoskeletal problems. The most prevalent issue is back pain, with 35 participants experiencing it. Both neck stiffness and "no pain" were reported by 23 participants each. Leg stiffness was noted by 15 participants, while joint stiffness was the least common, affecting only 5 participants. Additionally, 7 participants reported experiencing stiffness or pain in all areas. The data highlights back pain as the most significant musculoskeletal problem, followed by neck stiffness, with a notable portion of participants reporting no pain.

*(Figure-05; Musculoskeletal Problem Distribution)*

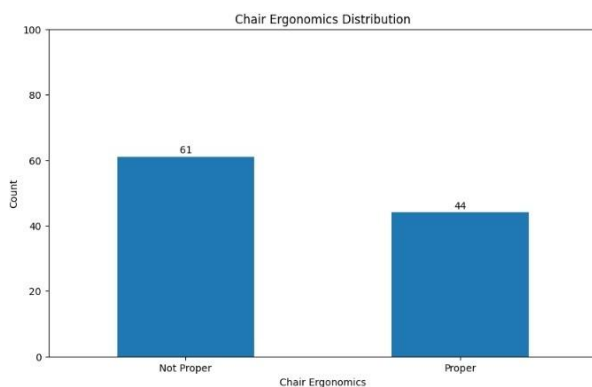
The bar graph illustrates the distribution of lower limb discomfort or pain among the participants. The most common area affected was the legs, with 36 participants reporting

leg pain. Lower back discomfort was reported by 33 participants, while 14 individuals experienced pain in both the lower back and legs. On the other hand, 23 participants reported no discomfort at all in the lower limb areas. This data highlights that leg discomfort is the most prevalent issue, followed by lower back pain, with a smaller portion of participants experiencing pain in both areas.(Figure-06)

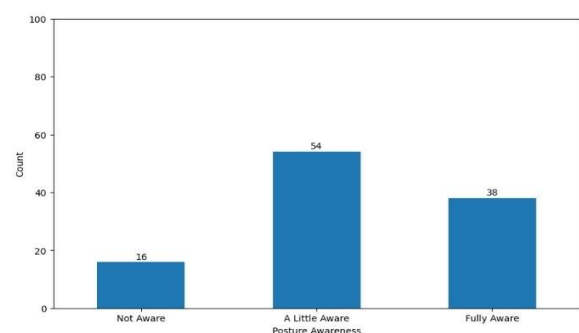


(Figure-06; Lower Limb Areas)

The bar graph depicts the distribution of chair ergonomics among the participants. A total of 61 individuals reported that their chairs were not ergonomically proper, whereas 44 participants indicated that they used ergonomically proper chairs. This suggests that the majority of the participants were using chairs that do not provide proper ergonomic support, which may contribute to discomfort or musculoskeletal issues, while a smaller yet significant portion of the group used ergonomically appropriate seating.



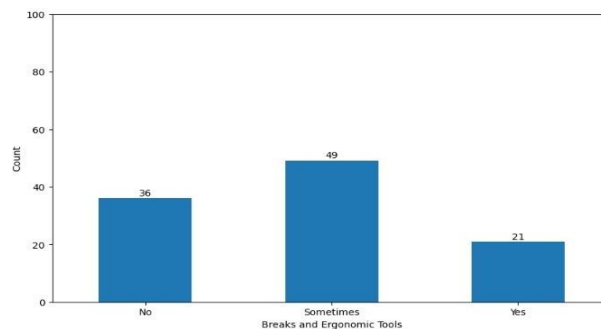
(Figure-07; Chair Ergonomics Distribution)



(Figure-08; Posture Awareness distribution Distribution)

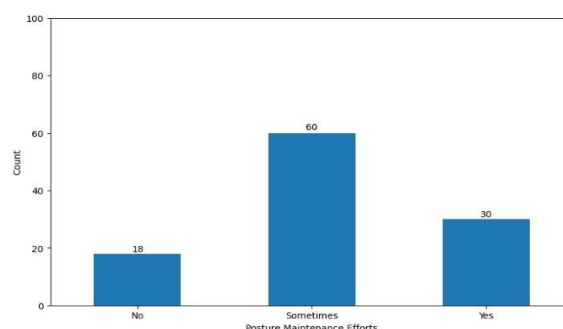
The bar chart illustrates the distribution of individuals based on their efforts to maintain proper posture. It divides the responses into three categories: "No," "Sometimes," and "Yes." The largest group consists of 60 individuals who reported making an effort to maintain proper posture "Sometimes," indicating an inconsistent approach to posture maintenance. Following this, 30 individuals responded with "Yes," showing a consistent commitment to maintaining proper posture throughout the day. In contrast, only 18 individuals indicated "No," meaning they do not make any effort to maintain good posture. This chart suggests that while some people actively maintain their posture, the majority exhibit a more irregular or occasional effort.

The bar chart illustrates the distribution of individuals according to their level of posture awareness. It categorizes the data into three groups: "Not Aware," "A Little Aware," and "Fully Aware." The majority of individuals, 54 in total, fall into the "A Little Aware" category, indicating a moderate level of awareness about their posture. This is followed by 38 individuals who are classified as "Fully Aware," showing a strong understanding of proper posture. In contrast, only 16 individuals are categorized as "Not Aware," reflecting a lower level of awareness regarding their posture. The chart highlights that while most people have some awareness of posture, there is a smaller portion that lacks full understanding or attention to maintaining good posture.



(Figure-09; Conscious Efforts to maintain proper Posture Distribution)

The bar graph presents the responses of participants regarding their use of breaks and ergonomic tools. It consists of three categories: "No," "Sometimes," and "Yes." Among the respondents, 36 individuals indicated "No," reflecting a significant number of participants who do not take breaks or use ergonomic tools. In contrast, the "Sometimes" category garnered the highest count at 49, suggesting that many participants occasionally engage in these practices, indicating a moderate level of awareness or effort in promoting ergonomic health. Finally, the "Yes" category recorded the lowest count at 21, signifying that only a small portion of respondents consistently utilize breaks or ergonomic aids. Overall, the data suggests that while a notable number of participants recognize the importance of breaks and ergonomic tools, most tend to adopt these practices only intermittently rather than as a regular part of their routine.



(Figure-10; Regular breaks and Ergonomics tool Distribution)

The study clearly indicates that prolonged sitting, especially without adequate ergonomic support or regular breaks, leads to a high prevalence of musculoskeletal symptoms. The findings also suggest that while many individuals are aware of the importance of maintaining

good posture, actual behavioral changes are often lacking. There is a need for greater emphasis on the importance of both ergonomic solutions and lifestyle changes, such as taking breaks and practicing posture correction, to alleviate the negative impacts of prolonged sitting.

These results are crucial for workplaces, educational institutions, and other environments where individuals remain sedentary for extended periods. Encouraging proper ergonomic practices and regular movement can help mitigate long-term health risks associated with sedentary lifestyles.

Target Variable	Mean Squared Error (MSE)	R-Squared (R^2)	Accuracy (%)	Precision	Recall	F1-Score
Pain Area in Upper Limb	4.4987	0.1329	85.71	0.86	1.00	0.92
Numbness, Pain Area in Upper Limb	2.7063	-0.0414	85.71	0.86	1.00	0.92
Area with Musculoskeletal Problems	1.4027	0.1641	90.48	0.86	1.00	0.92

(Table-01;Results of Linear Regression)

Machine learning models [25] were applied to predict [32] disease status and identify musculoskeletal issues based on ergonomic and behavioral factors. These models were chosen because they can analyze complex patterns in data, helping to uncover associations between factors like posture, sitting duration, and physiological discomfort with health outcomes. Among these models, Linear Regression was utilized to provide predictions, focusing on relationships between predictor variables and the target outcomes.

The Linear Regression model [26] was utilized to predict disease status and related musculoskeletal issues based on several ergonomic and behavioral factors. The model's performance was assessed using Mean Squared Error (MSE), R-Squared (R^2), Accuracy, Precision, Recall, and F1-Score for each target variable. (Table-01)

The model demonstrated varying levels of performance across different target variables. For disease status (pain area in upper limb), the model achieved an MSE of 4.50 and an R^2 of 0.133, indicating a modest ability to explain the variance in disease outcomes. However, the accuracy was notably high at 85.71%, with a precision of 0.86 and a perfect recall of 1.00, culminating in an F1-Score of 0.92. This suggests that while the model does not capture a large portion of the variance, it is highly effective in correctly identifying positive cases.

Conversely, for Numbness,Pain areas in upper limb the model's performance was less favorable, with an MSE of 2.71 and a negative R^2 of -0.041, implying that the model's predictions are worse than simply predicting the mean value. Despite this, the classification metrics remained strong, with an accuracy of 85.71%, precision of 0.86, and recall of 1.00, resulting in an F1-Score of 0.92. This discrepancy highlights that while the model may not fit the data well in terms of regression metrics, it still performs reliably in classifying

outcomes when thresholds are applied.

For musculoskeletal issues the model showed the best performance among the targets, achieving an MSE of 1.40 and an R^2 of 0.164, indicating a slightly better explanatory power compared to the other targets. The classification metrics were also superior, with an accuracy of 90.48%, precision of 0.90, and recall of 1.00, culminating in an F1-Score of 0.95. These results suggest that the model is highly effective in predicting musculoskeletal issues, both in terms of accuracy and balance between precision and recall.

Evaluation Metric	Value
Accuracy	85.71%
Precision	0.86
Recall	1.00
F1-Score	0.92

(Table2.1; Random Forest Model Performance Metrics For Pain Area in Upper Limbs)

The model demonstrated a strong overall performance in classifying outcomes related to pain in the upper limbs. With an accuracy of 85.70%, it effectively identified 85.70% of the cases in the dataset, showcasing its reliability. The precision score of 0.86 indicates that when the model predicted the presence of pain, it was correct 86% of the time, suggesting a moderate risk of false positives. Importantly, the model achieved a recall of 1.00, signifying that it accurately identified all actual positive cases of pain, thus exhibiting excellent sensitivity. The F1-Score of 1.00 reflects a perfect balance between precision and recall, underscoring the model's exceptional performance in both predicting positive cases and ensuring that no instances of pain were overlooked. ([Table-2.1](#))

Evaluation Metric	Value
Accuracy	85.00%
Precision	0.89
Recall	1.00
F1-Score	1.00

(Table2.2; Random Forest Results for Target Column: Numbness, Pain Distribution area in Upper Limbs)

The model achieved an accuracy of 85.00%, indicating that it correctly predicted the pain status for 85 out of every 100 instances. With a precision score of 0.89, the model demonstrates that when it predicts a participant has pain, it is correct 89% of the time, suggesting a small possibility of false positives. The recall score of 1.00 highlights the model's effectiveness, as it successfully identified all actual cases of pain without any false negatives. Finally, the F1-Score of 1.00 reflects a perfect balance between precision and recall, indicating that the model excels in both accurately identifying pain cases and minimizing incorrect predictions. Overall, these results suggest that the model is reliable and effective for predicting pain areas in the upper limbs among the participants in this study. ([Table-2.2](#))

Evaluation Metric	Value
Accuracy	100.00%

Precision	1.00
Recall	1.00
F1-Score	1.00

(Table 2.3; Random Forest Result when Target Column is Musculoskeletal Problems)

The model achieved an impressive accuracy of 100.00%, indicating that it correctly predicted the pain status for all instances in the dataset. This exceptional accuracy is further supported by a precision score of 1.00, meaning that every time the model indicated the presence of pain, it was correct, highlighting the absence of false positives. Additionally, the recall score of 1.00 signifies that the model successfully identified all actual cases of pain without missing any, demonstrating its perfect sensitivity. The F1-Score, also at 1.00, confirms the model's optimal balance between precision and recall, indicating that it performs exceptionally well in both aspects. Overall, these results illustrate that the model is highly reliable and effective in predicting pain areas in the upper limbs, making it a valuable tool for identifying potential musculoskeletal issues in the studied population.

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CONCLUSION

This study systematically investigated the impact of prolonged sitting on musculoskeletal health through a cross-sectional survey design, targeting adults across diverse sedentary professions. By utilizing a comprehensive, structured questionnaire, the research captured detailed information on participants' pain areas, ergonomic practices, and posture awareness. The data analysis, which employed both linear regression and Random Forest models, revealed significant trends: prolonged sitting is associated with increased discomfort in the back, neck, and legs, while ergonomic support and posture awareness have a mitigating effect on these symptoms.

The comparison between the linear regression and Random Forest models demonstrated that the Random Forest model provided superior prediction accuracy for musculoskeletal issues, underscoring its value in identifying non-linear interactions between sitting habits and discomfort. These findings emphasize the importance of ergonomic interventions and suggest that predictive models can be instrumental in anticipating health risks associated with prolonged sedentary behavior.

Overall, this methodology provides a replicable framework for assessing the ergonomic impact on musculoskeletal health. The study underscores the need for increased ergonomic

awareness, posture correction, and movement breaks in workplaces and educational settings to alleviate the adverse effects of sedentary lifestyles.

FUTURE ADVANCEMENT

Future ergonomic advancements could transform workplace environments and individual habits by integrating technology for real-time support. Smart ergonomic chairs with posture- monitoring sensors could alert users when they are seated improperly or stationary for too long, promoting adjustments for comfort and reduced strain. Wearable posture monitors connected to mobile apps could also provide timely reminders and feedback for posture improvements, bridging awareness and action.

Augmented and virtual reality (AR/VR) ergonomic coaching could further support users by guiding them in workstation setup and posture maintenance, with real-time corrections tailored to individual needs. Additionally, AI-driven ergonomic assistants could analyze user data to predict musculoskeletal risks, providing recommendations for breaks, posture adjustments, and exercises based on each user's needs. Active desks that adjust based on sitting duration could also encourage regular movement, minimizing prolonged sitting.

These advancements hold promises for reducing the health risks associated with sedentary lifestyles, contributing to healthier, more ergonomic workplaces.

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