MING-STYLE WOODEN SEAT FURNITURE FRAMEWORK FOR ENHANCED ERGONOMIC DESIGN

By

BAI YIFAN

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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February 2025

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Chinese Ming-style wooden furniture is widely recognised for its exquisite craftsmanship, minimalist elegance, and deep cultural heritage. Traditionally admired for its visual appeal and symbolic value, Ming-style seating occupies an important place in Chinese design history. However, as society continues to evolve and industrial design advances, the importance of ergonomics in furniture design has gained increasing attention. This shift calls for a revaluation of traditional furniture, particularly in terms of user comfort and functionality. Despite its cultural significance, the ergonomic aspects of Ming-style wooden seat furniture have long been neglected by designers and manufacturers. Most existing designs are not well-suited to modern ergonomic standards, often featuring rigid forms and fixed dimensions that compromise comfort. While these pieces succeed aesthetically and culturally, they tend to fall short in providing the level of physical support and usability expected by contemporary users. This disconnect highlights a critical issue in aligning traditional design values with present-day ergonomic requirements. In response to this challenge, the research aims to develop the Ergonomic Design Framework (EDF) a structured

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and innovative approach designed to harmonize the traditional aesthetics of Ming-style furniture with modern ergonomic principles. The framework seeks to assist designers in creating furniture that retains its historical identity while enhancing comfort and usability for today's users. To achieve this, the study adopted a multi-method research design, combining a comprehensive literature review, quantitative analysis, and expert validation. Two rounds of questionnaires were conducted to collect data, involving 52 designers and manufacturers from various organizations, as well as 305 users of Ming-style furniture. This diverse sample provided a broad understanding of ergonomic preferences and needs in furniture design, contributing to the development of a more inclusive and user-centered framework. The findings of the study identified five key ergonomic aspects that should be prioritized in the design and development of Ming-style wooden seating: aesthetics, comfort, safety, usability, and productivity/efficiency. These aspects are essential to ensuring that traditional designs are both visually compelling and functionally appropriate for modern use. The research also confirmed the practical relevance of the EDF framework through validation with industry experts, reinforcing its value as a guiding tool for future furniture development. In conclusion, the study recommends that designers integrate the Ergonomic Design Framework into their design processes. By doing so, it becomes possible to create Ming-style wooden furniture that not only preserves its cultural legacy but also addresses the ergonomic expectations of contemporary users. This approach promotes a meaningful cultural-ergonomic synergy, supporting the continued relevance, usability, and marketability of these iconic pieces in today's design landscape.

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Keywords: Chinese Ming furniture, ergonomic design, aesthetic and cultural, design and development

SDG: GOAL 3: Good Health and Well-Being, GOAL 9: Industry, Innovation and Infrastructure

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Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

RANGKA KERJA KERUSI BUATAN KAYU GAYA-MING UNTUK MEMPERTINGKATKAN ERGONOMIK REKA BENTUK

Oleh

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Perabot kayu gaya Dinasti Ming China diiktiraf secara meluas kerana tukangnya yang halus, keanggunan minimalis, dan warisan budaya yang mendalam. Secara tradisinya, perabot tempat duduk gaya Ming dikagumi kerana daya tarik visual dan nilai simboliknya, serta memainkan peranan penting dalam sejarah reka bentuk China. Namun, sejajar dengan perkembangan masyarakat dan kemajuan dalam reka bentuk industri, kepentingan aspek ergonomik dalam reka bentuk perabot semakin mendapat perhatian. Perubahan ini memerlukan penilaian semula terhadap perabot tradisional, terutamanya dari segi keselesaan dan fungsi pengguna. Walaupun mempunyai nilai budaya yang tinggi, aspek ergonomik dalam reka bentuk perabot tempat duduk kayu gaya Ming telah lama diabaikan oleh para pereka dan pengeluar. Kebanyakan reka bentuk yang ada pada masa kini tidak menepati piawaian ergonomik moden, sering kali menampilkan bentuk yang kaku dan dimensi tetap yang menjejaskan keselesaan pengguna. Meskipun perabot ini berjaya dari segi estetika dan budaya, ia sering gagal memberikan sokongan fizikal dan kemudahan penggunaan yang dijangkakan oleh pengguna masa kini. Ketidaksepadanan ini menonjolkan isu penting dalam usaha

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menyelaraskan nilai reka bentuk tradisional dengan keperluan ergonomik masa kini. Sebagai tindak balas kepada cabaran ini, kajian ini bertujuan untuk membangunkan Kerangka Reka Bentuk Ergonomik (Ergonomic Design Framework - EDF), iaitu satu pendekatan berstruktur dan inovatif yang direka untuk menyatukan estetika tradisional perabot gaya Ming dengan prinsip ergonomik moden. Kerangka ini bertujuan membantu pereka bentuk menghasilkan perabot yang mengekalkan identiti sejarahnya sambil meningkatkan keselesaan dan kemudahan penggunaan bagi pengguna masa kini. Bagi mencapai matlamat ini, kajian ini mengaplikasikan reka bentuk penyelidikan pelbagai kaedah, yang merangkumi tinjauan literatur yang komprehensif, analisis kuantitatif, dan pengesahan oleh pakar. Dua pusingan soal selidik telah dijalankan untuk mengumpulkan data, melibatkan 52 orang pereka dan pengeluar dari pelbagai organisasi, serta 305 pengguna perabot gaya Ming. Sampel yang pelbagai menyediakan pemahaman yang luas tentang keutamaan dan keperluan ergonomik dalam reka bentuk perabot, sekali gus menyumbang kepada pembangunan kerangka yang lebih inklusif dan berpusatkan pengguna. Penemuan kajian ini mengenal pasti lima aspek utama ergonomik yang perlu diberi keutamaan dalam reka bentuk dan pembangunan tempat duduk kayu gaya Ming: estetika, keselesaan, keselamatan, kemudahan penggunaan, serta produktiviti dan kecekapan. Aspek-aspek ini penting untuk memastikan reka bentuk tradisional bukan sahaja menarik dari segi visual, tetapi juga sesuai dari segi fungsi untuk kegunaan moden. Kajian ini turut mengesahkan kepentingan praktikal kerangka EDF melalui pengesahan bersama pakar industri, sekali gus mengukuhkan nilainya sebagai alat panduan dalam pembangunan perabot pada masa depan. Sebagai kesimpulan, kajian ini mencadangkan agar para pereka bentuk mengintegrasikan Kerangka Reka Bentuk Ergonomik ini ke dalam proses reka bentuk mereka. Dengan berbuat demikian, ia akan menghasilkan perabot kayu gaya

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Ming yang bukan sahaja mengekalkan warisan budaya, malah memenuhi jangkaan ergonomik pengguna masa kini. Pendekatan ini menyokong sinergi antara budaya dan ergonomik yang bermakna, serta memastikan kesinambungan, kebolehgunaan, dan daya saing pasaran perabot ikonik ini dalam landskap reka bentuk masa kini.

Kata Kunci: Perabot Ming Cina, reka bentuk ergonomik, estetika dan budaya, reka bentuk dan pembangunan

SDG: MATLAMAT 3: Kesihatan yang Baik dan Sejahtera, MATLAMAT 9: Industri, Inovasi dan Infrastruktur

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Nearly four years of my PhD career are emerging as strongholds as I tap the last paragraph of my thesis on the computer. Of the last 33 years, the pursuit of education has taken up a full 20 years. I have gone from being a small child in school uniform with a big school bag to a middle-aged adult returning home from Kuala Lumpur airport with a thick thesis on my back. Time flies, and I can only look back on it in a few words. When I was a few years younger, I always hoped that I could scare the world, but in the end, I still shook hands with the world in a hurry.

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BAI YIFAN
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LIST OF ABBREVIATIONS

ISO	International Organization for standardization
EDF	Ergonomic Design Framework
KD	Knock-down
IEA	International Ergonomics Association
MSD	Musculoskeletal Disorders
SLR	Systematic Literature Review
JBI	Joanna Briggs Institute
CNKI	China National Knowledge Infrastructure
PCA	Principal Component Analysis
KMO	Kaiser-Meyer-Olkin
CITC	Corrected Item-Total Correlation
SD	Standard Deviation
ANOVA	Analysis of Variance

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter introduced the research background and issue related to the ergonomics of Chinese Ming wooden seat furniture. The research questions, research objectives, scope and area of study, and research significance are mentioned here. The structure of the thesis is presented at the end of the chapter.

1.2 Research Background

With the development of society, the degree of industrialisation has become more and more developed. With the rapid development of China's economy, the economic differences between the East and the West are shrinking, and cultural exchanges are increasing, so that the economy, technology, trade, culture, and other aspects also have shown a trend of globalisation (Zhang & Chen, 2021; Xing, 2021). On the other hand, Chinese modern furniture has gained valuable experience that traditional culture can enhance the international competitiveness of Chinese modern furniture after a series of challenges and attempts. The key factor for whether Chinese furniture design can be lasting and brilliant is how to rationally apply national culture. The growing global interest in culturally authentic yet ergonomic furniture presents a significant opportunity for Ming-style seats to regain market share, as this interest has increased by 42.0 percent since 2020 (Wang & Chen, 2022). This trend is driven by a rising demand for furniture that not only reflects cultural heritage and traditional craftsmanship but also addresses the ergonomic needs of modern consumers. As more people worldwide seek furniture that is both aesthetically pleasing and health-

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conscious, Ming-style seats, with their historical significance and unique design, are well-positioned to meet this demand, provided they can be adapted to modern ergonomic standards. The increased focus on comfort, health, and sustainability, alongside the appreciation of authentic cultural designs, offers a promising market for innovative ergonomic Ming-style furniture that blends tradition with contemporary usability. As the cultural exchange between East and West in furniture design, many countries are upgrading their theoretical and practical capabilities in furniture design, such as ergonomics theory and green design. In the collision and integration of cultural exchanges between Chinese and Western furniture design, the designers, and producers of "East-and-West Furniture" are striving to realise the modern design innovation of traditional furniture (Jing, 2014).

In life, the seat is used for communication, work, and rest. It can be regarded as the most frequently used furniture, so it plays a vital role in connecting traditional culture and modern design style (Li & Zhu, 2002). Seats is a service for people, it not only needs to be compatible in function, but also needs to be pleasant in form. Timeless traditional style does not match the aesthetic preferences of modern Chinese when choosing seating (Liu et al., 2024). In the contemporary context, an increasing number of Chinese households are opting for Western-style seats, a trend in which modern Chinese seats struggles to compete. This disparity can be attributed to three key factors: superior ergonomic design, advanced material application, and the influence of global aesthetic trends. Western seats solutions are often developed in conjunction with in-depth ergonomic research, incorporating features such as adjustable lumbar support and dynamic seating mechanisms that cater to the demands of extended periods of work and leisure (Wang & Chen, 2022).

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Moreover, Western manufacturers consistently adopt innovative materials such as memory foam and lightweight composite structures which not only enhance user comfort and durability but also align with modern standards for environmental sustainability (Pang & Wu, 2021). From a cultural perspective, the effects of globalisation have significantly elevated the popularity of minimalist and modular Western aesthetics. These are frequently viewed as emblems of modernity and cosmopolitan living, whereas contemporary Chinese seating design often struggles to harmonise traditional cultural motifs with modern functionality (Hou & Deng, 2011). Taken together, this combination of ergonomic advantage, material innovation, and global stylistic appeal has firmly established Western seating as a dominant choice in China's domestic market. This highlights the urgent need to revitalise traditional Ming-style seating through ergonomic modernisation and innovative design integration. Therefore, the key to the development of Chinese seats is not to copy from the Western models, but to form a refreshing Chinese Style. It must be recognised that this style is more than just superficial, but a quality and spirit inherent in the seat. Chinese style" is deeply rooted in classical aesthetics, but it must continually evolve to move beyond being a static tradition. To understand this style, we must first break free from the shackles of traditional seating forms and grasp the context of Chinese seating design from the conceptual perspective (Pan, 2018). Today, cultural self-confidence and national culture have been strongly advocated in Chinese furniture design, which gives Chinese designers a good opportunity to re-examine and re-create traditional Chinese seating design. Designers can design and enhance Chinese seating furniture when they discover the commonalities that exist in traditional design and modern design.

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It is inevitable for the development of furniture design to use the principles of ergonomics to design modern furniture. Modern furniture design only fully utilises the principle of ergonomics, to make the designed furniture reflect user centred. The design of the seat is particularly important. Especially in relation to people's work and life, and the rationality of its design directly affects people's health. Unreasonably designed seats often cause problems such as abnormal cervical vertebrae and chest deformation (Siregar et al., 2023; Lu et al., 2023). Therefore, the core of the healthy seats design is to maintain the natural spine shape or correct the bad posture while sitting (Yu & Zhao, 2017; Wu et al., 2019). Compared with modern furniture design which focuses on ergonomics, traditional Chinese wooden furniture is famous for its unique tenon-and-mortise structure and elegant aesthetic appeal (Sun & Jin, 2021). It is worth noting that Chinese traditional wooden furniture not only pays attention to the shape, but also reflects the ergonomics (Yi & Zhou, 2022). The apparent contradiction between the ergonomic strengths and limitations of Ming-style furniture stems from shifting anthropometric standards and evolving user needs. While Ming-style seats were scientifically advanced for their time (Zhang et al., 2018), their dimensions no longer align with the physiological requirements of modern users. For example:

a) Historical Context: During the Ming era, designs were crafted with a focus on proportionality and minimalism, reflecting the ergonomic needs of the time. The average height of individuals during the 14th–17th centuries was between 160–165 cm, and their sedentary lifestyles required furniture tailored to support prolonged sitting (Yang, 2018). These principles led to the creation of functional, aesthetically pleasing furniture that met the physical demands of users at that time.

b) Modern Context: In contrast, today's users are generally taller, averaging between 170–175 cm (National Health Commission, 2023). Additionally,

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modern lifestyles are more dynamic, with people engaging in various activities such as desk work, leisure, and travel. These changes demand adjustable seating that accommodates a wide range of body types and supports various postures, a feature that traditional Ming-style wooden seats do not provide.

The misalignment between Ming-style furniture dimensions and the modern ergonomic needs of users presents a dual challenge: preserving the iconic aesthetics of Ming-style designs while adapting them to meet contemporary ergonomic standards. This gap highlights the necessity for a framework that bridges historical design with modern usability, ensuring that Ming-style furniture remains relevant and functional in today's context.

Therefore, in modern design, how the quantitative method of ergonomics can better provide objective evaluation for Chinese traditional wooden seat furniture and modern seat design, and how to apply the objective evaluation result to the design practice, are the topics that Chinese designer and design researcher should pay attention to and study.

To effectively operationalise the research's objectives, two (2) key concepts compatibility and adaptability are defined. Compatibility refers to the degree to which Ming-style wooden seats aligns with modern ergonomic standards. This involves ensuring that the seating dimensions, such as seat height, depth, and backrest angle, correspond with contemporary human body dimensions (National Health Commission, 2023). More specifically, it emphasises anthropometric fit, ensuring that these dimensions are suited to the average user's proportions, while functional alignment

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ensures that the furniture can support prolonged sitting without compromising the minimalist aesthetics characteristic of Ming-style design. The balance between comfort and aesthetics is crucial, as ergonomic features such as lumbar support and seat adjustability need to be integrated while retaining the traditional forms and motifs that define Ming-era furniture (Zhang et al., 2018).

On the other hand, adaptability refers to the ability of Ming-style design principles to evolve to meet modern needs while preserving their cultural identity. This can be achieved through modular adjustability, such as integrating hidden mechanisms like adjustable seat pans or backrests within the traditional joinery, allowing for a more flexible, ergonomic design without disrupting the aesthetic integrity (Sun & Jin, 2021). Additionally, material innovation plays a significant role in enhancing adaptability. The use of lightweight and sustainable materials, such as bamboo or engineered woods, can help reduce the bulkiness of traditional furniture while maintaining its structural integrity and aesthetic appeal (Li, 2017). This adaptability ensures that Ming-style furniture remains both functional and culturally relevant in today's market, meeting the growing demand for eco-friendly and ergonomic furniture solutions (Global Furniture Trends Report, 2023).

By integrating both compatibility and adaptability, the design framework seeks to bridge the gap between the cultural heritage of Ming-style furniture and the ergonomic requirements of modern users.

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1.3 Problem Statement

The Ming style wooden seat was not exactly designed in the most appropriate size from an ergonomic point of view (Liu & Sun, 2014). Although the Ming seats was very much in line with the prevailing aesthetic and cultural connotations of the time, there is still a lot of room for improvement in terms of the comfort of the seat. Compared to the average height of modern Chinese people, the average height of ancient Chinese people is lower than that of modern people, and the height, width, depth, and backrest height of most of the wooden seats in the Ming Dynasty are much larger than the size of the national regulations. This greatly reduces the comfort of the seat (Yang, 2018).

Furniture is a very representative traditional product in China's 5,000-year history. With the prosperity of the Chinese nation, furniture has always been with people, and it has been integrated into the ancient people's ideas of creation and wisdom. Many designers in Europe and the United States are inspired by traditional Chinese furniture and have created a series of Chinese-style furniture products (Olesen, 2014). However, in the development process of modern design, it is challenging for Chinese style to apply traditional culture and ideas to modern furniture design. Therefore, for furniture designers, studying traditional Chinese furniture design concepts is necessary to improve their design capabilities. However, in the field of advanced furniture design, disadvantages such as cultural loss and weak design skills exist in the field of advanced furniture design, resulting in blindly imitating the West and abandoning the fine traditional culture that exists around them (Lin, 2013).

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In the early 1990s, the Chinese design field began to frequently conduct research on the modern design of traditional furniture, but there are still many deficiencies. First of all, most of the works and papers on the research of traditional Chinese furniture focus on appreciation, collection and cultural decoration, and rarely involve the style of traditional furniture, and rarely mention the ergonomics, technology and structure of traditional furniture. Meanwhile, research status is poorly aligned with the demands of modern life (Fu, 2017). Secondly, the existing furniture research mostly takes historical background and culture as the research object, and few researchers conduct research from the perspective of modern design. When researchers study furniture, they often discuss its function, structure, and form separately, and there are only a few systematic studies on traditional furniture design. Xu Ping, a professor at the Central Academy of Fine Arts, said in the "Chinese Ancient Bedding Art Exhibition" in 2013: "There are more and more exhibitions focusing on ancient Chinese furniture, and the market for traditional Chinese furniture is getting hotter. However, there are still few studies that really focus on the context of furniture and its systems".

The selection of Ming-style wooden seats is based on several compelling factors that emphasise their aesthetic and functional advantages. The Ming Dynasty (1368–1644) represents the peak of Chinese furniture design, marked by minimalist aesthetics with clean lines and restrained ornamentation, which makes it highly adaptable to contemporary design trends (Zhang et al., 2018). This style is not only aesthetically pleasing but also structurally innovative, utilising mortise-tenon joinery that eliminates the need for nails or glue, thus ensuring durability and flexibility over time (Sun & Jin, 2021). Moreover, the Ming design emphasises historical ergonomics, where proportionality and posture were carefully considered according to traditional

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body dimensions, making it inherently conducive to comfort (Yi & Zhou, 2022). In contrast to Ming-style furniture, other styles such as Qing Dynasty furniture are less suited for modern ergonomic needs. Qing furniture is characterised by ornate carvings and bulkier forms, which make it difficult to adapt to modern ergonomic standards due to its excessive decoration and lack of flexibility (Xiao, 2020). Similarly, Tang Dynasty seating, with its low-floor designs, does not align with contemporary elevated furniture standards, further complicating ergonomic adaptation.

The significance of wooden seats also extends beyond their physical characteristics; they hold considerable cultural value, representing harmony with nature a core principle in Chinese philosophy and an essential feature of Ming design (Qiu, 2006). Additionally, the use of durable hardwoods such as huanghuali (rosewood) not only contributes to the furniture's structural integrity but also offers the necessary material quality to support ergonomic adjustments (Li, 2017). This sustainability aligns with the growing global demand for eco-friendly design, offering a stark contrast to the increasing reliance on synthetic materials in Western furniture.

Given these factors, Ming-style wooden seats are uniquely suited for ergonomic modernisation. Their timeless aesthetics, foundational ergonomic intent, and sustainability make them an ideal candidate for integration with contemporary ergonomic standards, thereby preserving both cultural heritage and comfort in modern contexts.

As the current level of economic development is increasing, the factor of humanisation in furniture design is important to be considered in contemporary design solutions.

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Ergonomics is gradually becoming an expression of humanisation. Among them, comfort, aesthetics, safety, and other aspects of furniture design plays a vital role. In modern design, the use of ergonomic principles in the design of modern seating furniture mainly focuses on simulation studies, combined with the human body's healthy sitting posture to carry out the theoretical design of the main geometric dimensions of the seat; there is less integration of the overall ergonomic elements of traditional Chinese furniture.

The integration of ergonomics into Chinese traditional culture is a topic worth exploring to gain better attention in seating design research. As for the ergonomics and modelling of sitting furniture, how to balance the "culture" of traditional furniture and the "theory" of ergonomics is a problem that is difficult to avoid. The purpose of this project is to analyse the ergonomics of Chinese Ming Dynasty wooden seat furniture and to develop a design framework based on the results of the analysis. This project aims to analyse the ergonomics of Chinese Ming Dynasty wooden sitting furniture and develop a design framework based on the results of the analysis.

The primary issue identified with Ming-style wooden seats is their failure to meet modern ergonomic standards, despite their cultural significance and historical value. Although these seats are iconic in Chinese design and carry deep cultural importance, they are not aligned with contemporary ergonomic requirements. This misalignment can lead to discomfort and potential health problems for users, as their design does not adequately support modern postural needs or promote long-term comfort, highlighting a gap between traditional craftsmanship and modern ergonomic demands.

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The first key problem is a physiological mismatch in the design of Ming-style wooden seats, particularly about seat height. The traditional seat heights of 48–52 cm exceed the contemporary ergonomic recommendation of 40–45 cm, which has been found to provide optimal knee and thigh angles for comfort and health (Liu & Sun, 2014). The higher seat heights can lead to leg discomfort and poor posture, which, over time, may result in musculoskeletal problems. Furthermore, the rigid backrests of Ming-style furniture lack the lumbar support necessary for promoting spinal health. The absence of lumbar support in the backrest contributes to excessive strain on the lower back, which can lead to spinal misalignment and discomfort (Lu et al., 2023). Given that back support is critical for preventing long-term musculoskeletal problems, especially in sitting posture, the design of Ming-style seats does not support modern ergonomic requirements. In addition to these physical mismatches, there are significant methodological gaps in the research surrounding Ming-style furniture. Most existing studies primarily focus on subjective cultural analysis, often neglecting empirical ergonomic evaluations. Jia (2018) points out that many studies on Ming-style furniture emphasise aesthetic and cultural values without considering the ergonomic needs of contemporary users. This lack of focus on empirical data leaves a gap in knowledge regarding the actual usability of these seats in modern settings. Another major challenge is the absence of a comprehensive ergonomic framework that can guide the design of Ming-style furniture to meet both cultural and ergonomic standards. There is currently no framework to help designers reconcile traditional design elements with modern ergonomic principles, such as those outlined in ISO 9241 ergonomic standards. This gap presents a challenge for preserving the cultural heritage of Ming-style furniture while making it suitable for use in modern living and working environments.

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Addressing these problems is not just about improving comfort but also about preserving cultural heritage. Ensuring that Ming-style furniture remains relevant in the global market requires a balance between traditional aesthetics and modern ergonomic functionality. Furthermore, improving the ergonomics of these seats is crucial for public health, as poorly designed seating can contribute to musculoskeletal disorders, which are prevalent in modern society due to long periods of sitting (Siregar et al., 2023). This issue is especially important as contemporary users spend extended periods sitting, whether at desks, in living rooms, or in offices, where proper ergonomics are essential for health and well-being. Therefore, addressing these ergonomic deficiencies in Ming-style wooden seats is essential for preserving cultural significance while enhancing user comfort and health.

In summary, improving the ergonomic features of Ming-style wooden seats involves not only addressing the physiological and comfort issues related to seat height and back support but also bridging the methodological gap in existing research by integrating empirical ergonomic evaluations. Creating a framework that combines the traditional aesthetic appeal with modern ergonomic principles will ensure the continued relevance of Ming-style furniture in the modern world.

1.4 Research Aim

This research aims to develop a comprehensive framework that integrates ergonomic design principles into the creation of Chinese Ming-style wooden seat furniture. The framework is intended to serve as a practical guideline for furniture designers during both the conceptualisation and development stages. By combining traditional aesthetic values with modern ergonomic considerations, the framework seeks to enhance user

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comfort, functionality, and overall usability. This approach not only addresses the physical well-being of users but also ensures that the cultural and historical significance of Ming-style furniture is preserved and adapted to meet contemporary needs.

1.4.1 Research Question

There are three (3) research questions were highlighted to be answered:

RQ1: What are the key characteristics of ergonomic design in Chinese Ming style wooden seat furniture?

RQ2: What are the ergonomic features that enhance the comfort of Chinese Ming style wooden seat furniture.?

RQ3: How to develop a new ergonomic design framework incorporates ergonomic features for Chinese Ming-style wooden seat furniture?

1.4.2 Research Objective

There are three (3) research objectives were defined as follows:

RO1: To identify the key characteristics of ergonomic design in Chinese Ming style wooden seat furniture.

RO2: To evaluate the ergonomic features that enhance the comfort of Chinese Ming style wooden seat furniture.

RO3: To develop a new ergonomic design framework that incorporats ergonomic features for Chinese Ming-style wooden seat furniture.

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1.5 Scope and Area of Research

Ergonomics occupies a very important position in the design and use of furniture, and it has a significant impact on the comfort and user experience of furniture. Chinese furniture of the Ming style is the most representative of the history of Chinese furniture, especially the wooden seats of the Ming style, so this study investigates the ergonomics of Chinese furniture of the Ming style as an entry point. Due to the age of Ming style furniture, there are certain problems in ergonomic design. In order to make the present Chinese furniture enhance ergonomic function and comfort, so that the user experience can be enhanced, this study conducted an in-depth exploration of Chinese Ming style wooden seats in order to improve the acceptance of Chinese furniture and the sense of identity of traditional Chinese furniture.

This research discusses the preferences of different groups of people for each item of ergonomics of Chinese Ming style wooden seats furniture, to provide ergonomic references for furniture designers. The design of ergonomic furniture for Ming-style wooden seats incorporates a careful balance between maintaining the traditional aesthetic value of Ming-era designs and adapting them to meet modern ergonomic standards. The aim is to respect the cultural and historical significance of Ming-style furniture while addressing the practical needs of contemporary users, who often face discomfort from traditional seats designs.

One of the foundational aspects of this design process is adherence to ISO 9241 standards, which are internationally recognised for ensuring that products meet optimal ergonomic criteria for comfort, safety, and usability. By using these standards as a guide, the design integrates modern ergonomic features that accommodate the

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diverse postural needs and body sizes of contemporary users. The inclusion of anthropometric data from modern Chinese adults aged 18 to 65 is crucial in tailoring the design to meet the physical dimensions and needs of today's users. For example, the average height of modern users is taller than that of Ming-era users, necessitating adjustments in seat height, backrest angles, and armrest positioning to support comfort and avoid strain.

A core element of Ming-style furniture, and a key feature in this design, is the use of mortise-tenon joints. These traditional joinery techniques are valued for their structural integrity, flexibility, and aesthetic appeal, and they continue to play a critical role in this ergonomic redesign. Not only does the use of mortise-tenon joints preserve the cultural identity of Ming-style furniture, but it also contributes to the durability and long-lasting functionality of the seating.

Informed by data collected from surveys with 305 users and feedback from 52 designers and manufacturers, this design process is deeply rooted in user-centred research. The surveys help to identify user preferences, comfort needs, and pain points associated with current seating options, while feedback from designers and manufacturers ensures that the design can be practically executed within the constraints of traditional craftsmanship and modern manufacturing processes. The collaboration with experts in Ming-style furniture production is vital to maintain authenticity in both aesthetic and functional aspects.

Ultimately, the product is designed for a target audience that includes urban Chinese households as well as international markets. Urban Chinese households are

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increasingly focused on health-conscious choices in furniture, particularly as concerns about musculoskeletal disorders rise due to prolonged sitting at desks and computers. The design also aims to appeal to a global audience interested in sustainable, culturally rich, and ergonomically sound furniture. By integrating ergonomic principles with traditional Ming aesthetics, this design provides a unique solution to the challenge of preserving cultural heritage while meeting modern demands for comfort and usability.

In summary, this ergonomic design approach is a step towards modernising Ming-style wooden furniture without compromising its cultural significance. By addressing both the physical comfort of users and the traditional craftsmanship that defines Ming furniture, the design is poised to meet the needs of contemporary users while ensuring that these iconic pieces remain relevant and functional in today's global market. For this reason, researcher conducted an in-depth study on the ergonomics of Chinese Ming style wooden seat furniture and used the results to develop a framework namely Ergonomic Design Framework (EDF) to facilitate the furniture designers in development of a new furniture that can fulfil user expectations, adapts to market demands, and improves work efficiency.

1.6 Significance of the Research

The significant of this research are.

a) Recognised the significance of ergonomic design in Chinese Ming-style wooden seat furniture.

b) Highlighted the value of ergonomic features that improve the comfort of Chinese Ming-style wooden seat furniture.

c) Introduced a novel ergonomic design framework incorporating ergonomic

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elements into Chinese Ming-style wooden seat furniture.

d) Improved user satisfaction and fulfilled the requirements for the redesign of Chinese Ming-style wooden seat furniture.

e) Boosted the marketability and demand for the redesigned Chinese Ming-style wooden seat furniture.

1.7 Thesis Outline

This thesis is divided into six (6) main chapters and each chapter is associated with each stage of the research process, as illustrated in Figure 1.1 below.

Chapter 1 Introduction - discusses the research background, problem statement, research question, research objectives, research significance, research limitation and research framework.

Chapter 2 Literature Review - describes the literature review part, and introduces the concept and research progress, design history and style characteristics of seat, Chinese traditional wooden seat furniture, Ming style wooden seat furniture and contemporary seat in detail. This chapter also discusses ergonomics-related concepts, and five (5) ergonomics aspects. Finally, the relevant literature on seat and ergonomics is reviewed.

Chapter 3 Research Method - presents the research methodology which explains the research and how it was executed. It also explains the process of analysing and validating the data.

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Chapter 4 Data Analysis and Results - describes the results from the process of the questionnaire and a series of analyses including descriptive analyses of a sample of questionnaires from 305 users, 52 designers and manufacturers. This chapter describes the questionnaire survey procedure and the prioritisation results of all Chinese Ming seat items.

Chapter 5 Development of New Framework - prioritises all the findings and constructs the design framework. Next, the validation process of the design framework is presented, with a double validation design framework. The validation process of the design framework is described next. The researchers performed a double validation of the design framework, firstly the authors used the support of the design framework to construct a new design model (design practice) and sought 30 designers to conduct a questionnaire survey, next the author looked for three participants to use the design framework for the design of the Ming style wooden seat furniture.

Chapter 6 Conclusion and Recommendation - summarises this study based on the findings and lists the contributions of this study. This chapter presents the authors'recommendations for future research.

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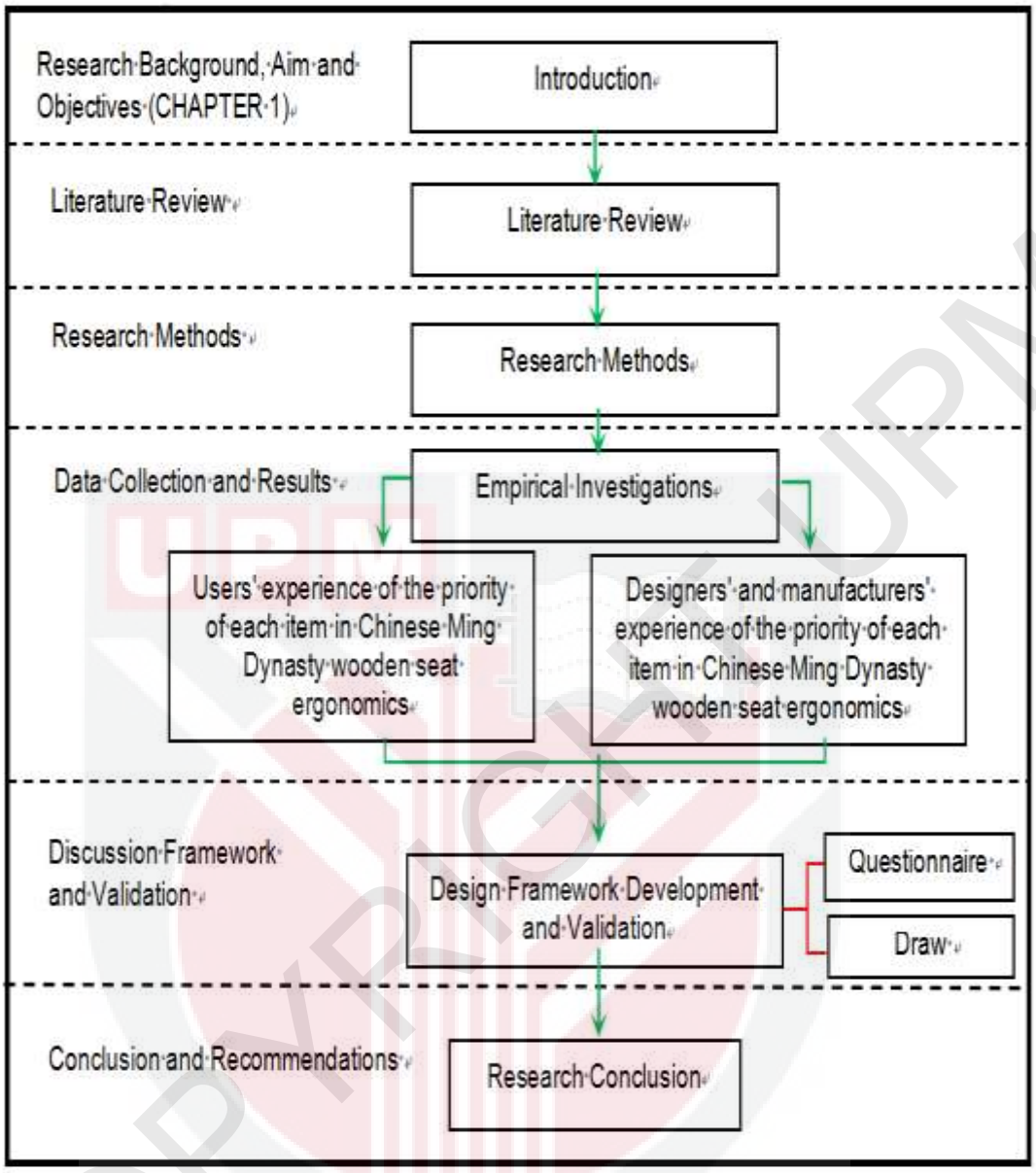

Figure 1.1 : Research Methodology and Associated Thesis Chapters
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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The focus of this chapter is to review the literature relevant to this study considering the research questions and aims, the theoretical foundations to assist this study. It begins with a description of seating furniture, including the concept and research progress of traditional and modern Chinese seating furniture, design history and stylistic features. Next is a detailed review of human characteristics, human physiological and psychological characteristics, and their influence on design. The third section presents a detailed introduction to the literature on ergonomics and other aspects. Finally, the background related to sitting furniture and ergonomics is described. This chapter culminates in an Ergonomic theory Model (Section 2.10), which integrates historical practices and modern ergonomic standards to address gaps identified in Sections 2.3-2.9.

2.2 Furniture Industry Overview

Furniture industry is a huge industrial chain, covering the whole process from raw material production, design, manufacturing, sales to consumer services. With the growth of the global economy and the improvement of people's living standards, the furniture industry has continued to develop and the market size has been expanding (Farahmand & Rahimiaghdas, 2024). In recent years, the size of the global furniture market has continued to grow. The global furniture market is expected to grow steadily at a rate of approximately 4.5 percent per annum to over US$550 billion by the next five years (Azam & Abdullah, 2020). The furniture market is segmented into several

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areas, including living room furniture, bedroom furniture, kitchen and dining room furniture, outdoor furniture, home office furniture, lamps and lighting, and floor coverings. Among these, living room furniture holds the largest market share (Volpe, 2017).

The major competitors in the global furniture market include IKEA, Opie, and Mazco among other well-known brands. Among them, IKEA is the market leader with about 10 percent share in the global furniture market (Golsefid, 2010). The furniture industry is facing challenges such as fierce market competition, fluctuating raw material prices, and environmental policy pressure (Wahlström & Bergström, 2010). Enterprises need to continuously improve their competitiveness to cope with market changes. With the sustained growth of the global economy and the improvement of people's living standards, the furniture industry still has a broad space for development (Medeiros, 2009). At the same time, the application of emerging technologies and the diversification of consumer demand have also brought new development opportunities for the furniture industry (Zhan et al., 2024).

2.2.1 Furniture Definition: Beyond Functional Utility

Furniture is an object that supports diverse human activities, such as stools, chairs and sofas that support human beings when they sit down, tables that are used when working or eating, and beds that are used when sleeping or resting. It is also used for objects to be placed at a reasonable height, such as desks, or for storage of objects, such as wardrobes, drawer shelves, etc (Kawasaki, 2012). Furniture is also recognised as a type of decorative art, or a product of design. In addition to its basic function, it sometimes serves a religious or symbolic purpose (Pedroso, 2020). The materials used

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for furniture are not limited to wood, plastic, or metal, but can be a composite of many materials (Martinovic et al., 2024), and the way it is joined is also diverse depending on the culture of each place (Bas et al., 2024). The definition of furniture extends beyond its basic role as a functional object. It is a dynamic reflection of cultural, social, and technological evolution, illustrating how the context in which furniture is created and used informs its significance (Bas et al., 2024).

Historical and Cultural Contexts play a crucial role in shaping the understanding of furniture (Pedroso, 2020). In ancient civilisations, such as in ancient Egypt around 3000 BCE, furniture like stools and beds served not only practical purposes but also symbolised status and divinity. A notable example is Pharaoh Tutankhamun's golden throne, which functioned as both a seat and a religious artifact, showcasing the intertwining of utility and sacredness. Similarly, in China's Shang Dynasty (1600–1046 BCE), ritual bronze vessels were repurposed as ceremonial furniture, emphasising their symbolic significance in ancestor worship (Li, 2003).

During the Medieval period in Europe, furniture transcended mere utility to become a medium for storytelling and spiritual expression. Gothic cathedral choir stalls, intricately carved, were designed not just for seating but to reflect spiritual narratives, blending functionality with theological storytelling (Krüger, 2003). This approach illustrates how furniture can convey cultural and religious values.

Philosophical Perspectives have also shaped conceptions of furniture (Wang, 2006). In Confucianism, for example, Chinese furniture is seen as emphasising harmony with nature and social hierarchy. A Ming dynasty huanghuali armchair was not merely a

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functional item but represented the Confucian ideals of uprightness and moral discipline. In contrast, the Modernist movement, particularly the Bauhaus from 1919 to 1933, redefined furniture as “machines for living.” This perspective prioritised minimalism and mass production, exemplified by Marcel Breuer’s tubular steel chairs, which focused on functionality and efficiency (Bergdoll & Dickerman, 2006).

In contemporary discussions, new definitions of furniture are emerging to reflect evolving values and concerns. UNESCO’s recognition of traditional craftsmanship as part of Intangible Cultural Heritage acknowledges the significance of artisanal techniques, such as Chinese mortise-tenon joinery, extending furniture’s definition to include cultural heritage. Additionally, sustainable design principles are increasingly relevant, with modern definitions incorporating eco-friendly materials, like bamboo composites, and circular economy practices that emphasise sustainability in furniture production and use (Martinovic et al., 2024).

Overall, as furniture continues to evolve, its definition remains a complex interplay of functionality, culture, history, and philosophy, representing both the needs of society and the values of its time.

2.2.2 Type of Furniture: Beyond Functional Utility

Furniture classification is not static; it is shaped by material innovation, cultural exchange, and ergonomic demands. This dynamic nature reveals how various styles, materials, functions, and structures coalesce to form a comprehensive understanding of furniture design (detail in Figure 2.1 and 2.2).

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By Style, furniture can be categorised into traditional and western styles, each rich with historical significance (Futter & Anderson, 2022). Traditional Chinese furniture showcases distinct styles such as the Ming and Qing dynasties. The Ming Style features minimalist quanyi (circle chairs) characterised by their curved armrests and S-shaped backrests, designed to provide ergonomic support. In contrast, the Qing Style is represented by ornate taishi chairs adorned with carved dragon motifs, which reflect imperial authority and grandeur. Western styles also exhibit remarkable diversity, such as the extravagant Baroque period, which is known for its French cabriole legs and gilded surfaces seen in Louis XIV commodes. Mid-Century Modern furniture, epitomised by organic forms like Arne Jacobsen's Egg Chair, emphasises comfort and sleek aesthetics, marking a shift towards functional design.

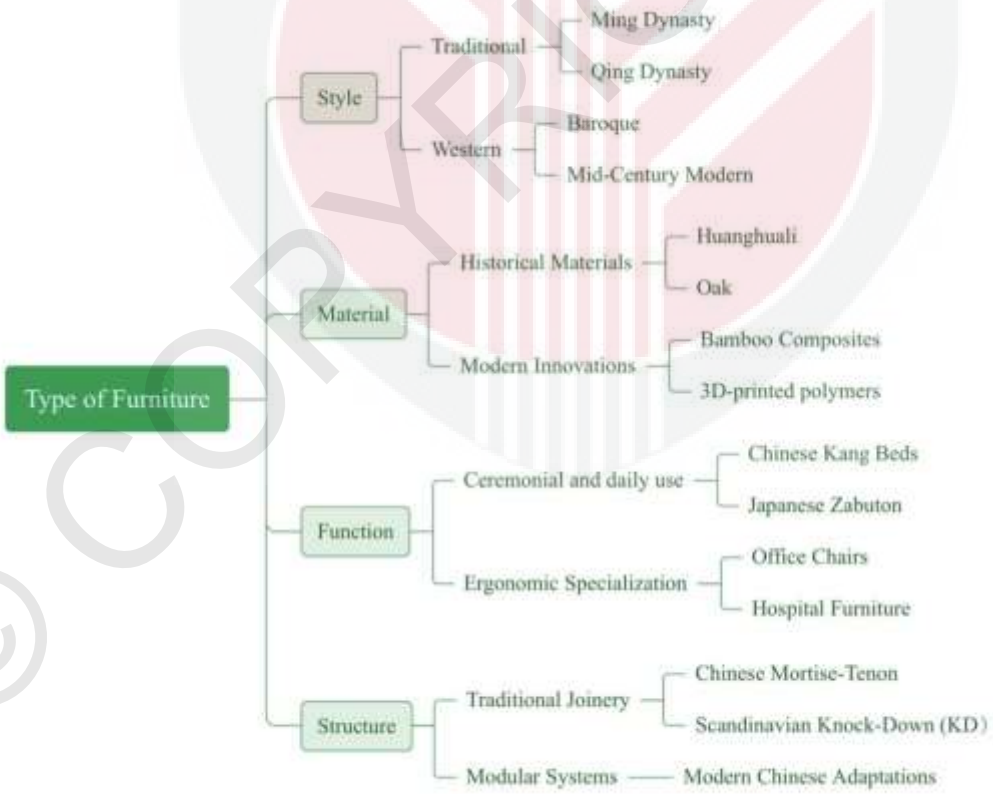

Figure 2.1 : Type of Furniture
(Source by Author)

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By Material, furniture can be considered through historical and modern innovations (Wang, 2022). Historical materials have their own cultural significance; for example, huanghuali wood is used in Ming dynasty cabinets and symbolises wealth while being believed to aid in meditation. Similarly, oak is commonly found in Medieval European chests, representing durability and feudal power. In contemporary contexts, modern innovations such as bamboo composites have gained prominence in Chinese furniture for their sustainability attributes. Additionally, 3D-printed polymers are redefining possibilities with customisable ergonomic designs, exemplified by Philippe Starck's A.I. Chair.

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Figure 2.2 : Example of Furniture
(Source by Author)

By Function, furniture can be distinguished between ceremonial and daily use items (Franchini, 2012). Chinese kang beds serve as multi-functional heated platforms that accommodate sleeping, dining, and socialising in rural areas. In Japan, zabuton cushions are used in tea ceremonies, reflecting the cultural practice of sitting on tatami

mats and emphasising the importance of tradition in functional design. Ergonomic specialisation also plays a key role, with items like Herman Miller's Aeron Chair designed specifically for office environments, offering lumbar support and breathable mesh materials for prolonged periods of use. Likewise, hospital furniture requires adjustable beds equipped with pressure-relief mattresses to prevent bedsores, underscoring the critical need for comfort in healthcare settings.

By Structure, furniture can be classified based on construction techniques (Wu, 2014). Traditional joinery methods, such as the Chinese mortise-tenon system, rely on interlocking joints without the use of nails or glue, as seen in the enduring craftsmanship of Ming cabinets. On the other hand, Scandinavian designs have popularised knock-down (KD) furniture like IKEA's BILLY bookcase, prioritising convenience and ease of assembly. Modern adaptations in China have introduced modular systems, such as modular kang units that transform from seating to sleeping platforms, catering to the needs of urban micro-apartments and highlighting the innovative spirit in contemporary design.

In summary, furniture classification reflects a rich tapestry of styles, materials, functions, and structures, all of which are continuously evolving in response to cultural influences and ergonomic demands, thereby enriching our understanding of furniture as a multifaceted aspect of human life. While furniture types vary widely in style and function, seating furniture particularly in Chinese tradition holds unique cultural and ergonomic significance. This leads us to examine how seating designs evolved in response to ritual, material, and physiological needs (reference to Section 2.3.2).

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2.2.3 The Development of Furniture

Some of the natural objects for example rocks, stumps, sticks and other natural objects have been used as furniture since mankind has been civilised and are even used to this day in scenarios such as camping (Smardzewski, 2015). Archaeological studies have shown that humans began to use objects such as rocks, wood, and bones to start building furniture about 30,000 years ago. The first surviving piece of furniture constructed from stone was in the home of Skara Brae in Scotland, where researchers found beds, dresser cabinets, and cupboards, among others. During the early dynastic period of Ancient Egypt, intricate wooden furniture began to appear, including stools and tables, and even some decorated with precious metals or ivory (Ole, 1980). Ancient Greece and Rome also continued the evolution of furniture, with multi-purpose sofas, thrones, etc. becoming extremely common (Blakemore, 2006). However, medieval furniture was mostly dominated by heavy oak-like wooden furniture. Furniture design developed rapidly during the Italian Renaissance (around the fourteenth to fifteenth centuries) (Jacquemart & Palliser, 2012). By the seventeenth century, European furniture was often presented in an ornate Baroque style. The next nineteenth century saw the prevalence of vintage styles, while much of the twentieth century mostly favoured modernism.

Cultural context shaped the golden age of Chinese furniture during the Ming Dynasty (1368–1644 AD), as economic prosperity, cultural refinement, and global trade particularly along the Silk Road fuelled innovation (Wang, 2013). Guided by Confucian ideals of harmony and simplicity, Ming furniture prioritised minimalism, functionality, and elegance, embodying the era's philosophical and cultural values (Liu, 2010).

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Material innovation during this period centred on the use of tropical hardwoods like huanghuali (yellow rosewood) and zitan (purple sandalwood), prised for their durability and intricate grain patterns (Handler, 2001). Craftsmen perfected mortise-and-tenon joinery, eliminating nails and enhancing structural integrity, which allowed pieces to withstand centuries of use while showcasing the wood's natural beauty (Chen, 1991).

Design principles emphasised both ergonomics and aesthetics. The iconic "S-shaped" backrest of the Quan Yi armchair (Figure 2.24), for instance, was meticulously curved to align with the human spine, reflecting early ergonomic awareness (Zhu, 2015; Sun & Song, 2016). Although there are some ergonomic features in the design of Ming chairs, there are still many aspects to be improved compared with ergonomic principles in general. Subtle carvings and an emphasis on the wood's natural grain replaced ornate decorations, embodying a philosophy of "less is more" that celebrated simplicity and harmony with nature (Wang, 2013).

Iconic pieces such as the Quan Yi armchair, rose chairs, and circle chairs became hallmarks of Ming design. These works blended form and function, with proportions tailored to human dimensions seat heights matched knee-to-floor distances, and armrests were positioned to support relaxed postures (Chen, 1991). Their timeless elegance transcended utility, transforming furniture into art (Handler, 2001).

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Table 2.1 : Key Characteristics of Furniture from Different Periods

Period	Key Features
Ancient Egypt	Stools and beds with symbolic carvings; use of ivory and gold.
Medieval Europe	Heavy oak furniture; utilitarian design for castles and churches.
Renaissance	Ornate carvings, curved legs; influenced by classical Greco-Roman styles.
Ming Dynasty	Minimalist aesthetics, mortise-and-tenon craftsmanship.
20th Century	Modernism (e.g., Bauhaus); industrial materials like steel and plastic.

(Source by Author)

Comparison with global furniture development reveals stark contrasts. While Europe's Renaissance embraced Baroque opulence, Ming designers championed understated sophistication (Handler, 2001). European furniture of the era featured heavy carvings and metallic embellishments, whereas Ming pieces relied on organic forms and material purity (Wang, 2020). This divergence underscores the Ming Dynasty's unique focus on human-centred design, balancing practicality with philosophical depth a legacy that continues to inspire modern minimalism and ergonomic innovation (Liu, 2010). Table 2.1 shows the key features of furniture in different periods. Figure 2.3 depicts the timeline of furniture development

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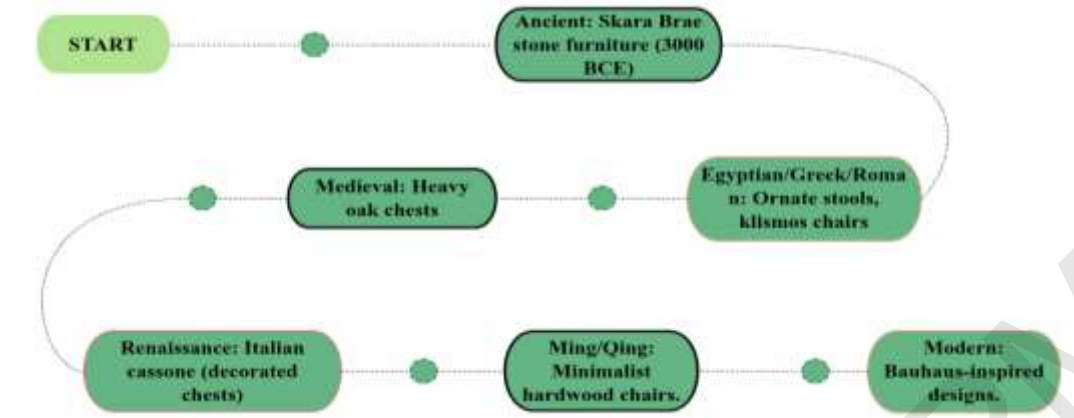

Figure 2.3 : Timeline of Furniture Evolution
(Source by author)

2.3 Seat

Many features of the human body are adapted to the environment as experienced by natural evolution, but not to the modern environment created by man (Daniel, 2017). In the past, the human body evolved for a flexible and versatile lifestyle, adapting to uninterrupted migration, hunting, escaping and other behaviours (Opsivik, 2009). Since the industrial revolution, people have gradually developed sedentary behaviours in the modern office environment. IMG Comfort released a research report on healthy sitting for Chinese users (Healthy Sitting Research Report, 2020). Among the Chinese users surveyed, 67.81 percent of them are sedentary for 5-8 hours a day on average, and 49.91 percent of them cross their legs unconsciously after sitting for long periods of time in the research on bad sitting behaviour (Jiang, 2021). There is also a high percentage of other poor sitting postures. In the history of human evolution, these short centuries are a very small part of the story. The prototype of the chair appeared in ancient Egypt as early as 4,000 years ago. According to the American scholar Donald Holzman, chairs began to appear at the end of the Western Jin Dynasty, around 310 AD. During the Tang Dynasty (618-907), chairs gradually became popular; and

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between 1127-1279 (Southern Song Dynasty), they became popular.

Sitting furniture has gradually become an irreplaceable part of human life in society, both in ancient and modern times. It is one of the most important tools in the history of human development, not only containing the human history of human development, but also expressing the aesthetic pursuit of people from all countries, regions, and eras. The meaning of the seat has gone far beyond its original significance as a tool. Looking back at the history of the development of seating around the world, it initially represented the supremacy of power and important status, and with the development of history and social progress the form of seating has continued to this day. The modern way of life and work has made it necessary for people to rely on the convenience of seating. Modern sitting furniture, which breaks away from the traditional forms, has emerged in people's life with different modelling. It still carries the function of "sitting" to meet the practical or spiritual needs of human beings. Sitting is not the result of an evolutionary adaptation of the human body, but a culturally created behaviour.

Human beings have evolved to naturally choose their current physical configuration, which is in great conflict with the environment created by modern civilisation, and the effects of this conflict can be clearly felt when we use sitting devices. When considering only physiological factors, it is the natural human posture when the thighs are at approximately 135° to the spine (see Figure 2.4). When the human body is in a seated position, the lumbar region bends outwards, creating a backbend in the spine and causing discomfort (Sanders & McCormick, 2009). Thus, regardless of the comfort level, a chair can only reduce the fatigue caused by its use, and a chair with a

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high comfort level cannot be fatigue-free (Jiro, 1990). This is the innate limitation that human physiology imposes on sitting devices and sitting postures.

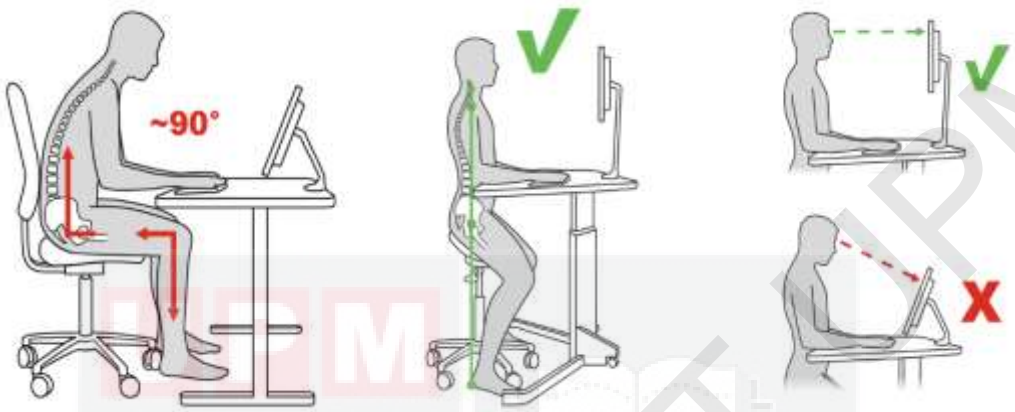

Figure 2.4 : Angle between Thigh and Spine
(Source by Yoshihiko, 1971)

A seat is scientifically designed to integrate the human-machine-environment system, with a primary focus on optimising human-machine interaction by considering human physiological structure, behavioural characteristics, and usage contexts. This definition addresses various dimensions that enhance the effectiveness and overall quality of seats.

a) Anthropometric Compatibility

The first dimension is anthropometric compatibility, which refers to the dimensional parameters of the seat that are designed according to anthropometric data such as sitting height, seat depth, shoulder width, and hip width. These dimensions ensure that seat height typically ranges from 400 to 480 mm, seat depth is between 400 to 500 mm, and backrest inclination falls within 100 to 115°. Such ergonomically sound design aligns with natural postures, thereby reducing spinal pressure (Zhu, 2015; Han, 2016; Figures 2.15–2.18). Furthermore, dynamic support features, such as lumbar pads, headrests, and adjustable armrests, adapt to changes in posture whether

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forward-leaning, upright, or reclining to maintain lumbar curvature (Sun & Song, 2016; Figures 2.22–2.23) and minimise muscle fatigue and intervertebral disc load.

b) Materials and Craftsmanship

The second dimension encompasses materials and craftsmanship. Functional materials such as high-resilience memory foam, breathable mesh, or temperature-sensitive gel are utilised to balance support and comfort effectively. For instance, wooden seats like those found in Ming-style hardwood furniture integrate aesthetic grain patterns with mechanical stability (Wang, 2020; see Figure 2.25). Adherence to technical standards, such as ISO 6385:2016, ensures structural integrity through methods like mortise-and-tenon joints and includes attention to smooth edges to prevent localised pressure points (ISO, 2016).

c) Interactive Functionality

The interactive functionality of a seat focuses on features that enhance user experience and adaptability. Adjustability is key, with functionalities like height adjustment, tilt locking, and armrest elevation, which cater to diverse body types and various scenarios be it office work, leisure, or driving (see Table 2.5). Additionally, smart integration through sensors that monitor sitting duration can trigger vibrations or adaptive adjustments, thus mitigating risks associated with prolonged sitting (Colim et al., 2020).

d) Environmental Adaptability

Environmental adaptability is another essential dimension. Chairs are designed to be scenario-specific; for instance, office chairs prioritise lumbar support and ventilation (Han, 2016; see Figure 2.19), while dining chairs emphasise lightweight aesthetics, and medical chairs require sterilisable surfaces. Space efficiency is also critical, with foldable or stackable designs, like theatre seats with a minimum width of 540 mm, optimising spatial utilisation.

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e) Psychological and Aesthetic Considerations

The consideration of psychological and aesthetic elements is vital in ergonomic design. The sensory experience is influenced by factors such as colour psychology (comparing calming cool tones versus warm hues), tactile feedback (soft leather versus cool metal), and form language (the fluidity of modern designs versus the philosophical principles behind Ming-style seating; see Figure 2.24). Additionally, cultural symbolism plays a significant role: traditional seats, such as the Ming official's armchair, blend ritualistic aesthetics with craftsmanship, while modern designs often convey sustainability through minimalist lines and eco-materials (Fang, 2004).

f) Safety and Health

Safety and health considerations are crucial in seat design. Risk mitigation involves the elimination of sharp edges and unstable structures such as low stools prone to tipping in accordance with safety standards like GB 3326-2016 (China National Standard, 2016). Furthermore, health interventions, such as dynamic bases or sit-stand designs, encourage micro-movements that can counteract sedentary habits (Zhu, 2015) as show in Figure 2.16.

In conclusion, from an ergonomic perspective, a seat transcends mere functionality as a supportive tool; it represents a holistic integration of physiological adaptation, behavioural guidance, environmental responsiveness, and emotional engagement. Its design harmonises engineering rigor with humanistic care, ultimately achieving long-term synergy in the "human-seat-environment" system.

2.3.1 The Definition of Seat

Seat is a kind of seating furniture with backrest and/or armrests, and its definition and function can be specified according to different usage scenarios and needs. In daily

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life, the seat is one of the indispensable furniture; in vehicles and other means of transport, the seat plays an even more important role, not only to provide the basic function of riding, but also to enhance the comfort, safety and convenience of riding through its design and technological innovation (Soulard, 1998).

2.3.2 Concept, Evolution and Research Progress of Traditional Chinese Seat

Building on the categorisation of furniture types, this section traces how Chinese seats designs evolved from floor mats to Ming-era chairs, reflecting broader sociocultural shifts and early ergonomic sensibilities.

2.3.2.1 The Concept of Traditional Chinese Seat

Furniture is one of the most important categories in the history of Chinese art and culture. Since its creation, Chinese furniture has occupied a pivotal position in the history of the world of furniture art. The evolution of furniture in the West has its origins in ancient Egypt, where the chair is a mature example of the Western furniture type. Unlike Western furniture, ancient Chinese furniture began as a seat on the floor, which slowly evolved into a draped seat due to the integration of lifestyles and foreign cultures (Dong & Peng, 2019). The historical and cultural backgrounds and the different seating devices have led to different civilisations having different seating positions.

According to the history of furniture development, chairs were introduced to Western Asia from ancient Egypt, then to Europe, and finally to Central Asia and India. Next, it was introduced to China through nomadic peoples (Cui, 1989; Pin̊a, 2009). The formation of the Chinese furniture system was influenced by Chinese culture, Indian

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Buddhism, and cultural exchanges along the Silk Road. Traditional Chinese furniture followed a completely different path to Western furniture, with the art of making things forming its own system. Due to the constraints of a ritualistic culture, specific social functions were fulfilled through furniture as the art of making things developed. The development of traditional Chinese furniture was marked by the existence of several heyday periods for different types of furniture.

a) Chu-style furniture (lacquered furniture, spring and autumn, and warring states period)
b) Song style furniture (mature type furniture, Song Dynasty)
c) Ming furniture (the heyday of traditional furniture, Ming Dynasty)
d) Qing style furniture (palace furniture, Qing Dynasty)

2.3.2.2 Revolution of Traditional Chinese Seats Devices

When historians study ancient Chinese ways of living, they generally refer to the ancient Chinese people who lived in the Yellow River Basin, carried out farming activities and formed social groups. The Yellow River Basin civilisation was one of the first five civilisations to emerge in the history of human development. It is usually considered to be the ancient Chinese civilisation of the Xia, Shang and Zhou Dynasties or the pre-Qin era (Zhao, 2006). As a result, the ancient Chinese people of the Yellow River Basin farming society have become an important object of study in Chinese history before the Spring and Autumn Period and the Warring States period.

From the beginning of recorded history until the Eastern Jin Dynasty and the Northern and Southern Dynasties, sitting on the ground was the basic sitting posture at the beginning of Chinese civilisation. A “mat” is something on which people sit on the

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ground and is made of grass, leaves, and reeds (*Li Ji - Li Yun*), which is the oldest form of sitting in China (see Figure 2.5). The mat is a living utensil created by ancient people in the process of adapting to nature to survive in the natural environment. It reflects ancient thinking about the creation of things, convenient and practical, and was an early prototype of furniture. This became a key step in the transformation from the use of nature to the manufacture of sitting furniture. Some of the more common furniture items during the Spring and Autumn and Warring States periods were beds, mats, tables, cases, chopsticks, bans, trays, bottles, chests, boxes, and screens (Dong & Peng, 2019). Although the ancients often sat on the floor, beds that were raised above the ground for sleeping were used from the Shang Dynasty onwards. In the Warring States period, beds were not only used for sleeping, but also for reading, writing, and eating. The bed had become a seating device that could be used for many people to sit together.

Figure 2.5 : Warring States Periods Map
(Source by Zhongzhou Museum)

From the Qin and Han dynasties through to the Tang dynasty, the bed slowly became the main means of sitting, as it was more comfortable than sitting on the floor. During the Han dynasty, the height of the couch was low, and people used it mainly to sit on their knees, while during the Wei, Jin and North-South dynasties, the bed was slowly

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increased in height and people gradually changed from sitting on their knees to sitting with their feet hanging down. This change from low to high seating posture and seating equipment was the result of the gradual improvement in productivity and construction techniques that matured during the different dynasties. On the other hand, China has been a multi-ethnic country since ancient times, and the influence of the living customs of various ethnic minorities on the Central Plains also played a very important role in the change of sitting posture.

During the Wei, Jin and Northern Dynasties, China was divided between the North and the South, with escalating wars and ethnic conflicts, as well as mergers and fusions, and Chinese culture developed in a new way during this period of history. This was also a historical opportunity for the introduction of non-traditional furniture by ethnic minorities, which led to the replacement of the original low furniture with taller furniture during the Sui and Tang dynasties. By the Tang dynasty, sitting with the feet hanging down had become the most common sitting posture. The book Chairs Changing China (Zhantai, 2009) mentions that the reforms not only changed Chinese literature and art during the Wei-Jin and Northern and Southern Dynasties, but also changed the long-standing tradition of kneeling in China. During the Wei, Jin and Northern Dynasties, the Hu bed was used in an extremely wide range of applications, covering basically all aspects of life. The historian Hu Sanyuan (1230-1302) suggested that the Hu bed was a folding stool, while a rope bed was a chair that could be leaned on but could not be folded, a view that was also confirmed in the 1967 article ‘On the Origin of Chinese Seating’by Donald Holzman (USA). At this time, sitting furniture was divided into several types, including chairs, Quan Ti, stools, and couches.

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During the Tang Dynasty, later known as the Great Tang Dynasty, the country was strong, the people were wealthy and ambassadors from neighbouring countries often came to pilgrimage. During the Tang Dynasty, there was the Silk Road in the west and the sea lanes were open in the east. These initiatives were used to facilitate trade and make the economy prosperous, while cultural exchanges were also very frequent. At that time, exotic peoples could be seen everywhere, and these Western Hu people brought the Western civilisation to the Tang Dynasty. Some of these skilled craftsmen were recruited into the court, where they copied Western craftsmanship and imported popular exotic cultures into China. This constant influx of foreign culture led to the emergence of many new types of furniture in the Tang dynasty, and a great variety. Sitting furniture such as stools, dunks, hu beds, Quan Ti and chairs often appear in wall paintings and drawings.

The sitting postures of the Tang were divided into kneeling, sitting cross-legged, and sitting with the feet hanging down. Because of the parallelism of the various sitting postures, can often see in ancient sources kneeling on a mat in Figure 2.6 by Liang (2012), sitting cross-legged on a couch in Figure 2.7 by He (2003) and on a chair and stool in Figure 2.8 by Li (2021). Sometimes, multiple seated postures and sitting devices appear in the same picture at the same time. In the first section of Gu's painting Han Xizai's Night Banquet, Han Xizai is depicted sitting cross-legged on a couch, while his guests are sitting with their feet draped over chairs without armrests. The artist intentionally depicted both seated positions in the same painting, showing a mixture of sitting on the floor and sitting with the feet down in Figure 2.9 by Jin (1984).

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Figure 2.6 : Sun Wei's Gao Yi Tu
(Source by Shanghai Museum)

Figure 2.7 : Sitting Cross-Legged in the Dunhuang Grotto
(Source by Shanghai Museum)

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Figure 2.8 : The Palace Music of the Tang Dynasty
(Source by Taipei Palace Museum)

Figure 2.9 : Han Xizai's Night Banquet by Gu Hongzhong (Song Dynasty)
(Source by Beijing Palace Museum)

The Song dynasty reached a new height in terms of economy, science and technology, culture, and education, especially in science and technology. Not only did it achieve

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unprecedented success in the history of ancient Chinese science and technology, but it also took the lead in the world during the same period. At the same time, Song aesthetics also reached a crest in the history of ancient Chinese art. Landscape painting, ceramics, poetry, and calligraphy were all considered to be at the highest level in the world. Throughout history, the Tang dynasty revered force, while the Song preferred civil rule (Wu, 2005). The ruling class of the Song dynasty promoted a simple and elegant way of life, as well as the development of the Song dynasty philosophy and many other factors. The art of the Song dynasty changed from the splendid and extravagant style of the Tang dynasty to the rational and pragmatic idea of pursuing simplicity and elegance. It was also during this dynasty that the history of Chinese furniture saw the emergence of a fixed pairing of chairs and tables, giving rise to a new pattern of furnishing that also became the source of the famous Ming dynasty furniture. In addition, Song craftsmen invented a variety of mortise and tenon construction based on the workmanship of previous generations of furniture. As can be seen from many paintings, there were three main types of bed and couch in the Song dynasty: the box-type bed and couch, the four-legged flat couch and the bed and couch with screen. The bed was mainly used as a sleeping apparatus in the bedroom, while the couch was used as a sitting apparatus in the living room or study, and could also be used for lying down, reclining, or resting (see Figure 2.10).

Song dynasty chairs and stools are mainly reclining chairs, armchairs, circle chairs and other high type sitting furniture. One of the Zhi-Da-Nao armchairs for the predecessor of the Ming and Qing rose chair, it is characterised by a low backrest, basically flush with the armrests. Cross chairs also began in the Song Dynasty. The cross chair also began in the Song dynasty and its predecessor was the Maza, which

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could not be relied upon. The Song dynasty transformed the Maza with the features of a lap chair into a cross chair, which was a common piece of furniture in the homes of people of distinguished backgrounds. The basic paradigm of the traditional Chinese chair is the circle chair, the cross chair, and the rose chair, which was basically perfected in the Song dynasty. The circle chair was already shaped in the Tang Dynasty, and the Song Dynasty changed it to a round backrest based on the original, which was used to support the force of people leaning back and adapt to the curves of the human body.

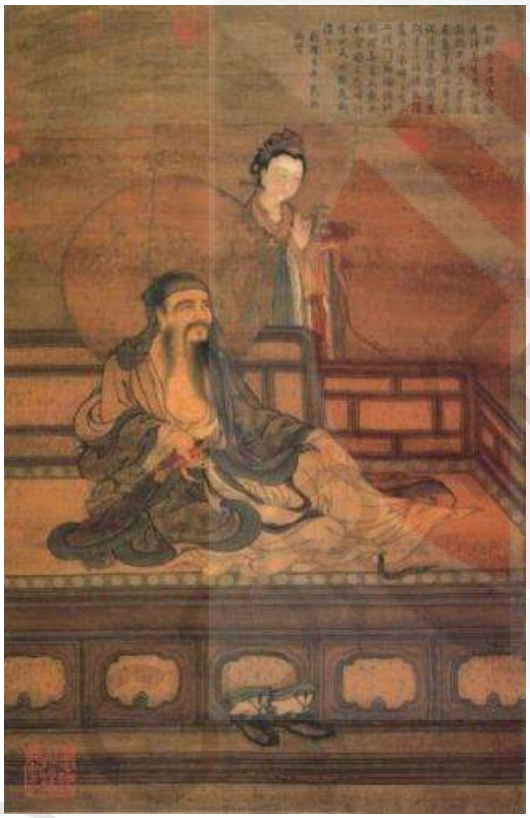

Figure 2.10 : A Painting of Wei Mo Acting Out His Teachings by the Northern Song Painter Li Gonglin
(Source by Beijing Palace Museum)

The Yuan dynasty was the greatest clash in Chinese history between nomadic peoples, represented by a grassland culture, and refined farming, represented by an agricultural

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culture. During its reign, the Yuan dynasty fully respected the cultures and customs of the various ethnic groups and encouraged exchanges and integration between them. The leadership retained many Mongolian aspects of life and living, clothing, food, and transport. The production of household items was elaborate and complicated (Gang, 1994). There are no outstanding innovations in Yuan dynasty furniture, which was mainly based on Song dynasty forms. In the early Qing dynasty, furniture remained relatively in the style of the Ming dynasty. However, due to the gradual promotion of fashion trends by the court, Qing-style furniture had gradually replaced Ming-style furniture by the mid-Qing period. The furniture also developed different local characteristics and was divided into three main schools: Su, Guang, and Jing. Unlike the Ming dynasty, which was represented by Su-style, Guang-style furniture gradually became the representative of Qing-style furniture; while Beijing-style furniture was mainly produced for the palace workshops and was later emulated by the folk. Chinese seating furniture has evolved over thousands of years, from short to tall furniture, and from mats to chairs. The main types of seating furniture from early to late, is mat, bed, hu bed, couch, rope bed, leaning bed, stool, dunk, chair and maza (see Table 2.2).

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Table 2.2 : The Main Types of Seat Furniture across Chinese Dynasties

Main types of seat \ Dynasty	Shang and Zhou	Spring and Autumn	Qin, Han	Wei, Jin	Sui, Tang	Song. Yuan	Ming	Qing
Mat	√	√	√	√				
Bed	√	√	√	√		√	√	√
Hu bed			√	√	√			
Couch			√	√	√	√	√	√
Rope bed				√				
Leaning bed					√			
Stool				√	√	√	√	√

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Table 2.2 : Continued

Dunk					√		√	√
Chair					√	√	√	√
Maza						√	√	√

(Source by Author)
**Hu bed: A portable folding stool introduced by nomadic tribes during the Wei-Jin period, later evolving into a common seating form.
Rope bed: A non-folding chair with a woven rope seat, often used for reclining.
Leaning bed: A raised platform with back support, transitional between beds and chairs.
Dunk: A low, armless stool used during the Tang Dynasty.
Maza: A square or rectangular stool prevalent in Ming-Qing households.

2.3.2.3 History of Traditional Chinese Seat Furniture

With a history of five thousand years, China has accumulated a wealth of cultural resources in the process of its development. Traditional Chinese furniture is heavily influenced by the literati and can therefore be considered to as 'literati furniture'in certain degree. In ancient times, traditional furniture was used as a household item for the upper classes and was often given many cultural connotations by the literati. The Kao-Gong-Ji was a work that recorded handicraft techniques during the Spring and

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Autumn and Warring States period. It describes in detail the content of thirty trades, including carpentry and metalworking, and is the earliest documentation of the specifications and craftsmanship of each trade.

Many Chinese scholars have studied classical Chinese furniture in terms of its collection and reflections on tradition. The study of Ming and Qing dynasty furniture has become the leading study of traditional Chinese furniture, with the famous scholars Liang Sicheng and Yang Yao leading the way in the study of Ming furniture. The Study of Ming Furniture written by Yang (2002) provides a detailed introduction to the classification, construction and research methods of Ming furniture. Subsequently, scholars of traditional furniture, represented by Wang Shixiang, Chen Zengbi, Pu Anguo, Zhu Jiayi, Tian Jiaqing, Hu Wenyan, Li Zongshan, Hu Desheng and Dong Boxin, have published many works of high academic research and value through their investigations of ancient Chinese furniture. Studies in Ming Style Furniture, Treasures of Ming Style Furniture, and Explanations of Xiu-Shi-Lu were written by Wang Shixiang, a famous Chinese furniture scholar. A large number of physical examples of Ming and Qing dynasty classical furniture are collected in the book Study in Ming Furniture, which is an accumulation of over 40 years of research by Mr. Wang Shixiang (Wang, 2013). The book records many Ming furniture chairs and stools in terms of structure, shape, decoration, and materials used, providing valuable material for later generations to study classical furniture of the Ming and Qing dynasties. The Connoisseurship of Chinese Furniture (Wang, 2010) is the same series of works as Study in Ming Style Furniture, which focuses on the stylistic origins, stylistic features, furniture types and practical values of classical furniture in Ming and Qing dynasty, collecting a total of 42 actual measurements of furniture and 332 colour

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pictures and partial close-ups. Connoisseurship of Ming and Qing Dynasty Furniture (Pu, 2004b), Chinese Mahogany Furniture (Pu, 2004a), Ming and Qing Dynasty Su-style Furniture (Pu, 2009), Art of Decorating Ming and Qing Dynasty Furniture (Pu, 2003) and other works written by Pu (2009), a renowned expert on Ming and Qing dynasty furniture, who has provided many unique insights into the appreciation of Ming and Qing dynasty furniture and has provided some assistance in the study of mahogany furniture.

Connoisseurship and Study of Ming and Qing Dynasty Furniture, edited by Tian Jiaqing (Tian, 2003) evaluates and appreciates Ming furniture and explains the origins, production and restoration of Qing dynasty furniture. Chinese Furniture Identification and Appreciation (Hu, 1996) edited by Hu Wenyan, contains a large number of excavated cultural relics and documentary materials, and provides an in-depth study of the humanistic characteristics and stylistic features of Ming and Qing furniture. In 2002, the Chinese Furniture Culture Series by Hu Wenyan and Yu Shuyan was published, introducing ancient Chinese furniture culture and painting culture in six parts (Hu & Yu, 2002). Illustrated History of Chinese Furniture edited by Li Zongshan deals with the history of Chinese furniture through a large number of cultural objects and heirloom materials (Li, 2001). Similar works include Dong Boxin's An Overview of Ancient Chinese Furniture, Chinese Traditional Furniture (Dong, 2004), Furniture Design (Liang, 2000), Chinese Folk Furniture (Zhang, 2005). Chinese Ancient Furniture Appreciation and Collection (Lu, 2006), etc., which summarises and refines various aspects of traditional Chinese furniture.

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In recent years, there are also some graphic works and literature on traditional Chinese furniture, mainly: Chinese and Foreign Furniture Styles Through the Age (He, 1998), The New Catalogue of Chinese Furniture Through the Ages (Ruan, 2001), Chinese Ming Style Furniture Catalogue (Jing & Shuai, 1999), Chinese Furniture Classic Art Gallery (Liu, 1998) etc. These works show the visual charm and aesthetic interest of traditional Chinese furniture with many photographic materials. At the same time, some scholars have also conducted research in sitting furniture. History of Chinese Furniture - Sitting Furniture by Cui Yongxue (Cui, 1989) uses images of sitting furniture from various periods to discuss the uses of sitting furniture from different periods. A Chapter of Wooden Chairs (Zhao, 2008) introduces the development of sitting furniture in China through a Ming-style official's Arm Chair and what the chair went through before it became commonly used by the people. Chinese Chair Sitting Customs by Weng Tongwen (Wen, 2010) tells the history of the evolution of the chair, from the Western Hu bed to the chair. Civilisation of Seating is written by Ma Weidu (Ma, 2009) describes the different materials used for sitting furniture through the distinction of materials and uses mainly pictures to illustrate the shape of traditional sitting furniture. Deconstructing Ming Furniture-Sitting Furniture by Wang Shuwan and Li Sha (Wang & Li, 2007) uses modern methods of iconography, psychology and design semiotics to analyse, classify and summaries the forms, stylistic details, nodes, materials and functions of Ming furniture, and to introduce them in relation to the process of production. It also attempts to use deconstruction to innovate. Chairs Changing China (Zhantai, 2009) focuses on the history of the chair.

Through the literature collection, there are 59 papers studying traditional furniture from 2012-2022, of which only two are dedicated to the study of sitting furniture, the

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remaining 57 are all studies of traditional furniture. Of these, 11 were on furniture appreciation, 23 on artistic features, 18 on furniture culture and 5 on market analysis in Figure 2.11. There are many scholars who have studied traditional Chinese furniture, but the main areas are focused on the artistic features of traditional furniture, culture, and furniture appreciation. Very few papers have been written on seating furniture, and it is extremely rare to find scholars who have studied the ergonomics of traditional seating furniture. At present, Western scholars in the study of traditional Chinese furniture are mainly concerned with the comparison of Chinese and Western furniture, and they have devoted more effort to modern furniture design. Modern furniture design is also mostly studied in terms of Western furniture and rarely involves Chinese furniture. Only a small number of scholars have studied the historical development and modelling of Ming and Qing furniture. From the beginning of the last century to the 1980s, research on traditional Ming and Qing furniture was still dominated by Western scholars, who started early and published a series of works. The earliest of these was the British Herbert Cesinsky's Chinese Furniture in 1922, the Frenchman Odilon Roche's Meubles de la Chine in the same year. A sequel to Chinese Furniture was published by Maurice Dupont in 1926. The three books contain over 50 pieces of Ming and Qing dynasty furniture from French and German collections.

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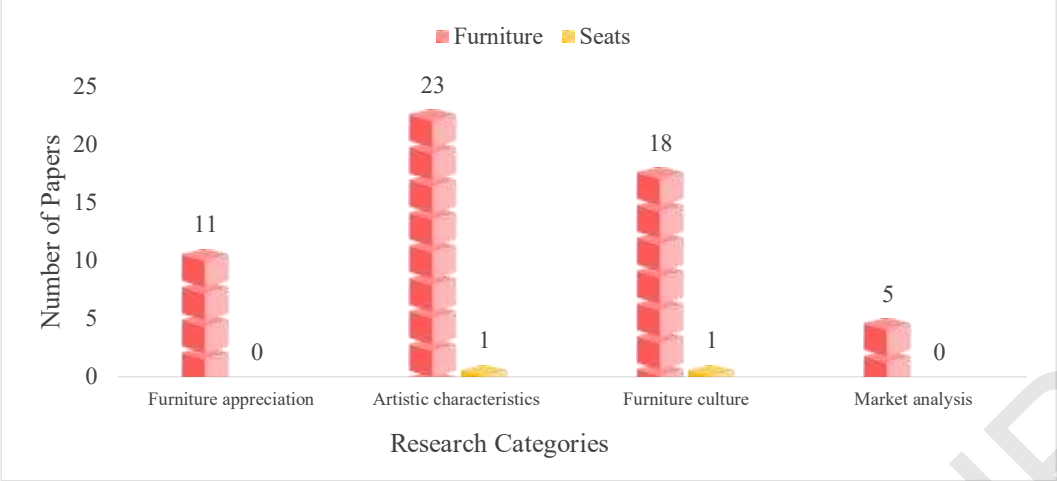

Figure 2.11 : Distribution of Research Focus Areas in Traditional Chinese Furniture (2012–2022)
(Source by Author)

In the 1930s, the German Gustav Ecke, together with the Chinese Yang Yao, studied classical Chinese furniture and began to make extensive drawings of Ming furniture. They published Chinese Domestic Furniture in 1944, which was later translated into a Chinese version by Chen Zengbi (Gustav, 1991). The book contains a total of 122 pieces of classical Ming furniture collected by Gustav Ecke and European socialites. Through the physical dismantling of the furniture, more than 30 mapping drawings of the furniture were obtained. The Chinese Domestic Furniture is the first scientific study of the dimensions of traditional furniture, and the detailed empirical data in it also provides a rich documentary basis for the study of Ming and Qing furniture forms. It was because of Ecke's research that Western scholar began to appreciate the exchange of Chinese and Western learning time. Sarah Handler's book Austere Luminosity of Chinese Classical Furniture details the history of Chinese hardwood furniture from the Shang Dynasty (1500BC-1050BC) to contemporary times (Handler, 2001). The author combines traditional Chinese furniture with Chinese calligraphy, painting, architecture, and literature to present Chinese art from a special and

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multifaceted perspective.

The Chinese society, culture, economy, and politics that Handler has come to understand provide a meticulous background to the writings, while the people's way of life, notions of hierarchy and perceptions of space are discussed. The German artist Adolf Hildebrandt studied the artistic expressiveness of the forms of classical Chinese furniture, providing experiences for the later studies of traditional Chinese furniture (Hildebrandt, 2010). In contrast to the furniture of the Ming and Qing dynasties, Western furniture is generally larger in size, both in terms of volume and dimensions, and can be more varied in its use of curves (Charles, 1985). Western researchers have studied Chinese Ming and Qing furniture mainly in terms of the shape and materials of the furniture and some scholars have summarised the stylistic features of classical furniture in terms of modelling (Kates, 1948). The vast majority of European and American researchers have analysed the choice of materials and form of seating furniture in their writings on Chinese Ming and Qing furniture (Ellsworth, 1970). The results of Western scholars'research on Chinese furniture from 1922 to 2013 were shown in Table 2.3.

Table 2.3 : Western Scholars'Research on Chinese Furniture from 1922 to 2013

No.	Era	Author	Book
1	1922	Herbert Cesinsky	Chinese Furnitrue
2	1922	Odilon Roche	Meubles de la Chine
3	1926	Maurice Dupont	Les meubles de la Chine
4	1940	John C. Ferguson	Survey of Chinese Art
5	1940	J. V. Jorge	Notas Sôbre an Arte Chinesa
6	1944	Gustav Ecke	Chinese Domestic Furniture
7	1948	George Norbert Kates	Chinese Household Furniture
8	1952	Louise Hawley Store	The Chair in China
9	1957	G. Ringler	Mobila Fina

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Table 2.3 : Continued

10	1962	Sothebys	Chinese Porcelain Clocks and Furniture
11	1963	R. Soame Jenyns William Watson	Chinese Art the Minor Arts
12	1965	C. P. FitzGerald	Barbarian Beds：The Origin of The Chair in China
13	1967	Margaret Jourdain	Chinese Export Art in The Eighteen Century
14	1970	Robert H. Ellsworth	Chinese Furniture - Hardwood Examples of The Ming and Early Qing Dynasty
15	1972	Carl L Crossman	The China Trade: Export Paintings, Furniture, Silver, and Other Objects
16	1979	Michel Beurdeley	Chinesische Möbel
17	1979	Joseph Aronson	The Encyclopaedia of Furniture
18	1982	Robert H. Ellsworth	Chinese Hardwood Furniture in Hawaiian Collections
19	1988	Craig Clunas	Chinese Furniture
20	1992	Sandra Lok Fu Chin	Classical Chinese Wood Furniture
21	1993	Robert H. Ellsworth	Essence of Style：Chinese Furniture of the Late Ming and Early Qing Dynasties
22	1995	Nancy Berliner & Sarah Handler	Friends of the House: Furniture from China's Towns and Villages
23	1998	Robert H. Ellsworth	Chinese Furniture: Hardwood Examples of the Ming and Early Ching Dynasty
24	1999	Robert D. Jacobsen	Classical Chinese Furniture in the Minneapolis Institute of Arts
25	2001	Sarah Handler	Austere Luminosity of Chinese Classical Furniture
26	2005	Sarah Handler	Ming Furniture in the Light of Chinese Architecture
27	2006	Karen Mazurkewich	Chinese Furniture: A Guide to Collecting Antiques
28	2007	Andrea & Lynda McCormick	Old China New Style Antique Furniture & Accessories 1780-1930
29	2009	Andrea & Lynda McCormick	Chinese Country Antiques Vernacular Furniture and Accessories1780~1920
30	2013	Herbert Cescinsky	Chinese Furniture A Series of Examples from Collections in France

(Source by Author)

While general studies on Chinese furniture often reference chairs, they rarely prioritise them as a focal point of analysis. For instance, Table 2.3 indicates that only 2 out of 30 publications specifically study sitting furniture, including chairs. In contrast, the

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remaining 25 studies address the broader category of "Chinese furniture," focusing on items such as cabinets, tables, and ceremonial objects without investigating the design, ergonomics, or cultural roles of chairs in depth. Consequently, while chairs are acknowledged as part of the furniture category, this does not translate to a rigorous or dedicated investigation into their significance or characteristics. According to Figure 2.12, there are 83.0 percent of foreign scholars studying Chinese traditional furniture and only 7.0 percent of the researchers are studying Chinese sitting furniture. It resulted that the topic of Chinese chair furniture is not really taken under investigation by other scholars.

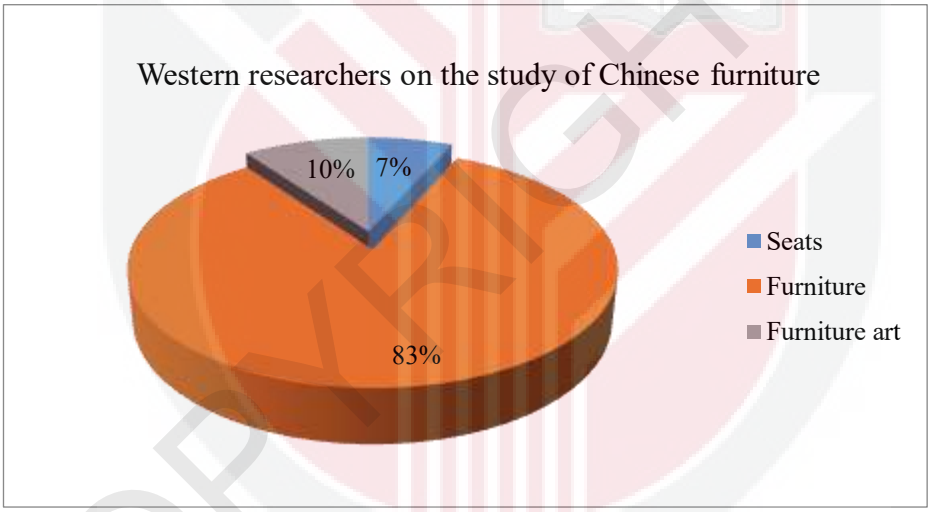

Figure 2.12 : Western Researchers on the Study of Chinese Furniture
(Source by author)

2.3.3 History of Traditional Chinese Seats Design

Early seating, such as the stone beds of Skara Brae (Smardzewski, 2015), prioritised utility over comfort a stark contrast to the ergonomic refinements of later dynasties (see Section 2.8.1). China is a country with a long history and culture. According to historical records, following cave life, China went through a rather long period of

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mixed warfare. Then came the Xia, Shang, and Zhou Dynasties, and up to the various vassal states of the Spring and Autumn Period, when people were already using furniture made of bronze or wood (see Figure 2.13 and Figure 2.14). Already at that time there were excellent casting techniques and good aesthetic skills, so that the furniture was made not only in beautiful shapes but also with patterns that represented the aesthetic level of the time. The furniture did not only meet the needs of everyday use, but also produced many ritual objects for ceremonial use. During the Warring States period, iron gradually replaced bronze, and the growing sophistication of ironmaking brought woodworking to a new level. At this time, lacquer ware gradually appeared on the scene, especially in the state of Chu at the time, where lacquered wood furniture was exquisite. During the Spring and Autumn and Warring States periods, lacquer furniture was available in large quantities, in many varieties, in unique shapes and with superior craftsmanship.

Figure 2.13 : Bronze Furniture Unearthed in Hualou Village, Liaoning
(Source by Liaoning Provincial Museum)

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Figure 2.14 : Excavated from Tomb No. 2, Jiulian Dun, Warring States Period (Lacquerware)
(Source by Hubei Provincial Museum)

By the Qin and Han dynasties, lacquered wood furniture entered its heyday. During the Han Dynasty lacquerware was mainly made in black and red, not because of immature colour extraction techniques, but because of the reverence for Confucian culture and the ritual system. The complex and creative process of baking lacquer on wood was not only a source of beauty but also of great practicality. After the Han Dynasty lacquerware began to decline. It was not until the Tang dynasty that China entered a high point in its ancient history, with a succession of large-capacity, multi-species, and intricately shaped implements. As the level of craftsmanship improved, the wares became more and more beautiful and functional. The Song dynasty has an important place in the history of modelling development and is a period of unprecedented popularity of furniture. Chairs, stools, and other highly stylised furniture had become commonplace, and the common people had ended the custom of sitting on the floor. The furniture was basically of frame construction, and people had a certain pattern for arranging and placing furniture in the interior (Huang & Dai, 2012). In the Song dynasty, simplicity was the order of the day in furniture, and there was basically no carving or decoration. At that time, the elegant life of qin, chess,

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calligraphy, painting, poetry, wine, flowers, and tea was prevalent among the literati, so the furniture also reflected the Song dynasty's pursuit of 'elegance'. The furniture of the Yuan dynasty not only inherited the situation of Song furniture, but also incorporated some of the styles of Liao and Jin furniture. In the pursuit of a more comfortable seating position, Yuan furniture was larger in size and shape than that of the Song dynasty, and the overall appearance was rounded and bold.

2.3.4 Revolution and Design History of Ming Dynasty Seat

2.3.4.1 Revolution of Ming Dynasty Seat

The Ming dynasty (1368-1644) was around the time of the European Renaissance. The term 'Ming-style furniture'must be mentioned when referring to Ming furniture. In his study of Ming furniture, Wang Shixiang suggests (Shixiang, 2013) that Ming furniture is broadly defined as all furniture in the Ming style, including Ming dynasty furniture as well as future generations of imitations. In a narrower sense, it refers to the beautiful furniture from the Jiaqing period of the Ming dynasty to the Yongzheng period of the Qing dynasty. Ming furniture was the heyday of traditional Chinese furniture. According to some Chinese and Western writings Ming furniture can be considered to consist of a combination of hardwood furniture and lacquered furniture.

The production of Ming furniture was centred in Suzhou because of the region's human environment, its geographical proximity to the founding capital of the Ming dynasty and its position as the hub of the Beijing-Hangzhou Grand Canal. Since then, Ming-style furniture has been divided into Su-style furniture, hardwood furniture and lacquered furniture. Ming furniture is also exemplified by Su-style furniture. Later, Beijing-style furniture and Guang-style furniture emerged. In the early Ming dynasty,

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lacquered furniture was the most common. It relied entirely on valuable decorative materials and many techniques to produce it, with no wood texture visible. In the late Ming period, although Su-style furniture had begun to circulate, lacquered furniture, which was the furniture of the nobility, continued to occupy the highest position in the court, followed by hardwood furniture. At this time, the technique of lacquer carving reached its peak, but the method gradually fell out of use during the Qing Guangxu period. During the two centuries of the Ming dynasty there was frequent contact between East and West and very intense cultural exchange, so that wood from Southeast Asia continued to enter China. Thanks to the hardness and lustre of these tropical woods, and the continued advancement of craftsmanship, Ming and Qing furniture gradually reached the peak of Chinese furniture history. During the Ming and Qing dynasties, benches were already popular in the upper classes, while the commoners still mainly used furniture that sat and lay in one piece, usually using stools. The main benches are thrones, cross chairs, lamp hanging chairs, official chairs, rose chairs, circle chairs, square stools, sitting piers, etc (see Figure 2.15). The postural support in Ming chairs (e.g., S-shaped backrests) foreshadowed modern ergonomic theories, which are analysed in depth in Section 2.5 (Five Factors of Ergonomics).

Figure 2.15 : Ming Dynasty Rose Chair, Circle Chair, and Official Chair
(Source by Shixiang, 2020)

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2.3.4.2 Design History of Ming Dynasty Seat

As artisans were free to operate during the Ming dynasty, the handicraft industry of the time had outstanding achievements. Traditional Chinese antique furniture entered its heyday after a thousand years of development. In the mid-Ming period, the pursuit of aesthetics grew, a great variety of furniture took hold and furniture production reached unprecedented heights, producing a wide variety of chicly modelled furniture. The designers of Ming furniture sought an overall balance in their designs.

According to Shixiang, a famous connoisseur of traditional Chinese furniture, Ming furniture can be summarised as: concise, simple, thick and clumsy, heavy, majestic, round and mellow, sunken and mournful, dense and flamboyant, literally beautiful, elegant, strong and straight, soft and gentle, airy, exquisite, elegant and fresh (Wang, 2013). Yao (2002) has also suggested that Ming furniture is basically characterised by simplicity and moderation, and that there is basically not much variation in such characteristics. The simple shape of Ming furniture is coupled with smooth detailing, while incorporating ergonomic principles. Its design is universally applicable and there is a degree of flexibility in the design of the dimensional proportions and angles of the various parts. This design has made Ming furniture a deservedly outstanding representative in the history of classical Chinese furniture and has had an important influence on Chinese and world furniture culture.

2.3.5 Bridging Tradition and Modern Ergonomics: The Legacy of Ming Seats

The design innovations of Ming-style seats furniture, as explored in Sections 2.3.4.1 and 2.3.4.2, reveal an intuitive grasp of ergonomic principles long before the

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formalisation of modern ergonomic science. Ming artisans prioritised anatomical alignment through features like the "S-shaped" backrest and tailored seat heights, which minimised spinal strain and optimised user comfort (Chen, 1991; Sun & Song, 2016). These practices not only reflected the aesthetic and cultural values of the Ming era but also laid a foundation for contemporary ergonomic design. For instance, the curvature of the Quan Yi armchair's backrest aligns closely with the natural lumbar curve, a principle now codified in ISO 6385:2016 for spinal support. Similarly, the use of tropical hardwoods like huanghuali prised for both their durability and sensory appeal demonstrates an early understanding of material ergonomics, balancing tactile comfort with structural integrity (Wang, 2020).

This seamless integration of form and function in Ming seats underscores a broader truth: ergonomic design transcends temporal boundaries. While Ming craftsmen lacked modern biomechanical terminology, their empirical adjustments to seat dimensions and posture support resonate with today's ergonomic standards. As we transition to Section 2.4, which examines the formal definitions and frameworks of ergonomics, Ming furniture serves as a historical precedent highlighting how cultural ingenuity and human-centred design can coexist to address universal physiological needs.

2.4 Ergonomic Aspect in Furniture

Ergonomics has not been developed for a long time, and in the process of development it has gradually incorporated the theoretical knowledge of various related disciplines and broken the boundaries between them (Han, 2016). Ergonomics has gradually formed a comprehensive fringe discipline with a wide range of theories and

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applications, after a long period of continuous improvement of the basic concepts, theoretical systems, research methods and technical standards and specifications (Ruan, 2010; Liu, 2012).

2.4.1 Definition of Ergonomic

Ergonomics, as defined here, is not a modern invention. As explored in Section 2.3.4, Ming dynasty artisans intuitively applied ergonomic principles such as lumbar support in circle chairs centuries before formal standards emerged. Because the scope of ergonomics is extremely broad, and the content of each field focuses on different directions, the naming of ergonomics varies from different fields and countries. The Americans often use Human Engineering or Human Factors Engineering; European countries use Ergonomics, and the International Organisation for standardisation (ISO) also uses Ergonomics; in the former Soviet Union, Engineering Psychology is used, in addition to Applied Experimental Psychology, Man-Machine Engineering, Man-Machine-Environment System Engineering, etc. (Naweed et al., 2018).

The term “Ergonomics” was first coined by the Polish scholar Wojciech Jastrzebowski in 1857. It was not until 1957, when the International Ergonomics Association (IEA) was established in the United Kingdom, that a definition of the discipline was formally proposed: a study of the anatomical, physiological and psychological characteristics and functions of human beings in various work environments; and the study of how to achieve the optimal human-machine-environment state in environments such as work or home (Mohamed et al., 2010). In 2000, John R. Wilson gave a new definition: ergonomics is the theoretical and fundamental understanding of how people behave when interacting purposefully with socio-technical systems, and the application of this

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understanding to the design of real interactions. Although there are different definitions of ergonomics, there is basic agreement on the object and purpose of the study. Ergonomic is the study of human beings and their interrelationship with the environment in a broad sense. The aim of ergonomics is to design human-machine systems in such a way that they can ensure human safety, maintain human health and comfort, and improve work efficiency, i.e., enhance human values (Mukhopadhyay, 2022).

2.4.2 Research Content of Ergonomic

Modern ergonomics consists mainly of theoretical and applied parts. People focus more on the applied part of the research as individuals. The speed of development varies from country to country and there are large differences in the scientific and industrial research base, leading to different emphases on ergonomics in each country. However, there are some general laws governing the development of ergonomic, with less industrialised countries mainly embarking on aspects such as anthropometry, environmental factors, work intensity and fatigue, and then slowly beginning to explore sensory perception/motor characteristics/working postures, etc.; while more industrialised countries look more at operation, display design, ergonomic system control and the application of ergonomic principles in industrial design; and finally arriving at some ergonomic frontiers such as human relations, human-environmental faculties, human-ecological relations, and even interpersonal relations, group behaviours, and organisational behaviours.

Although ergonomics has an extremely wide range of research content and applications, ergonomics is still based on the human-machine-environment, as shown

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in Figure 2.16. The research direction of ergonomics is to apply the laws of interrelationship between human, machine, and environment to maximise the efficiency of human-machine-environment systems (Lv et al., 2009). The overall properties of a human-machine-environment system depend on the organisation of the system and the degree of collaboration within it, rather than being a simple sum of its components. Therefore, the study of ergonomics includes all factors of human, machine, and environment, especially the relationship among them.

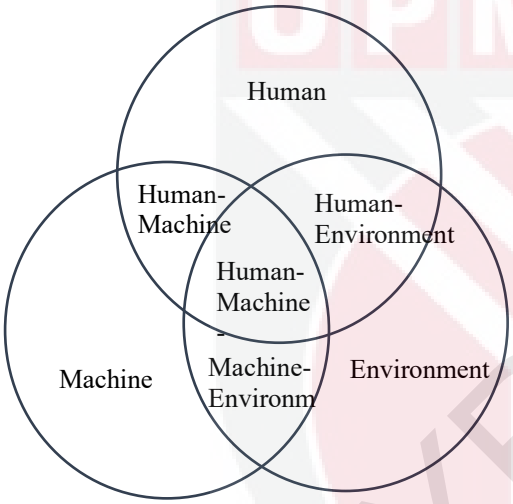

Figure 2.16 : Contents of Ergonomics Research
(Source by Ding, 2002)

2.5 Five Factors of Ergonomic

Ergonomics, in its simplest definition, is the study of people's efficiency in the work environment. Experts have studied five ergonomic aspects in order to improve design or "fit" - safety, comfort, easy-to-use, performance and aesthetics (Gangopadhyay, 2022)

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2.5.1 Aesthetics Domain

Aesthetics has become a dominant factor in product selection by users. Under ideal conditions, although ergonomic and aesthetic factors are different perspectives of aesthetics, both should be equally important in design. Designs that do not come to consider aesthetics may be functionally inadequate (Reich, 1993). Furniture is chosen to reflect the user's personal preferences and lifestyle and thus indirectly the user's cultural symbols (Wahab et al., 2015). Design elements can be harmoniously combined by excellent designers to get excellent visual products (Harada et al., 1999). The cognitive process of aesthetics is the evaluation of the overall performance of something and the relationship between its elements (Park & Togawa, 2019). Subjective assessment is often used to obtain aesthetics, and considering subjective requirements, especially aesthetic ones, is an ongoing research issue (A 3D shape generative method for aesthetic product design). At the same time, objective descriptions of certain specific criteria can be applied to assess aesthetics (Consoli, 2020). Design elements and design principles are two basic pillars of aesthetic theory. Design elements mainly include the ideal items that need to be considered in the design process, while design principles are the guidelines for integrating all design elements into a perfect whole (Liu, 2022). These aesthetic composition processes need to be reflected through human senses. Besides that, external influences, modelling data and aesthetic elements are basic components of aesthetics (French et al., 2023).

2.5.1.1 Senses as Aesthetic Components

Aesthetic experience is based on basic sensory pleasure (Reich, 1993). At the same time, aesthetics is also a way of communicating understanding and transmission, an

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emotionally felt behaviour dependent on the senses (Korsmeyer, 2018). Therefore, senses play an important role in generating aesthetic appeal of excellence.

Consumers need to be guided by their senses to distinguish the discomfort caused using an object (Helander, 2003). In general, the sensory system consists of five components - touch, see, smell, taste and hear. However, it is also important to note that emotions are also an important part of the senses. Product emotions are also emerging as an essential element of consumer enjoyment and business success (Roy, 2018). Customers'feelings and sensations towards products can be attributed to sensuality (Zhai et al., 2009). Thus, when product designing, emotional factors should be added to improve the appreciation of the product. At the same time, furniture is closely related to consumers'lives and affects their emotions in their daily lives (Loučanová et al., 2022).

a) Touch - Touch refers to the sensations of temperature, humidity, pain, pressure, vibration, etc. that are received from the outside world by the nerve cells distributed throughout the skin (Loučanová et al., 2022).

b) See - Seeing is a physiological term that refers to the sensation produced by the stimulation of the eyes by the image of an object.

c) Smell - Smell is a sense that involves the olfactory nervous system and the nasal trigeminal system (Rufenacht et al., 2024).

d) Taste - Taste is a sensation produced by the stimulation of the chemoreceptor system of the taste organ by food in the human mouth. The most basic taste sensations are sweet, sour, bitter and salty (Galande, 2019).

e) Hear - Hearing refers to the external sound stimulation effect on the auditory organs and the resulting sensation, is an important sensory activity for human beings to obtain external information (Shafik et al., 2005).

f) Emotion - Emotions are subjective human experiences that are psychological

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responses to external stimuli (Assens, 2020).

2.5.1.2 External Influences as Aesthetic Components

External factors that influence the design process include pattern, themes, values, commonality, manufacturing process, symbol, and language. As for designers, various factors in nature including the mechanism of movement of objects, shapes and colours can be applied in their own designs (Bumgardner & Nicholls, 2020). From an aesthetic point of view, an object is beautiful because it has good proportions and shapes, soft colours and textures, fine materials, and manufacturing processes. The distinguishing feature of design is the elevation of its objects from mere usability to having artistic qualities.

a) Pattern - a pattern is a repeatable solution to a particular problem (Connelly et al., 2015).

b) Themes - it usually refers to the central idea or main topic of a conversation, book, film, etc (Assens, 2020).

c) Values - it usually refers to the importance, usefulness, or price of something (NSB Academy et al., 2024).

d) Commonality - commonality is a shared characteristic or purpose between two or more things (Randhir et al., 2016).

e) Manufacturing Process - an ordered series of operations or steps that transform raw materials into a final product (Varga, 2019).

f) Symbol - A symbol is a mark used to represent some abstract concept or entity. It can be concrete (e.g. images or words) or abstract (e.g. mathematical symbols or musical notation) (Roy & Gretzel, 2022).

g) Language - the means of expression for human communication, a tool for human interaction, and an important carrier of culture (McEvilly et al., 2005).

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2.5.1.3 Modelling Data as an Aesthetic Component

Different parameters in the structure of seating furniture have a direct impact on the ergonomic data. In order to clarify how different factors, affect the designer or the consumer, it is necessary to quantify the data in the structure of the seat. In order to facilitate quantitative comparison, the design parameters of seating furniture can be distinguished as: the height of the headrest, the shape of the headrest, the shape curve of the backrest, the scale of the backrest, the shape of the armrests, the height of the seat surface, the dimensions of the seat surface, the shape of the seat surface, etc. (Zhang et al., 2022). In the design of chairs, it is necessary to maximise the coverage and refinement of dimensional data that will have an impact on ergonomics (Joshi & Deshpande, 2019). For this purpose, the chair was originally divided into whole and part for the selection of design data in the research process. The first part is the dimensional data of the whole part of the seat, which mainly includes the transmission length, width, and height of the seat. The second part is to analyse the dimensional data by dividing the seat into design parts. According to the spatial position and function, the Chinese seat can be divided into four parts from top to bottom: backrest, armrests, sitting surface, legs, and feet, as shown in Figure 2.16.

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Figure 2.17 : Chinese Seat Component Division
(Source by author)

Looking at the overall data of the seat, the highest part is the backrest area. The design data of the backrest includes mainly width, height, and thickness. The width of the backrest corresponds to the length of the seating surface. The thickness of the backrest is not easy to visualise in the research, and the impact on ergonomics is relatively weak, so the collection is less meaningful (Silviana et al., 2022). Comparatively speaking, the height of the backrests of different seat shapes is quite different. Therefore, the height of the backrest is mainly collected in the design of seat backrest dimensions. In addition, when designing the seat backrest shape, the change of flat and straight curvature will also affect its comfort; therefore, the curvature of the backrest is also collected as data in the design.

The armrests of the seat are located on both sides of the upper part of the seat surface, and the main dimensions that affect their ergonomics include length, height, and thickness (Ren & Feng, 2022). The length of the armrest is consistent with the width

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of the seat surface; while the thickness is not easy to visualise during the research process, and the data collection is less meaningful. However, the height of the armrest directly affects the position of the user's arm, which has a more obvious effect on ergonomics, so the dimensional modelling data of the armrest part of the seat is collected in its height dimension.

The design parameters of the seat surface include length, width, and thickness (Cardoso et al., 2019). Length and width directly affect the area of the seat surface, thus affecting the comfort of the user. The thickness of the seat surface, on the other hand, depends largely on the strength of the material, which bears the support of the force, and has a weaker impact on the ergonomics, with less significance in the collection. In the process of use, the seat surface and the body are in direct contact with each other, and the choice of material has a direct impact on the comfort of the seat, thus the seat surface material can be used as an influencing factor in the research of seat ergonomics (Moon et al., 2020). On the other hand, the height ratio of the seat surface directly affects the posture of the user's legs, thus affecting the user's experience. Therefore, the height ratio of the seat surface can be used as a data collection object in the design.

The main dimensions of the legs and feet, which are the supporting parts of the seat, are length and thickness. The length is consistent with the height parameter of the seat surface, while the thickness of the seat leg part affects the stability of the whole chair and has little influence on the direction of ergonomics, so its data is not very meaningful for research. Combining the above parts of the analysis, 9 styling data were collected in the seat in the ergonomics study. Among them, there are 3 sets of

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overall modelling data of the seat, which are length, width, and height. The modelling data of each part of the seat are 6 groups, which are leg and foot height, sitting surface height ratio, sitting surface material, backrest curvature, backrest height, and armrest height. As shown in Table 2.4 below.

Table 2.4 : Identify 9 Target Data

Integral/Component	Part	Data
Integral	Length	
	Width	
	Height	
Component	Backrest	Backrest height
		Backrest curvature
	Armrests	Armrest height
	Seating surface	Seat surface material
		Seat height ratio
	The legs of the chair	Leg height

(Source by author)

2.5.1.4 Aesthetic Elements as Aesthetic Components

With the development of society, people's living standards continue to improve. People are no longer satisfied with the pursuit of material. In order to improve the quality of life, people have higher and higher requirements for aesthetics. There are many aesthetic elements to be considered in the process of product design and manufacturing, mainly including form, colour, texture, balance, material, and functionality (Song, 2018). Their combination is mainly to reflect the beauty of the product features. Product design can only show a better combination of aesthetic elements in the product design process by fully considering various factors and coordinating the conditions in all aspects.

a) Form - often used to describe the outline or structural form of a product, such as the streamlined design of a car (Sulaiman et al., 2012a).

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b) Colour - colours are used to distinguish between different models, express brand characteristics or attract consumers'attention (Sulaiman et al., 2012a).

c) Texture - It describes the tactile or visual textural characteristics of an object's surface (Ziming et al., 2020).

d) Balance - balance refers to the equilibrium of a product in terms of its visual, functional and usage experience (Peru et al., 2024).

e) Material - the choice of materials directly affects the performance, cost and service life of the product (Kulkarni & Kolli, 2023).

f) Functionality - functionality is one of the most important indicators for evaluating product performance (Kulkarni & Kolli, 2023).

2.5.2 Safety Domain

Safety is crucial in the implementation of ergonomics. Safety focuses on the risk factors and potential hazards that exist during the use of a product. Ergonomic design reduces the cumulative damage to the user during use, resulting in a healthier working environment for the labour force (Sankar et al., 2024).

2.5.2.1 Ergonomic Risk Factors as Safety Components

In everyday life, objects related to our work and life, if carefully observed and analysed, will reveal the existence of ergonomic risks and potential areas for improvement. Based on ergonomic principles, improvements to each component of the work environment can reduce musculoskeletal disorders (MSD) in users during use; at the same time, they increase the safety of workers during use (Colim et al., 2020). Ergonomic safety mainly considers the risk factors that workers are exposed to during operation (Andersen, 2004; Qureshi et al., 2019), which include the following

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aspects:

a) Repetitiveness: Repetitiveness is one of the main causes of cumulative injuries and stress at work. For example, prolonged use of a mouse to maintain the same position of the wrist during office work. This damage to the body can build up over time and eventually lead to musculoskeletal disorders (MSD) or injuries to other body parts (Ramanankonenana & Randriamamonjy, 2023).

b) Force Required: The strength of the force required by the operator to complete a task. Excessive loads can cause injuries to the operator. Thus, the actual force required should be within the operator's capacity (McEvilly et al., 2005).

c) Prolonged positions: Prolonged static work or maintaining uncomfortable positions for long periods of time can be equally damaging to the body. For example, office workers working in uncomfortable chairs for longer periods of time can cause back and spinal discomfort.

d) Inadequate tools: The operator relies on the machine or equipment to do the job, and if the tools used are not up to scratch, ergonomically the operator is at risk of injury.

In addition to the factors mentioned above, the high and low temperatures, vibration, or noise that the operator faces during the work process can also cause cumulative damage, which can be physically and psychologically harmful (Cheng et al., 2022) to the operator over a long period of time.

2.5.2.2 Common Ergonomic Injuries as Safety Components

Factors affecting ergonomic safety can lead to operator injuries, and the type of injury caused, as well as its severity, depends on the type of risk factor. Common ergonomic injuries include the following:

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a) Musculoskeletal disorders (MSDs): these disorders primarily affect the operator's muscles, ligaments, bones, and joints. MSDs can be either acute injuries or chronic accumulations of loss.

b) Carpal Tunnel Syndrome: Carpal Tunnel Syndrome refers to symptoms of numbness and pain in the hand or arm area when the nerves in the wrist are compressed for long periods of time (Pramchoo et al., 2020).. For example, holding a mouse in your hand for a long period of time may cause soreness in the wrist area.

c) Rotator cuff injury: the rotator cuff area is the muscles and tendons located around the shoulder. Rotator cuff injuries may have an acute injury caused by excessive force or may be a functional deterioration caused by repetitive labour.

d) Lower Back Injuries: The main cause of lower back injuries can be excessive weight bearing or sedentary lifestyle (Siregar et al., 2023). Sitting in an office chair all day in a uniform position can cause lower back pain and complications.

2.5.2.3 Identifying Ergonomic Hazards and Fixing Them as Safety Components

The main principle of ergonomics is to make the workpiece more suited to the operator's habits, to prevent and reduce injuries, and to improve productivity, either in the design or in subsequent modifications. Therefore, it is important to identify potential ergonomic safety problems in the workplace and to be able to improve and repair them (Giangrego, 1986). In order to alleviate the ergonomic injuries received in the workplace, part of it can be done by improving the tools for the job, and on the other hand by changing the relevant work habits through relevant training (Kumari, 2018).

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a) Redesign of equipment: Redesign the problems of chairs, desks, monitors, and other equipment to improve their comfort during use. At the same time in the design of the programme, to meet the requirements of different users, each person can adjust their workspace according to their own needs. For example, the height of the monitor or the height of the chair (Sulaiman et al., 2012b).

b) Changes in wage habits: Certain habits or postures in the workplace may cause less damage to the body than other habits. For example, a monitor at the right height can make viewing easier, thus reducing cumulative damage to the cervical spine.

c) Alternate postures: Even if you use ergonomic equipment and follow ergonomic practices. However, maintaining a posture for a long period of time can cause muscle tension in the body, which may result in cumulative damage (Ilona et al., 2022). Thus, we can guide our employees through vocational training to pay attention to changes in posture as well as rest and relaxation at work.

d) Enhancement of the quality of the working environment: Planning the working environment and keeping it neat, clean, and welcoming will help to reduce employees'stress and enhance work efficiency.

2.5.2.4 Safety-Designed Items as Safety Components

In modern sitting furniture is broadly divided into types such as work chairs, armchairs, stools, light sofa chairs, large sofa chairs, recliners and so on. For the humane design of sitting furniture need to consider the comfort and safety of each part (Zhu, 2015). If the sitting furniture can be made to fit the function of human body, the following points need to be considered.

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a) Seat Height

The seat height of a chair refers to the vertical distance from the seat surface to the ground. As the chair surface is often tilted backwards, the sitting height of the chair is usually used as the height of front chair sitting surface of the high; if the seat surface exists backwards or is concave and curved, the sitting height refers to the vertical distance from the centre point of the sitting front to the ground. Seat height is the main influence on sitting comfort, and an inappropriate seat height can lead directly to incorrect sitting posture and back fatigue.

As shown in Figure 2.18, the figure shows a situation where the seat surface is too high, causing excessive pressure on the front part of the thighs and resulting in leg numbness. Another situation is that the seat surface is too low. When a person sits on a seat with a low seat surface, it causes the body to bend forward, with gravity concentrated in the front, making it extremely easy to fatigue, and it is not easy to get up when standing. Lastly, a reasonable seat height should be one in which the hips are fully seated, so that the thighs and hips distribute the body's gravity evenly.

Figure 2.18 : Seat Height is Too High, Too Low, and Moderate
(Source by Zhu, 2015).

The height of the seat should normally be considered most in terms of the length of the lower leg and to add a portion of the thickness of the heel and should also subtract the amount of clearance of the stone bench. The choice of percentile should follow Type IIB product size requirements, taking the P5 percentile as a lower limit for people of low stature to ensure that people of short stature can also use it. If the height of the

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seat is adjustable, it should follow the size requirements of Type IIA and take the P95th percentile as the upper limit for people of high stature to ensure that 90.0 percent of the people can use it. According to the national standard "GB 10000-2023 Chinese adult human body size", it can be obtained from the lower leg plus the foot height of 342-448mm. Thereby you can get some seat height reference size, general work chair seat height of 400-440mm (Chinese national standard GB 3326-2016), and lightweight sofa chair seat height of 330-380mm, height adjustable chair seat height of 380-500mm.

The special feature of the stool is that there is no backrest, so the stability of the lumbar spine can only be adjusted by the height in the absence of back support. There is a clear difference in the mobility of the lumbar spine when a person sits on a stool. Unlike chairs with a backrest, the lumbar spine is most easily fatigued when the stool height is 400mm and the lumbar activity is strongest. When the stool height is slightly higher or lower, the mobility of the lumbar spine decreases and the comfort level rises, as shown in Figure 2.19.

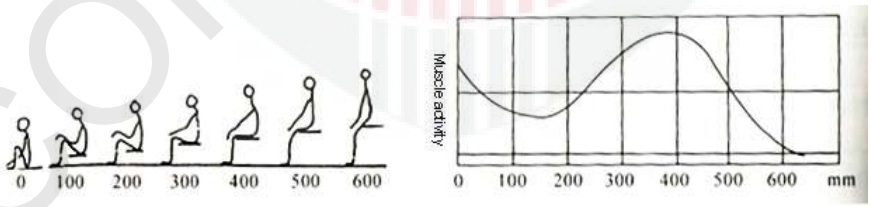

Figure 2.19 : The Relationship between Seat Height and Psoas Activity
(Source by Han, 2016)

b) Seat Width

The seat width is the width of the seat surface at the front edge of the seat. If the seat has an irregular trapezoidal shape, then the seat width should be

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divided into a front width and a rear width. The width of the seat surface should be slightly wider than the width of the hips, so that the seat can fully support the hips and leave some clearance for the user to adjust the seating position. In the selection of the number of percentiles, generally use type IIA product size requirements, according to the female hip width to take P95 percentile as the design basis, so that most people can have appropriate space to adjust the sitting posture. According to the Chinese national standard "GB 10000-2023", you can get P95 female hip width of 382mm. Thus, it can get some seat width reference size, general work chair seat width of not less than 350mm, back chair seat width of 380-450mm, armchair seat width of 460-510mm, cinema row chair should not be less than 540mm. Figure 2.20 show reflects the consequences of improper seat width dimensions.

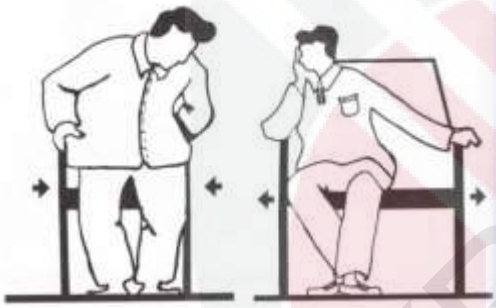

Figure 2.20 : Consequences of Incorrect Seat Width Dimensions
(Source by Zhu, 2015).

c) Seat Depth

The seat depth is the distance from the midpoint of the front edge of the seat to the intersection of the back and the seat surface (Han, 2016). A reasonable seat depth should use the support of the backrest to reduce the pressure on the lumbar spine. To provide support for the front of the thighs, the seat depth should be large enough, but not too deep. A seat depth that is too small will not provide sufficient support for the hips, while a seat depth that is too large will leave the lumbar region unsupported or the front part of the seat will press on the knee sockets.

In general, the front edge of the seat should be left with a 60mm gap to the knee socket. For seating with a backrest, the choice of percentile should follow

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the design of the size of the low stature group, taking the P5 percentile as a lower limit to ensure the effective use of the backrest for people of short stature. If the depth of the seat is adjustable, the P95 percentile should be considered as the upper limit. According to the Chinese national standard "GB 10000-2023", you can get the female P5-P95 seat depth of 401-469mm. Thereby you can get some seat depth reference size, general work chair is not more than 430mm, rest chair 400-500mm, ordinary sofa for 500-520mm. Figure 2.21 Reflects the consequences of improper seat depth dimensions and the correct seat depth.

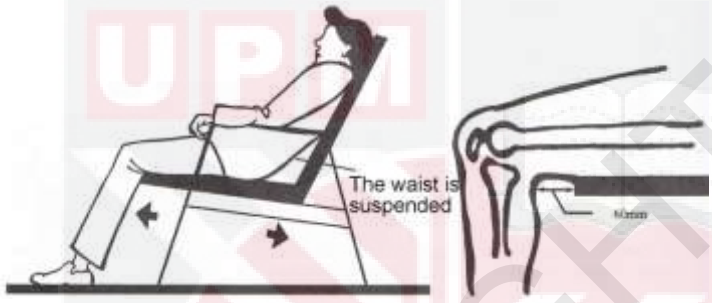

Figure 2.21 : Consequences of Improper Seat Depth Dimensions and Correct Seat Depth
(Source by Zhu, 2015)

d) Seat Curvature

Seat curvature refers to the degree of concavity or convexity of the seat surface, which directly affects the distribution of body pressure. In seat design, the seat surface is often made of a slightly stiffer material and is generally designed with the left and right seat surfaces horizontal, but with the front surface slightly higher than the rear surface. This allows the body's gravity to be distributed appropriately. Some designs have a hip shape cut out of the middle of the seat surface, however, in use this is difficult to adapt to a wide range of body sizes and can make it difficult to adjust the seating position. Unlike seats, sofa seating surfaces are generally raised in the middle, but should be designed so that the curvature is not too great, as shown in Figure 2.22.

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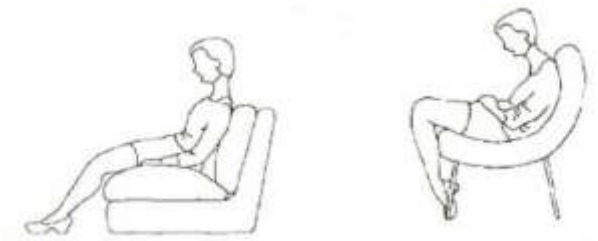

Figure 2.22 : The Sofa Seat Surface is Over-Curved
(Source by Han, 2016)

e) Seat Inclination and Backrest Inclination

The seat inclination is the angle between the seat surface and the horizontal plane, while the backrest inclination is the angle between the backrest and the horizontal plane. The backrest is mainly created for people to lean on their upper body in a seated position, reducing the pressure on the lower limbs and hips and reducing fatigue. The seat surface is generally inclined backwards at a certain angle, allowing the user to lean back naturally, making people feel relaxed. In general, the seat and backrest angle of the lounge chair will be relatively large, which is conducive to the body to relax and get sufficient rest. Unlike the work chair, the seat surface cannot be too far back, resulting in the user's upper body bent forward, destroying the normal curve of the lumbar spine. This can be obtained from some seat inclination and backrest inclination angle of reference angle as refer to Figure 2.23 and Table 2.5.

Table 2.5 : Reference Angles for Seat Surface and Backrest Inclinations

Type of seat	Seat surface angle/ (°)	Backrest angle/ (°)	necessary support point
work chair	0-5	100	lumbar support
light work chair	5	105	shoulder support
rest chair	5-10	110	shoulder support
lounge chair	10-15	110-115	shoulder support
recliner with headrest	15-23	115-123	shoulder and neck support

(Source by Zhu, 2015)

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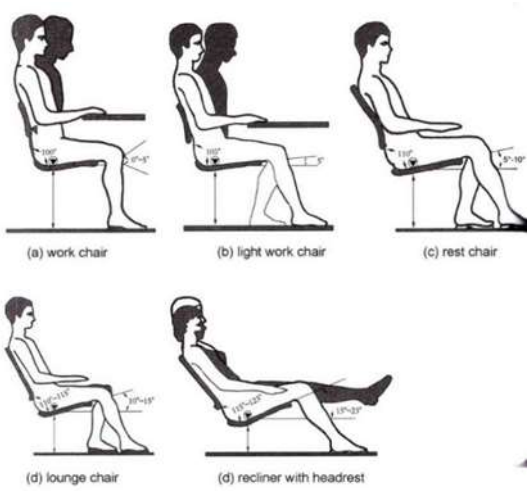

Figure 2.23 : Reference Angles for Seat Surface and Backrest Inclinations
(Source by Zhu, 2015)

2.5.3 Comfort Domain

There are more factors affecting comfort, and according to the research content of related scholars, the influencing factors are mainly divided into psychological, physiological, physical and environment aspects. In the physiological aspect, Kolich M. (2004), Warska M. (2021), Caballero-Bruno I. (2022), Akçay, S. (2023) and Ebe and Griffin (2001) etc. carried out interference experiments on car driving seat comfort. The results of the related experiments showed that parameters such as height, support, and shape of the car driving seat cause muscle fatigue and pain in users. In the psychological aspect, include emotion and mental. For physical main factors affecting seat comfort are seat modelling, seat support, seat adjustment, Breathability, and material. On the environment side, studies by Kolich (2004); Fazlollahtabar (2010); Fan (2017) found that changes in the external environment such as temperature, light, and noise affect the user's psychology and mood. Due to the large number of factors affecting comfort, this paper will select the components that are most relevant to the user for the relevant design.

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2.5.4 Easy-to-Use Domain

The easy-to-use of a product refers to the ability of the product to be easy to operate and effective. Literally, it means that the product is not difficult to operate, and the user can easily get started. The concept of ease of use was first introduced around 1980, initially for the purpose of product testing, testing in the use of the product in the process of the existence of the product, so that the latter from the design of the use of other means to improve. Easy-to-use design is a theoretically guided approach to product design that examines the rationality of the division of functional areas of a product. This design method takes the user as the centre and improves the operability of the product to meet the user's operating habits and needs (Jing, 2022). Easy-to-use design aims to solve the problem of whether the interaction between the product and the user is harmonious and comfortable, and whether the product can achieve the degree of user satisfaction. Easy-to-use mainly includes the following aspects (Cai, 2017):

a) Effectiveness: the correctness and completeness of the user's fulfilment of specified goals.

b) Efficiency: the user's commitment to the correct and complete completion of the specified goals.

c) Satisfaction: the pleasure of using the product and the attitude of recognition.

d) Context of use: the user, the work, the device, and the physical and social environment in which the product is used.

The attributes of easy-to-use are summarised in the "ISO FDIS 9241211" standard. That is, easy-to-use refers to the effectiveness, efficiency, and user satisfaction of the interaction process when the user uses the product to accomplish specific tasks in each

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environment. Easy-to-use design research focuses on the “ease” of use, so that the device has a better “human-computer interaction”. Although the concept of ease of use is recent, the principle of easy-to-use has been demonstrated throughout the history of manufacturing, from the simplest tools of labour to complex electrified equipment (Yang & Xiong, 2022). For products with simple functions, it is relatively easy to design for improvement while satisfying the function; while the study of ease of use for large equipment and electrified integrated equipment is relatively complex and is the focus of research in easy-to-use design.

In the design process of easy-to-use design, it is necessary to study and investigate the problems and discomforts of operators in the operation process. After analysing the various problems, on the premise of realising the functions, various operation steps are simplified, important functions are prompted, and the operators are guided to operate in the order. Therefore, easy to read, easy to operation, and satisfaction during the operation process are the keys to easy-to-use design (Lv, 2007).

2.5.5 Productivity and Performance Domain

Ergonomics has been widely used in the field of industrial design, for the corresponding shape, colour, material, and performance of the product humanised design. Comprehensive aspects of the design, so that the product to better meet the physiological and psychological needs of people in the use or operation process. Good design makes people safer and more comfortable in work or use, the goal is to improve people’s work efficiency (Leamon, 1987). The purpose of ergonomics design is to analyse the equations between the product and the person, to obtain the optimal product, so that the operator can be better adapted to the use of the process, thus

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enhancing production efficiency. Ergonomics seeks to meet the functionality of the product based on better fulfilment of the human-machine-environment combination. Comprehensive analysis of the user's human body structure, manipulation habits, psychological needs, and other requirements for product design (Westover et al., 2010). Products based on ergonomics are designed to minimise user injuries during use and maximise product performance. Instead, the primary avenue of verification for productivity/performance is typing speed and accuracy (Baltezarević, 2020).

2.6 General Ergonomic Domain

General ergonomics usually refers to the physical elements of ergonomics, which include human posture, product dimensions, product handling, and user movement (Fan, 2021). These four aspects have a wide range of applications and importance in ergonomics, product design, user experience, and movement science. While anthropometry varies depending on the secular growth of various populations, designers can create the ideal atmosphere for their environments by paying attention to human posture and scale (Wu, 2022). For instance, as certain populations get older, the need for accurate human factors design increases (Hamad et al., 2021).

2.6.1 Human Posture

Human body posture includes standing, sitting, lying and other forms, and these postures not only affect the comfort of the human body, but are also closely related to health conditions. Correct posture helps to reduce the burden on the body and prevent cervical spondylosis, lumbar spondylosis and other occupational diseases (Reis et al., 2012).

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a) Standing Posture: When standing, you should keep your eyes level, chest up, waist and back straight, avoiding the centre of gravity to one side. When standing for a long time, you can change your posture appropriately to reduce the pressure on your legs and back (Xu et al., 2014).

b) Sitting Posture: The correct sitting posture should follow the principle of "three 90 degrees", i.e., elbows bent at 90 degrees, knees bent at 90 degrees, thighs and back at 90 degrees. At the same time, the height of the chair and table should be adjusted so that the eyes and the monitor to maintain an appropriate distance, to avoid prolonged low or tilted head (Yamamoto et al., 1985).

c) Lying Posture: When lying on the back, the pillow should be padded under the head and neck to avoid neck suspension; when lying on the side, the height of the pillow should be equal to the shoulder width on one side to maintain the natural curvature of the spine (van Dieën et al., 2001).

2.6.2 Product Size

Product size refers to the length, width, height, weight, and other physical parameters of the product, which need to be designed with full consideration of ergonomics to ensure ease of use and comfort.

a) Human Size Data: In product design, reference should be made to human size data, such as height, shoulder width, hip circumference, etc., to ensure that the product can be adapted to the use of most users. For example, furniture design should take into account the user's height and sitting habits to provide a comfortable sitting experience (Wölfel, 2017).

b) Functional Dimensions: In addition to construction dimensions, attention should also be paid to the functional dimensions of the product, i.e., the range of space required by the user when using the product. For example, the height and depth of kitchen cabinets should be designed according to the user's height and operating habits to facilitate access to items (Abyzov et al., 2022).

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2.6.3 Product Handling

Product handling refers to the actions and steps that the user needs to perform when using the product. Good product operation design should simplify the operation process, reduce the rate of misuse and improve user satisfaction (Shin et al., 2015).

a) Handling Interface Design: The operation interface of the product should be intuitive and easy to use, with reasonable button layout and clear and readable display information. For example, the operation interface of a smartphone should be simple and clear, and important functions should be easy to find and operate (Hirokawa et al., 2014).

b) User Manual: Provide a detailed user manual for the product to guide the user to use and maintain the product correctly. The user manual should include basic information about the product, operating procedures, safety warnings, etc., to help users get started quickly and avoid unnecessary losses (Oliveira, 2016).

2.6.4 User Movement

User movement refers to the physical activities involved in the use of the product by the user. Ergonomics plays a vital role in user movement design to ensure that users remain comfortable and safe during movement.

a) Exercise Equipment Design: The design of exercise equipment, such as treadmills and fitness equipment, should take full account of the human body's movement patterns and biomechanical properties. For example, the width of the treadmill's running belt and the range of slope adjustment should be designed according to different users'heights and stride lengths to ensure that users remain comfortable and stable during the running process.

b) Exercise Assessment System: With the development of technology, exercise assessment systems such as the Keep exercise assessment system are gradually emerging. By assessing the user's exercise load and exercise

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capacity, these systems provide users with personalised exercise programmes and recommendations to help users train scientifically and reduce the risk of injury.

2.7 Human Characteristics in the Use of Seat

From ancient times to the present day, there have been many different types of seating furniture. Modern sitting furniture can be functionally divided into several categories: chair furniture, stool furniture and sofa furniture. Sitting and lying are the most frequently used postures in daily life, for example, for working, studying, eating, and resting. However, the basic function of sitting furniture is to make people comfortable, reduce fatigue and improve efficiency when using it. Of these, the most important is to reduce fatigue. By studying the relationship between the human skeleton, muscles and scale in the design of seating furniture, and by minimising fatigue while supporting the body's movements, a person can be comfortable and at the same time maintain good productivity (Hossian et al., 2022).

The human body is supported in a seated position mainly by the spine, pelvis, legs, and feet, while the pressure on the upper part of the trunk is carried by the intervertebral discs, sacrum, and lumbar spine. Sitting comfort is influenced by many factors and one of the most important is the pressure on the intervertebral discs. The pressure on the discs is mainly caused by the body's posture, and when the pressure is too high it can directly damage the discs (Hey et al., 2021). Sun and Song (2016), the spine changes very significantly when the body is standing and sitting (see Figure 2.23). In a standing position, the lumbar spine appears to be substantially convex. When sitting down, the lumbar spine changes very much in a "c" shape from the

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opposite direction, and the posterior thoracic curve changes as well. The change in the spine is formed by the rotation of the hip bone by the acetabulum as the thigh bone changes from a vertical to a horizontal position. The change in curvature of the lumbar spine causes the intervertebral discs to be compressed and bulge backwards, which increases the force on the discs.

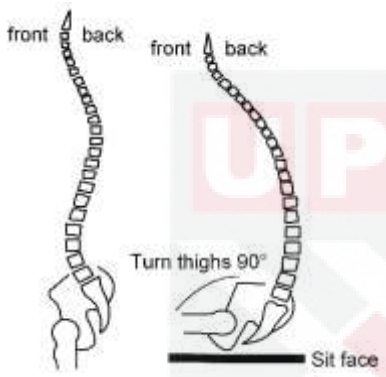

Figure 2.24 : Changes in Vertebrae during Standing and Sitting Posture (a) Standing Posture, Lumbar Lordosis, (b) Sitting Posture, Lumbar Kyphosis
(Source by Sun & Song, 2016)

Furthermore, there are many reasons for fatigue, however, the most important of which is the intense stress caused by the contracting movements of the muscles and ligaments. The body needs to supply nutrients to muscles that are in a state of contraction for long periods of time. When the body is not able to feed them in time, a feeling of fatigue develops. At the same time, the ligaments can become less resilient due to prolonged poor sitting and are unable to restore the disc to its original position. The loss of toughness is an irreversible process. This condition can lead to back pain and in severe cases can cause the disc to compress the nerves, leading to a herniated disc (Graveling, 2018). The curvature of the spine, particularly in the lumbar region, is clearly influenced by changes in human posture during daily human activity. Figure 2.24

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shows the curve of lumbar curvature produced by a human being in different postures, where curve B is the curve of lateral recumbency when relaxed; as in posture C in the figure, the curve of the lumbar region in a seated position can remain almost normal when some support is added to the lumbar region and when the angle between the trunk and thigh is greater than 90°. However, reducing the pressure on the intervertebral discs in the sitting position and keeping the curve of the spine and lumbar region normal is the key to a more comfortable sitting position. The curves F and G in the figure are common sitting positions in modern life, and prolonged sitting in a straight and forward bending position can lead to severe disc distortion.

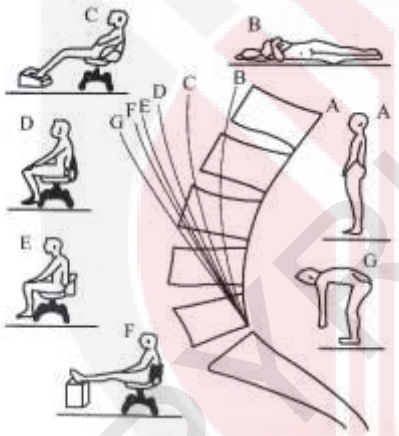

Figure 2.25 : Lumbar Curvature in Different Positions
(Source by Rongji, 1999).

When sitting in an upright position, with the back resting lightly on the backrest of a chair and the trunk straight, the thoracic spine is more extended than the lumbar spine (Kett et al., 2021). Grandjean suggests that the back is the most uncomfortable part of upright sitting (Grandjean & Hünting, 1977). Compared with the upright sitting posture, the forward leaning posture shifts the body's center of gravity forward and the muscles of the back are stretched to a certain extent, while the forces on the intervertebral discs are unevenly distributed. At this point, the elbows, which are

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placed on the table, share part of the body weight, while the hips can be pressed too hard and too long, resulting in poor blood circulation and musculoskeletal pain and numbness (Rezapur-Shahkolai et al., 2021). Keegan (1953) suggested that a forward leaning sitting position that bends the back for a prolonged period is highly likely to produce back pain. When the body is seated in a reclined position, the backrest relieves some of the burden on the lumbar spine and carries some of the body's weight as the back rests fully on the seat back.

2.8 Seat and Ergonomic

Sitting furniture is the most frequently and widely used piece of furniture and is used in most places. Reasonably designed seating furniture can make the user feel more comfortable and get proper relaxation and rest; on the contrary, poorly designed chairs do not allow the user to relax, and even have a great sense of fatigue. Therefore, the design of seating furniture should consider the physiological structure of the human body and use reasonable body dimensions as a basis. The sitting posture can be divided into three types according to the depth of the posture: sitting forward, sitting at the end, and sitting backwards. When a person is at work, he or she often sits in a forward position, with the sacrum moving and the pelvis rotating in an inclined position. Prolonged sitting in a forward position causes the spine above the waist to lurch backwards, which is known as a hunchback. When sitting upright, the pelvis and sacrum are positioned more vertically and the spine above the waist forms an anterior convexity. By analysing the physiological characteristics of the human sitting posture, designers can help to design more rational sitting furniture.

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2.8.1 Traditional Chinese Seat and Ergonomic

Classical Chinese furniture has gone through many dynasties, including the Shang and Zhou Dynasties, the Spring and Autumn Period, the Qin and Han Dynasties, the Wei, Jin and North and South Dynasties, the Sui, Tang, Song and Yuan Dynasties and the Ming and Qing Dynasties. However, the Ming and Qing dynasties have become the representative works of traditional Chinese furniture with their simple and beautiful artistic connotations and elegant and fresh structural shapes (Liu, 2010). Not only that, Chinese Ming and Qing furniture also had a pivotal position and splendid achievements in the history of world design at that time. This section explores the relationship between traditional Chinese seating furniture and ergonomics, using Ming and Qing furniture as an example.

Unlike the rudimentary stone beds of Skara Brae (Smardzewski, 2015), Ming chairs exemplify how cultural and ergonomic priorities converged to create enduring functional art. The exploration and imitation of Ming and Qing furniture by designers from all over the world continues unabated, and it remains one of the classic examples of furniture. In addition, the ancient people's grasp of the interaction between man and tool in the making of furniture has left us in awe (He, 2000). In addition to its elegant appearance, its proportional shape, lines, and scale are a profound reflection of the wisdom of the ancients. Although there was no systematic research and study of ergonomics during the Ming and Qing dynasties, the ancient Chinese used their own experience and the social context of the time to make bold attempts at the scale and proportions of traditional seating furniture. The classic Ming and Qing chairs show us how the ancients used ergonomics.

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2.8.1.1 Ergonomic Theory

The base of the Ming-style seating furniture is very rigid in its shape. To improve the safety of the seat and increase its stability, the designers built the Yazi at the joint between the horizontal and vertical wood of the seat. Rings were added between the four legs of the seating furniture to support the weight of the upper members and to strengthen the solidity. A more comfortable option is the armchair, as the user can use the armrests to support arm strength and relieve fatigue. For example, the overall proportions and structure of the Armchair is very appropriate (see Figure 2.26). It is set according to the height of the upper part of the spine when sitting, while the lower part is set according to the lower limbs of the person, and the height of the head is flush with the person's neck so that the head can rest on it. The Book Integration mentions: Sitting in silence and concentrating, needing a wide and comfortable seat, you can lean back on your feet. The middle of the neck is supported and the head is resting backwards on the brain pillow, this state allows the muscles and bones to be relaxed and the blood to flow (Wang, 2000).

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Figure 2.26 : Armchair
(Source by Wang, 2020)

The design of the back of the chair is based on the characteristics of the spine to make the backrest inclination angle of about 100-105° comfortable angle, so that the comfort of sitting on it increases (Cui, 1989). The armrests of the circle chair and the cross chair are attached to the backrest of the seat, and the addition of the armrests allows one's entire body, shoulders, and arms to lean more relaxed against the backrest. The armrests are attached to the backrest at a gentle angle, which is very much in keeping with the proportions of the body and arms. The headrest is a crossbeam at the top of the backrest, named after the way in which the head can rest on it when sitting, temporarily relieving the user's neck fatigue. This component itself is very much in line with the ergonomic principles required.

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2.8.1.2 The Use of Ergonomics Theory in Dimensions

The profound study of human dimensions in Ming-style seating furniture makes it very comfortable. The following are some of the dimensions of Ming-style seating furniture: the height of the seat surface of the lamp-hanging chair is approximately 480mm; the height of the seat surface of the armchair, rose chair and circle chair is approximately 500mm; and the height of the seat surface of the cross chair is approximately 550mm. From the above data, the seat height of Ming-style seating furniture is basically above 460mm from the ground. This height allows the feet to rest on the front footrest while remaining seated, and the height of the seat surface minus the footrest (approximately 100-140mm) is in accord with the ergonomic standard of knee height.

The height of the armrest should be slightly less than the sitting elbow height, as mentioned earlier the general armrest height is 200mm-250mm, the front of the armrest can be slightly elevated. The height of the armrest of the armchair is approximately 220mm, when the user rests his arm on the armrest, it can reduce the pressure on the upper part. The tilt angle of the armrests of the cross-chair circle is about 15°, such an angle can make people's arms on the armrests present a very relaxed state, so that users eliminate fatigue, in line with ergonomic design requirements. The back of the circle chair is attached to the armrests, from the highest point of the circle chair backrest to the lowest point of the armrests, the height difference is about 350mm, which makes it extremely comfortable for people to sit and lean, and the arms can all lean on the circle-shaped armrests.

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The height of the backrest of Ming chairs is approximately 420-570mm. Among them, the lamp-hanging chair, the armchair, the circle chair, and the cross chair are high-backed chairs, with a backrest height of about 520-570 mm. among them, the armchair has a high backrest, while the upper part of the rose chair takes up a smaller proportion of the whole, with a backrest height of about 420-450 mm. The "S" backrest is also very characteristic of Ming chairs, "The 'S'shape matches the spine of the human body, suggesting that ergonomic design by Ming craftsmen had already begun centuries earlier (Fang, 2004). It is extremely comfortable for the user's back and eliminates from fatigue problem.

2.8.1.3 The Use of Ergonomic Theory in the Use of Material

Wood is the main material used in the production of Ming style seating furniture, and the beauty of the wood's own grain and colour is revered in its production. In traditional Chinese culture, the hardwood timber used in Ming style seating is of great benefit to people's physical and mental health. At the same time, the physical and psychological pleasures provided by the wood is also fully compatible with ergonomic principles.

The woods used in Ming furniture such as chicken wing, rosewood, ironwood, huanghuali and other precious woods, have certain environmental properties. In traditional Chinese culture, such precious woods have some unique pharmacological effects and are very beneficial to the human body. People reasonably apply the pharmacological effects in the design of furniture is also in line with the ergonomic regulation of the behaviours. For example: the fragrance of Hainan Huanghuali is sporadic, rainy, and cloudy days, especially on rainy days will be thicker, sunny days

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are lighter. The biggest characteristic of Hainan Huanghuali is that the fragrance will still have residue after a long time past, which is also the mysterious allure of Hainan Huanghuali. The folklore rumour is that the most fragrant part of Hainan Huanghuali is the root material with scars and tumours combined with the tree.

The modern pursuit of ergonomics is mainly the pursuit of comfort, while the Ming and Qing dynasties often required sitting on a chair due to the etiquette restrictions of the time. For example, in the case of the Qing dynasty Taishi chair, if one were to sit on it according to the dimensions of the Taishi chair, one would appear to have an overly large chair with one's feet off the ground, but when the cultural context is considered, one feels that its design is very reasonable (see Figure 2.27). In a time of elaborate etiquette, the Taishi chair was a symbol of the status of the master, and only the male master was allowed to use it; other women and children in the household were not allowed to sit on it. On the other hand, the Taishi chair is not for people to use when relaxing, it is tall in size for two main reasons: firstly, it is a ceremonial requirement not to be relied upon at will, and because bricks were often used as floor coverings in ancient homes, feet would feel cold in winter, so the Taishi chair must be used with a footrest. Secondly, it can show the beauty of the embroidered patterns on the hem of traditional Chinese dress.

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Figure 2.27 : Taishi Chair
(Source by Wang, 2020)

Through these analyses one can appreciate the care with which the craftsmen designed the chair and the humanistic spirit that is manifested in the traditional seating. Chen Zengbi has compared the scale of Ming furniture with that of modern furniture and has concluded that it is reasonable even from the point of view of modern technology (Chen, 1991). The dimensions and even the shapes of each part of the Ming and Qing chairs were designed through careful thinking, but since this study mainly focuses on the experience of modern people on the use of Ming style furniture, it is obvious that the once reasonable dimensions can no longer match the body size of modern people. Moreover, the ergonomic requirements of modern people have far exceeded the standards of Ming Dynasty people, so it is imperative to change the ergonomic of Ming furniture in a reasonable way. It makes people feel more comfortable and safer when using it.

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2.8.2 Modern Seat and Ergonomic

Modern sitting furniture is broadly divided into types such as work chairs, armchairs, stools, lightweight sofas and chairs, large sofa chairs, and recliners. For the ergonomic design of sitting furniture, it is necessary to consider the comfort and safety of each part (Zhu, 2015). The following points need to be considered if the sitting furniture is to be adapted to the functions of the human body.

2.8.3 Material Selection of Modern Seat Design Combined with Ming Aesthetics

When selecting materials for furniture designs particularly for projects blending traditional Chinese aesthetics with modern ergonomics various factors are prioritised to achieve a balance between cultural authenticity, functional performance, and user-centred innovation (Wang, 2006).

Aesthetic Considerations play a crucial role in material selection. Traditional materials such as Huanghuali, Zitan, and rosewood are favoured for their historical prestige and symbolic ties to Confucian values, which emphasise concepts like harmony and longevity. Lacquered wood, adorned with auspicious motifs such as dragon carvings or floral inlays, serves to reflect rich cultural narratives (Zhang, 2012). On the modern side, adaptations like bamboo composites or textured polymers that mimic traditional wood grains are employed to maintain visual continuity while also reducing costs.

Texture and tactility are essential in creating a pleasant user experience. Smooth, polished surfaces enhance tactile comfort, particularly in features like rounded edges on Ming-style armrests. Designers often use contrasting textures such as pairing matte

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rattan seats with glossy lacquered frames to add visual interest to the furniture pieces (Norman, 2013). In terms of colour harmony, earthy tones like amber and mahogany align with traditional Feng Shui principles, while sustainable dyes are considered for modern designs to achieve vibrant hues using non-toxic chemicals (Wang, 2006). To maintain the integrity of traditional aesthetics, there is also a focus on grain and pattern consistency, with techniques like book-matching wood veneers used to create symmetrical patterns on table surfaces, thus avoiding synthetic materials that clash with minimalist Ming aesthetics.

Ergonomic Considerations are equally important in the material selection process. Durability and load-bearing capacity are prioritised, with traditional joinery methods, such as mortise-tenon joints in hardwoods like oak and huanghuali, providing structural integrity (Wang, 2006). In contrast, modern composites, such as carbon-fibre-reinforced polymers, present lightweight yet sturdy options for adjustable furniture designs. Comfort and pressure distribution are vital, especially in seating surfaces (Zuo & Hope, 2014). For modern ergonomic chairs, memory foam or latex cushions upholstered in breathable linen are ideal, while traditional Ming-style seats often utilise horsehair padding for firm, posture-correcting support. Additionally, the use of materials like bamboo or rattan enhances thermal regulation, making them suitable for humid climates (Kumar et al, 2017).

Weight and portability are additional ergonomic factors to consider. Lightweight rattan is often chosen for foldable stools or modular furniture, while reinforced hardwoods are selected for fixed, heirloom pieces, like Qing-era taishi chairs. Safety and injury prevention are also key considerations; designers ensure splinter-free finishes on wood

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surfaces and rounded corners to minimise impact injuries, adhering to ISO 6385:2016 compliance. The environmental impact of materials is another critical factor, leading to the preference for FSC-certified woods or reclaimed timber to mitigate deforestation, as well as biodegradable composites like mycelium-based materials for eco-conscious designs (Jones & Smith, 2021). Furthermore, designers pay attention to toxicity, opting for low-VOC adhesives and finishes to promote indoor air quality (Leung, 2015).

The synthesis of aesthetic and ergonomic considerations paves the way for Traditional-Modern Hybrids, where materials like huanghuali-style veneers are employed over ergonomic steel frames to combine cultural symbolism with lumbar support. A user-centric approach is encouraged, offering clients a material "library" from which they can choose between traditional hardwoods and modern composites tailored to their ergonomic needs.

As an illustrative example, a case study on a Ming-style office chair highlights the importance of this balanced approach: Using bamboo composites that mimic huanghuali grain serves an aesthetic function while ensuring the chair remains lightweight, sustainable, and breathable (Wang, 2006). The inclusion of a memory foam cushion hidden beneath linen upholstery enhances comfort by reducing pressure on the ischial tuberosities, while a powder-coated steel frame provides a matte black finish for minimalism and adjustable lumbar support (Handler, 2001).

In conclusion, material selection in furniture design is a negotiation between heritage and innovation. By prioritising aesthetics that preserve cultural identity alongside

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ergonomics that ensure modern usability, designers can create furniture that honours tradition while addressing contemporary human-centred demands.

2.9 Research GAP and Strategy

Based on the literature review, there are parts of the study area that have not been fully explored. These "gaps" provide opportunities for this study. The research aims to fill several critical gaps identified in the existing literature on Ming Dynasty furniture. First, although the literature review yielded an evaluation of Chinese Ming wooden seat and modern furniture, the relationship between ergonomics and Chinese Ming wooden furniture has not been addressed. The key question remains, "What represents Ming dynasty wooden furniture?" Therefore, the researcher investigated sitting furniture representing Ming wooden seat furniture through questionnaires and literature review and will fill the gap by using a representative sample of Ming dynasty wooden sitting furniture as the subject of ergonomics. Subsequently, the researcher found that many scholars have studied traditional Chinese furniture, but mainly on the artistic characteristics, culture, and furniture appreciation of traditional furniture. However, there were very few papers on seating furniture, and scholars who studied the ergonomics of traditional Ming dynasty seating furniture were extremely rare. There is a notable gap in systematic ergonomic evaluations of traditional seating designs, despite a wealth of studies exploring the aesthetic, cultural, and historical significance of Ming furniture. Much of the existing literature primarily emphasises stylistic features and craftsmanship, while overlooking the alignment of Ming seating with essential human physiological needs, such as spinal support, posture, and comfort. This lack of focus restricts our understanding of how Ming designs effectively balanced both form and function in their practical use. Additionally, while Ming

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furniture is widely admired for its human-centred proportions, epitomised by design features such as the “S-shaped” backrest of the Quan Yi armchair, there is no formal framework linking these historical design principles to modern ergonomic standards. Therefore, the researcher investigated the ergonomic data of Ming dynasty wooden seat furniture by means of a questionnaire to analyse the ergonomics of Ming wooden seat furniture to ensure that this part of the research gap was filled.

Previous research has predominantly relied on historical or theoretical analyses, offering limited empirical data regarding user experience with these designs. This study aims to fill this gap by incorporating user surveys to assess aspects such as comfort, safety, and overall usability of Ming-style seating, thus providing evidence-based insights into its ergonomic efficacy. Furthermore, while Ming furniture has undeniably influenced global minimalist and ergonomic trends, little attention has been given to how its principles can inform contemporary furniture design.

This research aims to introduce an ergonomic design framework that integrates the aesthetic principles of Ming furniture with modern ergonomic standards, showcasing its practical applicability through prototypes tailored for contemporary lifestyles. By bridging the gap between tradition and modernity, the study repositions Ming Dynasty seat furniture as a precursor to ergonomic design, deepening our understanding of its historical significance in the evolution of design. The framework offers actionable guidelines for seamlessly merging traditional craftsmanship with modern ergonomic principles, providing a replicable methodology for evaluating historical furniture through a user-centered perspective. This approach not only revitalises Ming design principles but also ensures their lasting relevance in the ongoing discourse of

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contemporary ergonomics.

Additionally, Ergonomics plays a critical role in the design process of Chinese Ming chairs, both in terms of seat performance and beyond. Ergonomics encompasses the five aspects of aesthetics, safety, comfort, easy-to-use, and productivity that are the cornerstones of design and will directly impact the user experience of Ming seats. Hence, a new design framework will be developed to mix ergonomic design principles and Ming dynasty wooden seat furniture to develop chair designs to provide guidance for furniture designer. Finally, the researcher designs a new concept of seat furniture based on Ming style wooden seat furniture. The design process based on the ergonomic design framework of the Chinese Ming style seat wooden furniture that integrates the ergonomic design aspects in the design and development process for a new furniture. In this study, the researcher addressed on the ergonomic design issues in taken into consideration all the ergonomic design aspects in design process of the new chair, which will help to improve it usability. Consequently, the purpose of this research is to provide a detailed documentation of ergonomic design framework based on the design process of Chinese Ming style wooden seat furniture for furniture designer.

2.10 Theoretical Knowledge

Drawing from the historical evolution of seats (Section 2.3.3), Five (5) Ergonomics Domains theory (Section 2.5) and General Ergonomic Domain, this model provides a roadmap for culturally grounded ergonomic innovation.

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2.10.1 Ergonomic Theories and Principles Related to Chinese Ming Style Furniture Design

Chinese furniture design, particularly from the Ming dynasties, embodies ergonomic principles that align with both traditional craftsmanship and modern ergonomic theories in some parts. These principles highlight the intricate balance between aesthetics, functionality, and cultural significance, thereby offering valuable insights for contemporary design. Below are the key principles mapped to established ergonomic conceptual frameworks, addressing gaps in existing studies.

The first principle is Anthropometric Alignment, which focuses on tailoring dimensions to human body proportions, such as seat height and backrest curvature. This principle is supported by the Human-Machine-Environment System (H-M-E), which ensures harmony among human measurements, furniture, and the spatial context. Additionally, ISO 6385:2016 provides guidelines for applying anthropometric data to optimise user comfort and efficiency. Next, Postural Support and Stability emphasises structural design that promotes healthy posture through considerations like backrest angles and seat depth. This principle is grounded in ISO 6385:2016, which emphasises the reduction of musculoskeletal strain with posture-friendly designs.

The principle of Material Ergonomics pertains to the use of hardwoods such as huanghuali and rosewood, which offer both sensory and functional benefits. This approach is framed within Activity Theory, where materials serve as tools mediating cultural practices such as the aroma of wood enhancing ritual experiences. The Five Domains (Aesthetics/ Safety) also emphasise balancing aesthetic with material. Another critical principle is Aesthetic Harmony, characterised by minimalist lines and

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symbolic proportions like the 3:5 ratio. This principle is aligned with the Five Domains (Aesthetics), prioritising visual and psychological comfort through balanced forms, and the Human-Machine-Environment System, which aligns aesthetics with environmental harmony, ensuring that furniture complements architectural spaces. Meanwhile, safety and injury prevention are another foundational principle, featuring rounded edges and sturdy joinery techniques like mortise-and-tenon. This design approach is supported by the Five Domains (Safety), which aim to mitigate physical risks, and ISO 6385:2016, which standardises safety protocols within design processes. Finally, the principle of Modern Adaptability involves blending traditional styles with contemporary needs, exemplified by adjustable seat designs. This principle is linked to Systems Theory, which integrates traditional designs into modern living contexts, and Universal Design, ensuring accessibility for diverse user groups through ergonomic foams in hardwood frames.

Bridging ergonomic theories with Chinese design philosophy reveals that existing studies often overlook the alignment between traditional Chinese furniture principles and formal ergonomic frameworks. For instance, the Human-Machine-Environment System illustrates how Ming chairs harmonise the relationship among body, object, and space. The Five Domains of Ergonomics validate the holistic nature of Ming designs, balancing aesthetics, safety, and comfort. In addition, ISO 6385:2016 offers a modern lens through which to reinterpret historical practices, such as employing anthropometric software to refine traditional dimensions. By anchoring these principles in established theories, Chinese furniture design transcends cultural specificity and provides universal lessons in ergonomic innovation. This integration not only addresses gaps in the literature but also repositions traditional craftsmanship

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as a precursor to modern ergonomic science.

2.10.2 Theoretical Models

Ergonomics principles in the design of work systems (Iso6385:2016) make it clear that, if applied appropriately, ergonomics can serve to optimise the work system as well as the performance and effectiveness of the worker without compromising the worker's physical and mental health, well-being, and safety. Following the realisation and implementation of a work system, it is appropriate to establish a process of evaluation and monitoring of the work system. In addition to evaluation during the design process, evaluation of the work system design can help to develop a complete understanding of the project results, compare the outputs of the initial planning of the project with the results, and build on the experience gained. The impact of the system should be monitored on an ongoing basis to protect users from long-term damage to their work performance or physical and mental health.

Furthermore, the overall assessment should be carried out after the system has reached a steady state of operation. It is desirable to consider the quality of the work in the assessment, with the aim of ensuring the long-term effective performance of workers in the established work environment. Assessment and monitoring should include the following relevant guidelines as shown in Figure 2.28. Figure 2.28 outlines the core ergonomic principles of the ISO 6385:2016 standard, which include safety, efficiency, cost-effectiveness, usability, and health and well-being. To apply these principles to Ming-style seating design, the theoretical framework is restructured by merging traditional craftsmanship with contemporary ergonomic needs:

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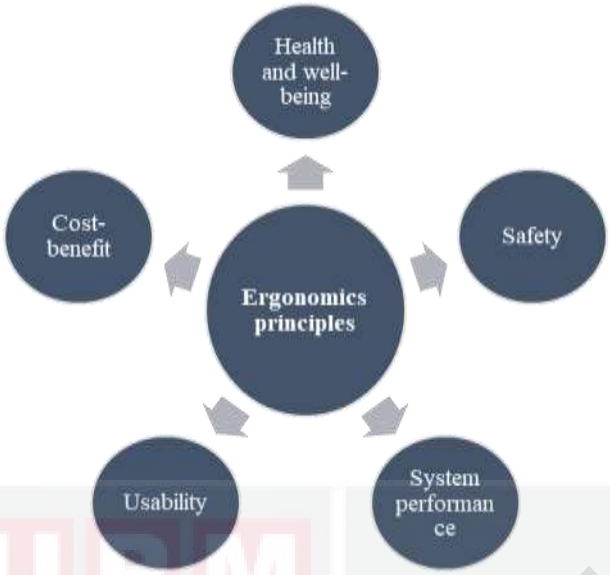

Figure 2.28 : Theory of Ergonomics Principles in the Design of Work Systems (Source by ISO 6385:2016)

a) Safety - The safety of Ming-style seats is achieved through the mechanical stability inherent in traditional craftsmanship. Structural stability is a hallmark of this design approach, exemplified using mortise-and-tenon joints that eliminate the need for nails. For instance, the "heaven-round, earth-square" (tian yuan di fang) form of the circle chair effectively distributes pressure through precise joint interlocking, thereby avoiding localised stress concentration (Chen, 1991). Additionally, to align with modern safety standards, quantitative load-bearing analysis is employed, utilising pressure testing equipment to ensure compliance with current requirements

b) Efficiency - To enhance efficiency, the production process of Ming-style seats combines traditional hand-carving techniques with contemporary CNC machining technology. This integration streamlines production while maintaining high craftsmanship standards. For instance, laser engraving can replicate traditional patterns, such as cloud and fret motifs, effectively preserving intricate details while reducing labour time (Liu, 2010). Furthermore, user experience efficiency is improved by optimising seat dimensions. Adjusting the seat height from the traditional 500mm to a range of 430–450mm minimises the need for postural adjustments, significantly

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enhancing long-term comfort and usability for modern users (Sun & Song, 2016).

c) Aesthetics replaces cost-effectiveness - In this revised theoretical framework, aesthetics replaces the traditional focus on cost-effectiveness. The priority on material aesthetics is evident in the use of rare woods, such as huanghuali (yellow rosewood) and zitan (purple sandalwood), which serve as the essence of Ming-style seating design. These woods are not only admired for their natural grain and colour but also carry cultural significance; for example, the "ghost-face grain" of huanghuali functions both as a decorative element and as a cultural symbol (Wang, 2013). Moreover, the emphasis on traditional craftsmanship reinforces the notion that value lies in "exquisite materials and flawless execution," rather than in cost reduction often associated with modern industrial production. Consequently, Ming furniture is appreciated for its cultural heritage and artistic merit, rather than economic efficiency (Handler, 2001).

d) Easy-to-use replaces usability - The concept of easy-to-use replaces the more technical notion of usability, focusing instead on enhanced user experience. The "S-shaped" backrest, for example, is designed to align with the spinal curve, effectively reducing lumbar pressure during use (Zhu, 2015). Modern user studies indicate that this thoughtful design can decrease muscle fatigue by as much as 15.0% (Sun & Song, 2016).

e) Health and well-being (comfort) - The Comfort aspect of Ming-style seating design emphasises both spinal health support and psychological comfort. The innovative "S-shaped" backrest design is particularly noteworthy, as it reduces intervertebral disc pressure by conforming to the natural lumbar curve with a curvature radius of R=250–300mm, thus promoting better posture and comfort during use (Sun & Song, 2016). Additionally, Ming-style design prioritises psychological comfort with natural wood textures and tactile experiences, such as the distinctive "ghost-face grain" of huanghuali (yellow rosewood). This sensory engagement enhances users'psychological well-being, fostering a sense of tranquillity and satisfaction that positively impacts the overall user experience (Wang, 2013). Furthermore,

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biomechanical studies indicate that the lumbar support provided by Ming-style circle chairs can significantly reduce muscle fatigue by 20.0%, highlighting the importance of ergonomic design in promoting health and well-being.

In conclusion, this study establishes a comprehensive theoretical framework that harmonises the five core elements of ISO 6385:2016 safety, efficiency, cost-effectiveness, usability, and health/well-being with the cultural characteristics of Ming-style seating. This framework not only addresses existing gaps in ergonomic research on traditional furniture but also provides valuable methodological support for the modernisation of cultural heritage, ensuring that it remains relevant and beneficial in today's ergonomic landscape.

2.10.3 Theoretical Framework

For the research object aimed at in this research is the traditional Chinese wooden seats, which has a small user group and cannot be mass-produced, so cost- benefit is difficult to be used as one of the indicators to measure ergonomics. However, through the collation of the literature review, the cultural significance brought by Chinese traditional wooden seats cannot be ignored, and the cultural inheritance is realised through the research in the field of aesthetics.

The decision to replace "cost-effectiveness" with "aesthetics" and "usability" with "easy-to-use" stems from a deeper understanding of the priorities inherent in Ming-style seating design, particularly in its cultural and ergonomic contexts. The primary rationale for prioritising aesthetics is the emphasis on cultural value in traditional Ming furniture. This style is deeply influenced by Confucian philosophy, which

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espouses the aesthetic ideal of "harmony between heaven and humanity." In this context, elements such as wood grain and proportional harmony are regarded as equally important as functionality. The natural grain of huanghuali (yellow rosewood), for instance, serves not just as material but as a critical design element that embodies cultural significance (Wang, 2013). Furthermore, there is a diminished focus on cost in traditional craftsmanship, which emphasises meticulous material selection and artistry over economic efficiency. Ming furniture is often considered a form of art, with its value rooted in cultural heritage rather than the constraints of cost control typically dominant in modern industrial production (Handler, 2001).

Similarly, the concept of "easy-to-use" replaces "usability" as it reflects a deeper understanding of the user experience. While ISO's definition of usability centres on functional adaptability such as interface operations the Ming emphasis on easy-to-use focuses on ensuring physical comfort and psychological satisfaction during use. For example, the "S-shaped" backrest in Ming seating reduces fatigue by aligning with the natural spinal curve, enhancing the user's physical experience (Zhu, 2015). Additionally, the Ming framework integrates traditional designs with modern needs by adapting seat heights to contemporary anthropometric standards (approximately 430–450mm as opposed to the traditional height of about 500mm), thereby improving practical convenience (Sun & Song, 2016).

The differences in terminology also reflect divergent design philosophies. ISO 6385:2016 is founded on universal principles of modern industrial design that emphasise standardisation, economic efficiency, and functional performance. In contrast, the Ming theoretical framework is rooted in traditional culture and

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craftsmanship, embodying the philosophy of "tools as vessels of Dao" (qi yi zai dao). This approach uniquely integrates aesthetics, cultural identity, and ergonomics to create what can be termed "humanistic ergonomics." Moreover, the application scenarios differ significantly: ISO standards are broadly applicable to various system designs, including machinery and software interfaces, while the Ming framework specifically focuses on furniture design, particularly in balancing the preservation of traditional craftsmanship with modern user needs.

Illustrative Examples "Concrete examples further illustrate the distinctions between these concepts. For instance, the "heaven-round, earth-square" (tian yuan di fang) form of the Ming circle chair not only adheres to ergonomic principles but also symbolises cosmological harmony, emphasising aesthetic value that transcends cost considerations (Handler, 2001). In modern designs that prioritise low-cost materials, such as composite boards, the risk of compromising traditional aesthetic integrity is significant. Similarly, Ming seating's emphasis on ease-of-use is demonstrated through details such as armrest heights (220–250mm), which align with modern elbow heights, enhancing user comfort. In contrast, ISO's "usability" metrics might only consider whether a chair is functional, often overlooking the critical element of comfort.

By replacing "cost-effectiveness" with "aesthetics" and "usability" with "easy-to-use," the Ming theoretical framework highlights the prioritisation of cultural value and user-centric experience. This adjustment reflects the integration of traditional craftsmanship with modern ergonomic science, offering a meaningful pathway to revitalise cultural heritage for contemporary applications (Handler, 2001).

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Therefore, the ergonomics of traditional Chinese wooden seat contains five domains of aesthetics, safety, comfort, easy-to-use and productivity which are the cornerstones of the design and will directly affect the user experience of the Ming wooden seat furniture. The ergonomics of Chinese Ming style wooden seat furniture is highly related to the user and designer experience and general ergonomic in addition to the above five (5) domains. By integrating all these aspects, the ergonomics of Chinese Ming style wooden seat furniture can be marketed.

The elements of general ergonomics are primarily a reflection of user behaviour. Behaviour is a human response to sensory reception and further validates the degree of product ergonomics. Behavioural assessment is carried out to facilitate ergonomic adjustments during design to improve product user satisfaction and product performance (Manning & Amare, 2013; Aromaa & Väänänen, 2016; Cai & Chen, 2016; Lin et al. 2016; Taifa & Desai, 2017). The five (5) domains of ergonomic and generic ergonomics are the main elements in the development of a new Chinese Ming style wooden seat furniture (see Figure 2.28). This theoretical framework provides a comprehensive guideline for the furniture designer an attempt to prioritise the importance ergonomic design elements for a new furniture.

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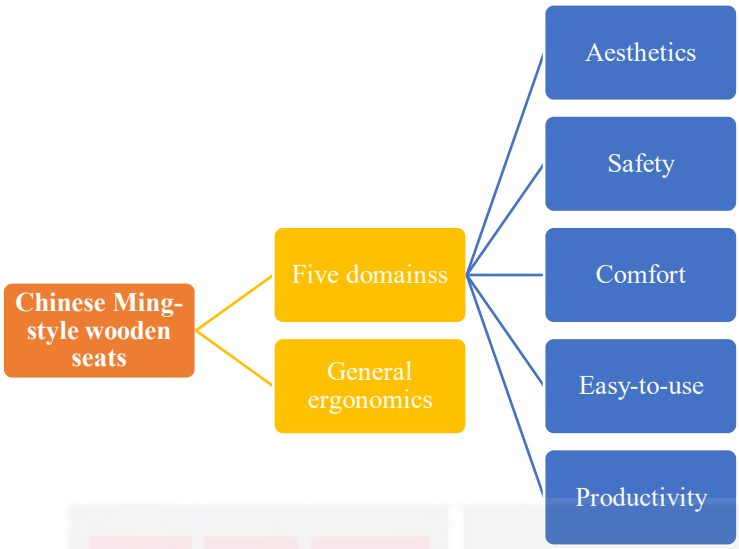

Figure 2.29 : Theoretical Framework of Chinese Ming Style Wooden Seat Furniture
(Source by author)

2.11 Summary

Ergonomic of Chinese Ming style wooden seat furniture is a new theory in which each of the five (5) aspects of ergonomic design, general ergonomics, as well as user/designer experience each element is critical. By examining these elements, the researcher will optimise the ergonomic elements in each designed product to enable faster and better acceptance of the product by the user. The main work of Chapter two is to sort out all the elements involved and the historical development and design evolution of Chinese Ming style furniture, especially Ming style wooden seat, to prepare the work for the next chapters. A theoretical framework applicable to this research that was obtained through the survey, which will then be used as a reference for the development of ergonomic design framework. The ergonomic goal of the Chinese Ming style wooden seat is to balance up the relationship between the comfort of the furniture as well as its appearance, so that the product developed by applying this framework is attractive enough to the user. Therefore, by adapting the ergonomic

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design aspects into a new development of Chinese Ming style wooden seat furniture, will be contributing for a simple and smooth design, and ensuring the high of user acceptance, as well as reduce the production costs and increase the profitability of the industry.

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CHAPTER 3

RESEARCH METHOD

3.1 Introduction

This chapter describes the methodology chosen for the research and the entire research process. This thesis has used quantitative research methods. In particular, the chapter describes how the researcher conducted the research and how the researcher collected and analysed the data. Each step of the methodology and process is explained in detail to ensure the quality and accuracy of the research.

3.2 Research Structure

The framework for the detailed presentation of this thesis research is divided into three (3) stages (see Figure 3.1):

a) In Stage 1, a Systematic Literature Review (SLR) was conducted to address Research Question 1. The process commenced with a structured search strategy that utilised a predefined protocol to identify relevant studies across databases such as Scopus, CNKI, and JSTOR, employing keywords like "Ming-style seats," "ergonomic design," and "traditional Chinese furniture." Studies were filtered based on inclusion and exclusion criteria, focusing on relevance, publication date (2000–2023), and peer-reviewed status. Additionally, the Joanna Briggs Institute (JBI) checklist was employed for a thorough quality assessment of the sources, evaluating factors like historical accuracy and methodological clarity. The rationale for this systematic approach lay in its comprehensiveness, ensuring all relevant literature on Ming-style seats was included, thereby reducing selection bias typical of traditional reviews, and in its transparency, as a replicable protocol enhances the validity and reproducibility of the findings. The outcome of this approach resulted in a robust synthesis of 85 studies comprising 60 historical/textual

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and 25 quantitative analyses that highlighted key ergonomic priorities in Ming-style seats, such as the curvature of backrests and the proportionality of armrests. Ultimately, the SLR provided a structured framework that effectively mapped both historical and modern ergonomic principles relevant to Ming-style wooden seat furniture. Due to the extensive literature review provided in Phase I, which was sufficient to obtain conclusions for Research Objective 1, no additional methods were used.

b) The second stage is to collect data through a questionnaire survey to investigate what are the aspects on ergonomics applied on Chinese Ming style wooden seat are shown, and this stage's result is used to answer the research question two (RQ2). As the previous stage has been described in detailed, and only questionnaires were used in this stage to investigate the respondent preferences.

c) The third stage is to identify the ergonomic aspects of Chinese Ming style wooden seat and to analyse the questionnaire results. Then, a design framework is proposed in conjunction with research results. Next, a new seating device is designed as a new proposal based on the design framework using 3D software (design practice). Finally, the use of the design framework was double validated through a questionnaire survey and the usage of three participants.

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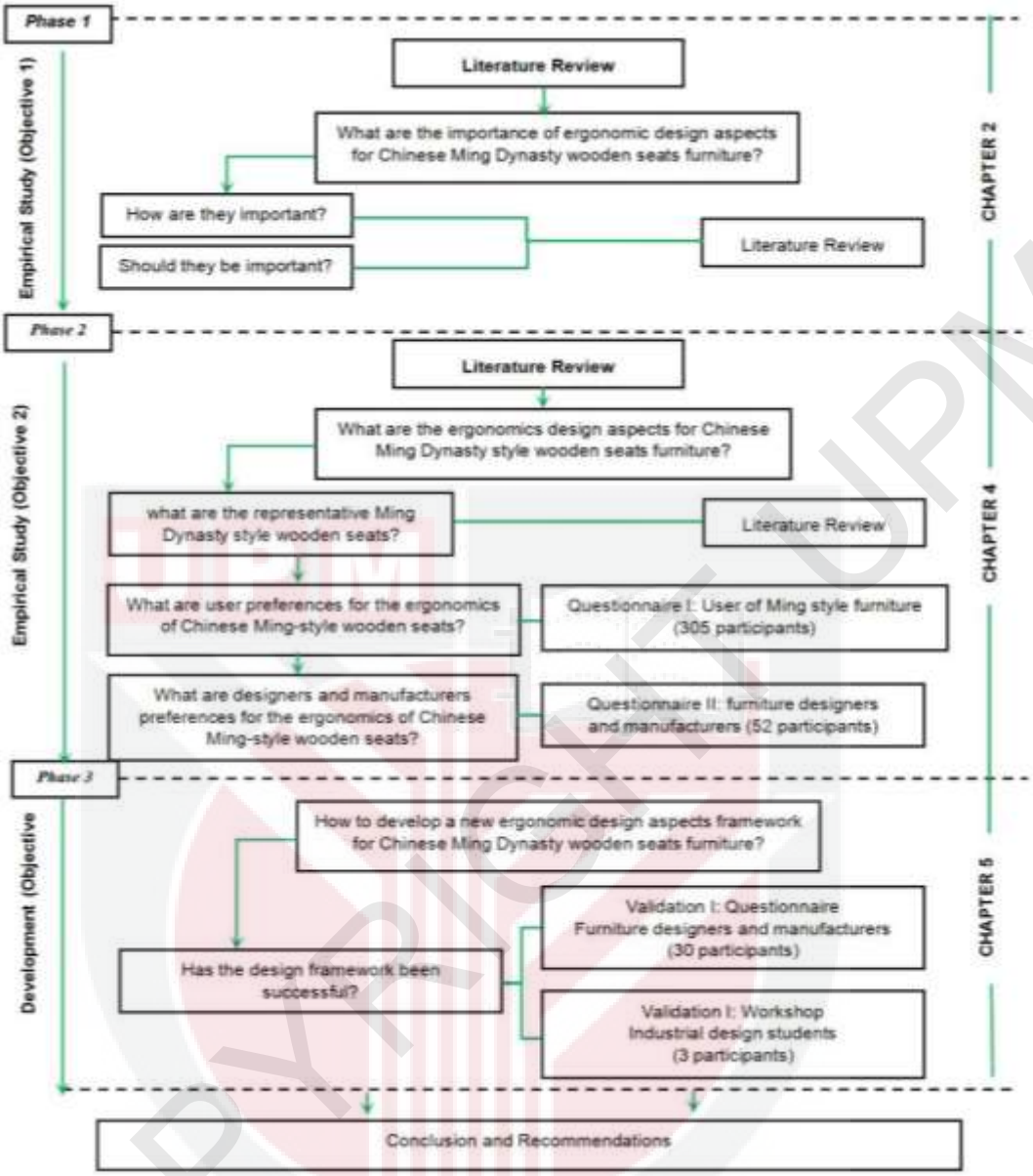

Figure 3.1 : Research Methodology Framework
(Source by author)

The results of each stage of the study were used to answer the research objectives of the current stage. This chapter will detail all the research methods used in the study and show how the researcher carried out the research, thus providing a solid foundation for subsequent research. Table 3.1 shows the methodological strategies used to address the research questions and describes the research methodology used by the researcher.

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Table 3.1 : The Methodological Strategy for Research Questions

Research Question	Research Objective	Methodological Strategies	Analyse
What are the characteristics of ergonomic design aspects for Chinese Ming style wooden seat furniture?	To identify the characteristics of ergonomic design aspects for Chinese Ming style wooden seat furniture.	Systematic Literature Review	Content Analysis
What are the ergonomic features that enhance the wooden seat furniture in the Chinese Ming style?	To evaluate the ergonomic features that enhance the wooden seat furniture in the Chinese Ming style.	Structured questionnaire survey on user (N=305) Structured questionnaire survey on designer (N=52)	Descriptive Analysis: Mean, Standard Deviation, Percentage, Frequencies
How to develop a new ergonomic design framework incorporating ergonomic elements for Chinese Ming-style wooden seat furniture?	To propose a new ergonomic design framework incorporating ergonomic elements for Chinese Ming-style wooden seat furniture.	Structured questionnaire survey (N=30 designers). 3D modelling (CAD software). Workshop sketches (three participants).	Descriptive statistics. Qualitative sketch analysis.

The quantitative research method was strategically selected to align with the study's objectives, ensuring rigor, generalisability, and actionable outcomes. Below is the rationale for its relevance:

a) Alignment with Research Objectives

Objective 1 (Identify ergonomic design aspects): Through the investigation of a large number of literature reviews on Chinese Ming Style wooden seats, all the ergonomic items involved in the study were determined. Clarify the content of research objective one.

Objective 2 (Evaluate ergonomic value): Quantitative methods enabled systematic measurement of ergonomic priorities through structured questionnaires (e.g., Likert scales). Numerical data from 305 users and 52 experts allowed statistical identification of high-priority factors (mean, standard deviation), ensuring objective prioritisation. Quantitative surveys

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provided standardised, comparable responses across large samples. Statistical tools (SPSS) facilitated analysis of trends, frequencies, and correlations, critical for evaluating the perceived value of ergonomic aspects.

Objective 3 (Develop a design framework): Quantitative data provided empirical evidence to construct the framework. Descriptive statistics highlighted dominant preferences, ensuring the framework was rooted in measurable user and expert inputs rather than subjective interpretations.

b) Generalisability and Replicability

The large sample sizes (305 users, 52 designers) enhance representativeness, allowing findings to be generalised to broader populations of Ming-style furniture users and professionals. Structured questionnaires with fixed-response options (e.g., five-point scales) ensured consistency, enabling replication in future studies or cross-cultural comparisons.

c) Objectivity and Reduced Bias

Quantitative methods minimised researcher bias by relying on predefined, closed-ended questions. This was critical for objectively ranking ergonomic factors (e.g., safety, comfort) without interpretive ambiguity. Statistical reliability tests (Cronbach's alpha > 0.7) confirmed internal consistency, reinforcing the validity of the data-driven conclusions.

d) Support for Evidence-Based Design

Quantitative data provided empirical evidence to justify design decisions, critical for persuading stakeholders (e.g., manufacturers, designers) to adopt the framework. Numerical results offer clear directives for practical implementation.

Furthermore, the quantitative approach was indispensable for achieving the study's objectives. It provided measurable, statistically validated insights into ergonomic preferences, ensured objectivity, and supported the development of a replicable,

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evidence-based design framework. While qualitative elements enriched validation, quantitative methods remained central to addressing the core research questions with precision and rigor.

3.3 Methodology in First Stage of Study

Traditional Chinese seating has a long history, but it is so old that only partial information can be obtained from literature reviews. The author needs to investigate the traditional Chinese seating, especially the Ming style seating and general modern seating literature review in the first stage and describe their evolution process. In the second chapter, the author describes the evolution process of Chinese Ming style seats and modern seats, obtains the importance of wooden seats in China's Ming style, and selects a wide range of Ming wooden seat forms based on the results of the literature review of Ming style seating.

3.3.1 Research Design and Research Process for Stage 1

The first stage of the research employed a systematic literature review and multimodal data collection to establish a foundational understanding of Chinese Ming-style wooden seats and their ergonomic evolution. This comprehensive process was structured to ensure a thorough exploration of both historical and modern contexts surrounding Ming-style furniture.

The literature review focused on two main scopes: historical sources and the modern context. Historical sources included primary documents, such as woodworking manuals from the Ming dynasty (notably the "Lu Ban Jing"), as well as scholarly analyses that examined the aesthetics of Ming furniture. In contrast, the modern

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context involved a review of peer-reviewed articles that addressed ergonomic principles in traditional furniture design, alongside comparative studies that analysed the differences between Ming-style seating and contemporary seating designs. To gather relevant information, various databases were utilised, including JSTOR, CNKI (China National Knowledge Infrastructure), and museum archives such as the Palace Museum in Beijing.

Data collection methods incorporated a range of approaches, with textual analysis being a significant component. This involved the critical examination of Ming-era texts to identify underlying design philosophies that have influenced the development of these wooden seats. The findings from this analysis were visualised in Figure 3.1, which illustrates the literature review process from the initial formulation of the proposal to the identification of significant forms of Ming seating. Ultimately, the purpose of this stage was to establish a taxonomy of Ming-style seats and to identify gaps in the existing ergonomic analysis. This foundational work directly addressed Research Objective 1, laying the groundwork for subsequent stages of the research.

Figure 3.2 : The Flowchart of Stage 1 Research Process
(Source by author)

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3.3.2 Methodology of First Stage Analysis

The first phase of analysis was entirely descriptive analysis, and all data collected through documentation and physical evidence are recorded. The results from this stage used to interpret the research objectives 1.

3.4 Methodology of Second Stage Study

The author needs to divide the second phase into two (2) steps, firstly to conduct Questionnaire I with Ming style wooden seat users as respondents, and finally to conduct Questionnaire II with designers and manufacturers as the respondents. The questionnaire was designed to investigate what are the ergonomic aspects of Chinese Ming style wooden seat. The research method used in the second stage was the questionnaire. Both questionnaires provided quantitative findings for this study and both above steps were quantitative.

3.4.1 Research Design and Research Process for Stage 2

The second stage of the research utilised structured questionnaires to quantitatively assess ergonomic priorities among users and designers. This process was meticulously structured to ensure comprehensive and accurate data collection, facilitating a clear understanding of ergonomic preferences in relation to Ming-style wooden seats.

The refinement of the questionnaire began with a pilot testing phase, where a draft version was administered to 20 participants comprising 10 users and 10 designers. This initial testing was critical for clarifying questions and eliminating ambiguities. The questionnaires were designed to cover specific domains tailored to each group.

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The User Questionnaire I focused on collecting personal details, user experience, and aesthetic preferences. In contrast, the Designer Questionnaire II encompassed personal details related to design experience as well as factors such as general ergonomics, aesthetics, safety, comfort, ease of use, and productivity / performance. Additionally, five-point Likert scales were employed for responses and were validated for reliability, achieving Cronbach's α values of 0.82 for users and 0.79 for designers.

For the implementation of the survey, a thoughtful sampling strategy was employed. The user group consisted of 305 participants, selected through stratified sampling that considered age (18–60 years) and gender distribution (50% male and 50% female). Meanwhile, the designer group included 52 professionals who were purposively sampled based on their experience in Chinese Ming-style furniture design. Data collection occurred through two primary methods: online distribution via Wenjuanxing, a Chinese survey platform that included IP checks to prevent duplicate responses, and face-to-face surveys conducted in furniture workshops in Suzhou and Beijing. This approach allowed participants to physically inspect the seat models, thereby enriching their feedback.

The overall process flow, detailed in Figure 3.3, involved several key steps. Step 1 included the selection of eight chair forms, chosen from an initial pool of 100 candidates based on criteria of material (solid wood) and design diversity. Step 2 involved the distribution of the questionnaire, which was designed for a completion time of approximately 15 minutes. Finally, Step 3 consisted of data cleaning, which involved the removal of incomplete or inconsistent responses, followed by coding the data in SPSS for analysis.

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In summary, the purpose of this stage was to generate empirical data regarding ergonomic preferences, directly addressing Research Objective 2 and providing essential insights for understanding user and designer priorities in relation to Ming-style seats.

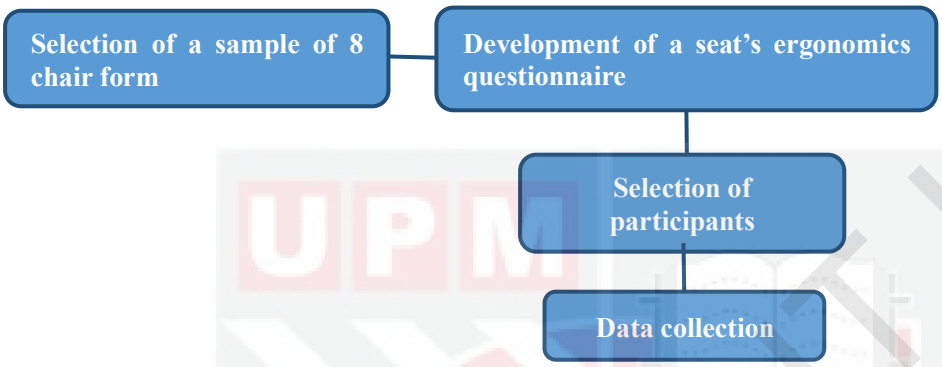

Figure 3.3 : The Flowchart of Stage 2 Research Process
(Source by author)

3.4.2 Selection of Seats Form

Chinese Ming style wooden seats are available in a wide variety of forms and shapes, with a wide range of seats. Mat, Bed, Hu bed, Couch, Rope bed, leaning bed, Stool, Dunk, Chair and Maza were the types of Chinese seating furniture, and to ensure the comparability and consistency of the research objects, the Chinese Ming style wooden chair were selected as the objects of this study. Ming style wooden seating belongs to the category of cultural relics and antiques literature and physical collections present difficulties such as the span of research time, the complexity of research types and the lack of information. This study focuses on modelling collections in four (4) ways：

a) Book and literature search

b) Furniture stores

c) Museum collections

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d) Internet

After the initial screening, it was found that many of the Chinese Ming style seating furniture products have a high degree of similarity, for example, the same seat surface, armrests, and backrest design with different leg forms; the same furniture shape design changes to different materials and other techniques, which invariably increases the design richness of the products, but reduces the complexity of the development process and reduces development costs. Secondly, in the process of screening the samples, pictures of furniture samples whose materials are solid wood were selected. After the above-mentioned selection process, Finally, from the 100 Ming Style wooden seating pictures screened out samples of eight relatively ideal chair form.

3.4.3 Selection of Participants

Considering that this survey-based study investigates the ergonomics of Chinese Ming style sitting furniture, then it requires some knowledge and understanding of the ergonomics of furniture, and the mainly evaluates the ergonomics of Chinese Ming-style wooden seats by using or designers'participation in the design. To ensure methodological rigor, the participants were chosen to be relatively balanced in terms of age, gender and education. The Participants mainly included Chinese traditional furniture users, designers, and manufacturers.

The selection criteria for users were designed to ensure a balanced demographic composition that includes age, gender, and education, thereby promoting representativeness. Additionally, participants were required to have no visual impairments to accurately assess both ergonomic and aesthetic preferences.

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Importantly, only active users of Ming-style furniture were selected, as their practical insights into usability were deemed essential for this study.

For the expert group, participants were required to be professionals with a minimum of three years of experience in the design or manufacturing of Ming-style furniture. The selection criteria ensured gender balance and stipulated that participants should have no visual impairments. This was crucial for ensuring that their specialised knowledge could effectively evaluate both ergonomic design principles and historical authenticity.

The rationale behind the participant numbers reflects a careful consideration of statistical power and representation. The 305 users were chosen to achieve a significant sample size that ensures generalisable results, with a 95% confidence level and a 5% margin of error for a population of approximately 10,000 Ming-style furniture users in China, as outlined by Krejcie and Morgan (1970). Meanwhile, the selection of 52 experts aligns with established expert panel standards, such as the Delphi method, where a smaller number of participants (typically between 10 and 50) can provide focused and valuable insights, as noted by Hsu and Sandford (2007). The participant numbers and criteria are methodologically sound, balancing statistical validity, practical constraints, and the need for specialised expertise (Tashakkori & Teddlie, 2010).

3.4.4 Structured Questionnaires

Based on the literature review in Chapter 2, the author developed two structured questionnaires for the ergonomic study of Chinese Ming style wooden seat furniture;

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Questionnaire I is specifically for users of Chinese Ming style wooden seat furniture, while Questionnaire II is mainly for Chinese traditional furniture designers and manufacturers. The Questionnaire I is divided into three (3) parts in total, which are:

a) Part A: Personal Information - The personal information section consists of the respondents'basic personal information such as age, gender, marital status, education, location, occupation, income, and physical condition to help the author to determine the demographic range.

b) Part B: User Experience Structure - The user experience structure section focuses on users'familiarity with Ming-style furniture, frequency of use, whether they use Ming-style wooden chairs, and their preference for the eight seating forms. Among them, users'preference for the eight seating forms are assessed using a five-point preference scale as Not at all=1, Slightly=2, Moderately=3, Well=4, and Extremely=5.

c) Part C: Aesthetic Domain - The aesthetic domain of part 3 is divided into four directions which are sense application, external influences, modelling data and aesthetic elements. The entire Part 3 will be evaluated through a five-point preference scale as Not considered=1, Low=2, Medium=3, High=4, Essential=5. The details of these four directions have been elaborated by the authors through the literature review in Chapter 2.

Furthermore, the Questionnaire II is divided into eight (8) parts in total, which are:

a) Part A: Personal Information - With a slight difference from Questionnaire I, the personal information section here includes the designer's area of specialisation and years of design experience in addition to basic personal information such as the respondent's age, gender, marital status, education, location, occupation, income, and physical condition to help the author determine the demographic range.

b) Part B: Design Experience - The design experience section focuses on the designers'and manufacturers'familiarity with the Ming furniture design process, time spent designing, whether they specialise in designing Ming

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wood seating, the specific ergonomic design process, and preferences for the eight seating forms. The designers'and manufacturers'preferences for the specific ergonomic design process and the eight seat forms were assessed using a five-point preference scale (Not at all=1, Slightly=2, Moderately=3, Well=4, Extremely=5).

c) Part C: General Ergonomic Domain - The general ergonomic domain section includes the extent to which designers and manufacturers consider ergonomics to be important in furniture and Chinese Ming-style wooden chairs, and the extent to which physical ergonomic properties are important in the development and designing of Chinese Ming- style chairs. The last question in Part C will be assessed through a five-point preference scale, i.e. Not considered=1, Low=2, Medium=3, High=4, Essential=5.

d) Part D: Aesthetic Domain - The aesthetic domain of part D is the same as part C of Questionnaire I.

e) Part E: Safety Domain - For the safety domain, it is also divided into four directions which are risk factors, common ergonomic injuries, discovering ergonomic hazards and fixing and several safety items. Part E will be assessed by a five-point preference scale (Not considered=1, Low=2, Medium=3, High=4, Essential=5). The details of these four directions have been elaborated by the authors through the literature review in Chapter 2.

f) Part F: Comfort Domain - The comfort domain consists of four components: physiological comfort factors, psychological comfort factors, physical comfort factors, and environmental comfort factors. five-point scales will be consistently applied to this section (Not considered=1, Low=2, Medium=3, High=4, Essential=5).

g) Part G: Easy-to-Use Domain - The terms of easy-to-use and common attributes for the easy-to-use together make up this section. The author used a five-point scale to assess the ease-of-use priority of Chinese Ming-style wooden seat.

h) Part H: Productivity and Performance Domain - This is the last section of

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Questionnaire 2, and consists of only one aspect, productivity factors.

All the set of questionnaires can be referred in Appendix A and B.

3.4.5 Questionnaire Development and Validation Process

The development and validation of two structured questionnaires Questionnaire I for users and Questionnaire II for designers/manufacturers were rigorously conducted to ensure reliability, relevance, and clarity. The process involved several key stages.

a) Questionnaire Design: The questionnaires were designed based on themes identified in the Stage 1 Systematic Literature Review, focusing on ergonomic domains such as comfort, safety, and aesthetics. This ensured alignment with Research Objectives 2 and 3, which aimed to emphasise ergonomic priorities and facilitate framework development. Questionnaire I for users was structured into three sections: Personal Information, User Experience, and the Aesthetic Domain. Conversely, Questionnaire II for designers was divided into eight sections: Personal Information, Design Experience, and Ergonomic Domains. Both questionnaires employed five-point Likert scales for responses (e.g., 1 = Not considered, 5 = Essential), providing consistency in data collection.

b) Expert Review: A panel of five experts was convened, comprising two ergonomists, two Ming-style furniture historians, and one industrial designer. The experts evaluated the relevance of each question, ensuring clarity and alignment with the research objectives. The feedback gathered during this review process led to necessary revisions, resulting in a Content Validity Index (CVI) of 0.89, which was above the acceptable threshold of 0.75, confirming the relevance of the questionnaires.

c) Pilot Testing: To assess the effectiveness of the questionnaires, pilot testing was conducted with a sample of 20 participants, including 10 users and 10 designers, representing the demographics of the main study. Participants

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completed the draft questionnaires and provided feedback on ambiguity, length, and ease of understanding. During cognitive debriefing, participants were asked to paraphrase questions to evaluate their comprehension. As a result, ambiguous terms were rephrased, and the average completion time was reduced from 25 to 15 minutes through the removal of redundant items.

d) Statistical Validation: Reliability testing was performed to establish the robustness of the questionnaires. Cronbach's Alpha scores indicated good internal consistency, with Questionnaire I achieve $\alpha = 0.84$ for the User Experience section and Questionnaire II scoring $\alpha = 0.81$ for the Ergonomic Domain section. Additionally, test-retest reliability was assessed with 15 participants re-tested after two weeks, yielding a Pearson's r of 0.79, indicating strong consistency. Factor analysis using Principal Component Analysis (PCA) confirmed the unidimensionality of the scales, as all safety items loaded onto a single factor.

e) Final Adjustments: The questionnaires were then translated into Mandarin by a bilingual expert, followed by back-translation to ensure accuracy and maintain the integrity of the content. This comprehensive validation process ensured that the questionnaires effectively measured ergonomic priorities as outlined in Objective 2 and provided valuable data to inform framework development in Objective 3. Overall, the structured validation approach enhances the methodological credibility of the study, ensuring that the findings are both accurate and actionable.

3.4.6 Survey Procedures

The survey employed a mixed-mode approach (online and face-to-face) aimed at optimising data quality, accessibility, and participant engagement. Each method was carefully selected and executed, with clear rationale outlined below.

a) Online Survey (Wenjuanxing Platform)

The primary target group for the online survey consisted of 305 users of Ming-

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style furniture. The procedure began with the platform setup, where the questionnaire was digitised using Wenjuanxing, a popular Chinese survey platform that provides built-in data encryption to ensure participant confidentiality. Logic checks were incorporated to prevent incomplete submissions, with mandatory fields designated for Parts A through C.

Distribution of the survey was achieved through several channels, including social media platforms like WeChat and Weibo, Ming furniture forums, and email lists targeting antique collector groups. Additionally, to facilitate on-site participation, a QR code linking to the survey was displayed at Ming-style furniture exhibitions in Beijing and Shanghai. Participants were allotted 15 minutes to complete the survey, and reminders were sent after 48 hours of inactivity to encourage completion.

The rationale for adopting the online method included several factors. The geographic reach of users across both urban and rural areas of China made online accessibility crucial, as it provided a cost-effective means of participation. Users might be reluctant to critique traditional designs in a social context, and the online format helped mitigate social desirability bias. Furthermore, the online approach offered convenience, allowing participants to respond at their leisure, which is likely to improve completion rates.

b) Face-to-Face Survey (Printed Booklet)

The target group for the face-to-face survey included 52 designers and manufacturers of Ming-style furniture. To facilitate the survey, researchers selected specific venues such as furniture workshops, including the Suzhou Woodcraft Guild, and industry conferences like the China Traditional Furniture Expo.

During the execution of the face-to-face survey, researchers provided physical samples of Ming-style chairs for tactile inspection, which enriched the participants'evaluations. Participants were given printed booklets with the survey questions, and researchers guided them through complex terminology to ensure comprehension. Duration of each session ranged from

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15 to 20 minutes, during which researchers were available to clarify any doubts or questions participants may have had.

The rationale behind choosing the face-to-face method stemmed from the need for expert engagement. Designers and manufacturers required contextual understanding to accurately assess ergonomic nuances, which was facilitated by the ability to physically examine the furniture models. Additionally, in-person interactions enhanced data quality by minimising ambiguities surrounding technical questions. Face-to-face recruitment also fostered trust-building among participants, which is particularly important in the niche field of Ming-style furniture design.

c) Ethical Considerations (Both Methods)

Ethical considerations were paramount in both survey methods. Informed consent was rigorously followed; in the online format, participants were required to complete digital consent forms before starting the survey. For the face-to-face method, written consent was obtained, highlighting that participation was voluntary.

3.5 Methodology of Third Stage of Study

3.5.1 Research Design and Research Process for Stage 3

The main research process in the third stage is to conduct a priority analysis of each item of ergonomics through the structure, obtained from the Questionnaire I and II. Next, the researcher needs to use the results to propose a design framework and validate it in the third phase. The first two (2) phases have provided the researcher with a certain amount of literature material and quantitative analysis to provide a basis for the next design framework of the seat.

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Therefore, the third stage of the research design was specified and is shown in Figure 3.3 below. In order to verify the validity of the design framework, the researcher in the third stage of the study needs to use the design framework to proceed with the design of the new Chinese seat design (design practice), and a new round of questionnaires on the design options to ensure good use of the design framework. At the same time, the researcher will select three participants to sketch using the design framework and detail their use of it. It is also a summary of the previous results. The researcher is to use the research methodology of sketching to conduct the design practice. Next, the research method using Questionnaire for the design proposal.

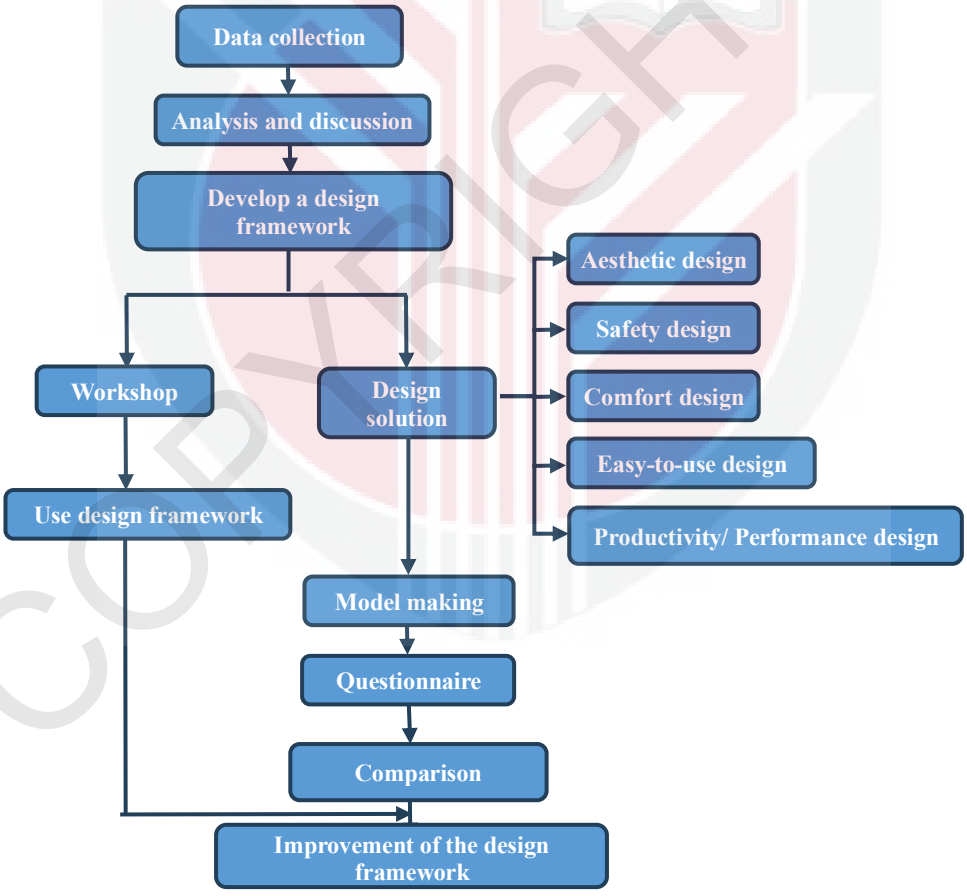

Figure 3.4 : The Flowchart of Stage 3 Research Process
(Source by author)

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3.5.2 Questionnaire and Survey Analysis Methods

Through the structured Questionnaires I and II, the results of the subjects'priorities for each ergonomic aspects item will be organised and statistics and the data from the users as well as the designers and manufacturers of the Chinese Ming Style seat ergonomics priority samples will be inputted into the SPSS software for the descriptive analysis. As a result, the researcher will obtain the trend of preference for each seat form, general ergonomics, and specific ergonomics. The high priority items for each domain will be highlighted in the ergonomics design framework for Chinese Ming Style wooden seats so that they can be quickly used by designers in the design process.

The author uses the results of structured questionnaires I and II to present the average values of each component separately to determine the high-priority situation through the level of values. Next, the items will be grouped in detail in terms of priority. Through the charts generated from the above analysis, the researcher can accurately obtain and tabulate the priority data for each of the seating form, general ergonomics, and special ergonomics. Finally, the researcher validated the problems of the design framework by means of a redesign and make possible improvements.

3.5.3 Validity and Reliability of Questionnaires

The validity and reliability of the two rounds of questionnaires will be thoroughly assessed, with the main key points for a high-quality survey being rational sampling, incorporation of theoretical constructs, choice of seat form and descriptive statistical analysis. Detailed information on each validity and reliability is presented in Table 3.2 and Table 3.3, respectively.

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Table 3.2 : Research Validation

		Measures to Improve Reliability	
Types of Validity		Survey: Validating the ergonomic field of Chinese Ming-style wooden seats	Analysis and evaluation of seat redesign and ergonomic design frameworks; use of design frameworks by workshop: validation of ergonomic frameworks
External Validity	Environment Validity	Surveys are conducted in the respondent's daily/common activity area (e.g., daily study area or respondent's office) to make sure that each respondent can answer the questions in his or her normal environment.	Correct and accurate use of design frame data to obtain an accurate 3D design model of the new seat to maximise the use of questionnaires to analyse design frame accuracy.
	Population validity	Questionnaire one selected users of Ming furniture and respondents in Questionnaire two were selected only if they were in the relevant design field to ensure the reliability and measurability of the number of respondents.	In order to obtain valid ergonomic data, consider reasonable seat dimensions when building the 3D model using the software.
Internal Validity	Hawthorne effect	Reduce unnecessary interaction with the respondent.	
	Content Validity	Preliminary theoretical support and rational personnel selection	

(Source by author)

Table 3.3 : Research Reliability

	Measures to Improve Reliability	
Types of Reliability	Survey: Validating the ergonomic field of Chinese Ming style wooden seat	Seat redesign and ergonomic analysis evaluation: validation of the ergonomic framework
Instrument Reliability	Statistical correlation test of survey should be between the optimum range of 0.7 until 1	Cross-analysis between closed-ended survey results and ergonomic analysis of redesigned seat

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Table 3.3 : Continued

Interrater Reliability	Established a clear guideline for survey data collection
Internal Consistency Reliability	Cronbach's alpha test should be within the optimum range of 0.7 until 1
Statistical Reliability	

(Source by author)

3.5.4 Sketching Approach

The sketching approach was strategically employed during Phase II of Stage 3 (Validation Phase II) as part of the design framework validation process. This phase focused on practical application and qualitative assessment of the proposed ergonomic framework.

Sketching is an essential tool for recording observations, creative ideas and visual communication (Martin, 2019). Sketching is often an integral and unavoidable part of the design process and is a tool that designers are familiar with. As an important part of the design process, it is a direct way of expressing the designer's ideas and thoughts. In addition to this, it is an effective tool for communication and for communicating the designer's ideas to others, such as clients, users, or even other designers. In addition to the traditional hand-painted method, sketching, and rendering can also be done using several software and devices. Modern technology offers more possibilities for sketching, as people can use digital tools such as hand sketch pads and computers to produce more accurate sketches.

3.5.5 Participants for Validation (Phase I) Questionnaire

In Stage 3 of the study, the validation participants are divided into two phases: Phase

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I involves 30 design experts, while Phase II includes three industrial design students. The experts in Phase I meet the same criteria established for the experts in Stage 2, ensuring a consistent level of expertise and reliability in the feedback received. The selection criteria for the Phase I experts emphasise proven expertise in Ming-style furniture design, along with an ability to critically assess the technical aspects of the design framework. This expert feedback is essential to validate the framework's effectiveness and relevance in the field.

3.5.6 Validation (Phase I) Structured Questionnaires

Validation questionnaire is mainly for Chinese traditional furniture designers and manufacturers. The validation questionnaire is divided into two parts in total, as follows:

a) Part A: Personal Information - Same as Questionnaire II.

b) Part B: Design Framework Validation - The second part consists of six questions with 74 items on general ergonomics, aesthetics, comfort, safety, easy-to-use and productivity and performance. The participants are asked to select the items that could be used out of the 74 options based on a 3D model of the seat drawn by the author.

The set of questionnaires of this activity can be referred in Appendix C.

3.5.7 Validation (Phase I) Survey Procedures

The data collection process for the survey was done through a face-to-face survey. It has been distributed using a printed questionnaire booklet. The time to answer the questions was 15 minutes and all respondents were anonymous and voluntary. All

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respondents were thoroughly briefed on each attribute in all the specific sections regarding the terms and definitions used.

3.5.8 Validation (Phase II) of Participant and Survey Procedures

Given that this study investigates the ergonomics of Chinese Ming style seating, it requires some knowledge and understanding of the ergonomics of furniture. Therefore, the author chose three students majoring in industrial design from the North Minzu University in China to use the design framework for hand-drawing the Chinese Ming-style seating. In order to avoid data errors caused by unnecessary factors, the participants were from one sophomore and two juniors'students.

The survey process was conducted in the industrial design lab of North Minzu University for 120 minutes, and all respondents were anonymous and voluntary. The researcher began by explaining the design framework and informing the three participants how to use it, and the designers drew the seats through their own understanding. All participants were thoroughly briefed on each attribute in all specific sections regarding the terms used and definitions. Importantly, they have had no prior exposure to the framework, which is intentional; this ensures that their evaluation focuses on the clarity and usability of the design framework.

The rationale behind the participant numbers in this stage reflects a careful balance between feasibility and reliability. The inclusion of 30 experts provides a statistically robust sample, which is considered sufficient for validating frameworks, as noted by Field (2018). Conversely, the selection of three students creates a small, controlled group for qualitative usability testing. This small sample, while limited, is enhanced

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by triangulating their feedback with that of the experts, thus mitigating the limitations inherent in a smaller group, as discussed by Creswell and Poth (2016).

3.6 Summary

This study consists of three (3) steps, each answering one research question. The main research method is the questionnaire survey approach, in which a structured questionnaire was used to obtain the preferences of users, designers and manufacturers on the ergonomic items of Chinese Ming style wooden seat furniture. The content covered in the text is evaluated by using descriptive statistical analysis. The theoretical framework and previous literature provided support for this structured questionnaire and for data analysis. The validity and reliability of the survey was also analysed in detail, using accurate measures. Finally, the 3D model of the under-design guided by the design framework was obtained by sketching. The first step of the validation was to evaluate the usability of the design framework using the questionnaire again, and the second step was for three participants to draw the model using the framework to double-validate the content of the framework.

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CHAPTER 4

DATA ANALYSIS AND RESULTS

4.1 Introduction

This chapter discusses the results of the **r**esearch objective 1 and 2. Result from research objective 1 is based on literature review and result from research objective 2 is based on Questionnaire I and II. Figure 4.1 is the flow chart of Chapter 4.

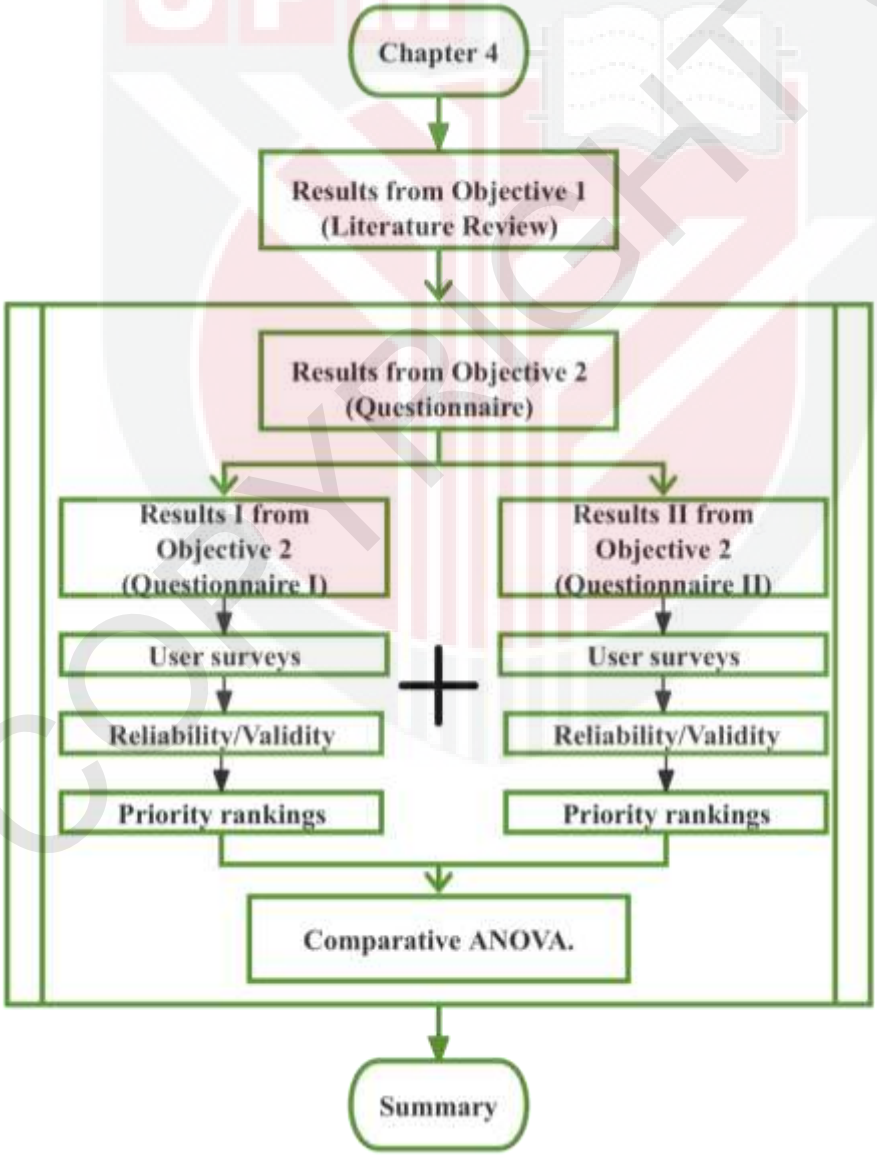

Figure 4.1 : Flow Chart of Chapter 4

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4.2 Result from Research Objective 1 (Literature Review)

The first research question, which focuses on the importance of ergonomics, was addressed through an exhaustive literature review. The analysis identified five specific ergonomic domains (aesthetics, safety, comfort, easy-to-use, and productivity/performance) and their sub-items, which collectively form the theoretical foundation for Chinese Ming-style wooden seat furniture design. The conceptual framework (Figure 4.2) visually synthesises these domains and their interrelationships, illustrating how they integrate to enhance both functional and cultural aspects of furniture design. Figure 4.2 shows the conceptual framework of the ergonomic domain for Chinese Ming-style wooden seat furniture. This framework is constructed based on a literature review and theoretical research and serves as an important support for Research Objective 1. Overall, it encompasses the general ergonomic domain and five specific ergonomic domains, comprehensively presenting the key elements influencing the design of Chinese Ming-style wooden seat furniture.

The general ergonomic domain includes elements such as human postures, product dimensions, product handling, and user movement. These elements are directly related to the way users interact with the seat. For example, different human postures (standing, sitting, lying, etc.) determine the size and shape characteristics that the seat should possess to ensure user comfort and convenience during use.

Among the five specific domains, the aesthetic domain involves multiple aspects such as senses application, external influences, modelling data, and aesthetic elements. Senses application covers smell, sight, hearing, taste, and touch, which play an important role in users'aesthetic evaluation of the seat. External influencing factors,

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such as symbols, patterns, and commonalities, affect the cultural connotations and styles of seat design.

Figure 4.2 : Research Conceptual Framework
(Source by author)

Modelling data defines the specific dimensions and materials of each part of the seat, serving as the basis for achieving aesthetic design. Aesthetic elements such as form, colour, and texture directly shape the appearance and texture of the seat.

The safety domain mainly focuses on risk factors, common ergonomic injuries, identifying and resolving ergonomic hazards, and safety items. Risk factors such as repetitiveness and required force may cause user injuries. Understanding these factors helps to take preventive measures in the design. The identification of common ergonomic injuries enables designers to optimise seat design accordingly. Measures to

identify and resolve hazards, such as redesigned tools and adjustable equipment, as well as the specifications for seat height, width, depth, etc. in safety items, are all crucial for ensuring the safe use of the seat by users.

The comfort domain is divided into physiological, psychological, physical, and environmental comfort factors. Physiological comfort factors consider muscle fatigue, local pain, etc. Psychological comfort factors focus on users'emotions and mental states. Physical comfort factors involve the seat's modelling, support, and adjustment functions. Environmental comfort factors include noise, temperature, vibration, and illumination. These factors are interrelated and jointly affect the user's comfort experience when using the seat.

The easy-to-use domain includes terms of easy-to-use and common attributes. The terms of easy-to-use, such as effectiveness, efficiency, satisfaction, and context of use, measure the quality of the interaction between the product and the user. Common attributes such as easy to learn, efficient, easy to remember, and fewer mistakes reflect the convenience of the product during use.

The productivity and performance domain is mainly measured by typing net speed and accuracy. A good seat design should contribute to improving users'productivity and performance in related tasks.

This conceptual framework systematically organises the relationships between each domain and its sub-items, providing a clear structure for a deep understanding of the ergonomic design of Chinese Ming-style wooden seat furniture. It also serves as an important theoretical basis for subsequent research and design practices.

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4.3 Result I from Objective 2 (Questionnaire I)

4.3.1 Personal Background of Respondents in Questionnaire I

This chapter provides a discussion of the questionnaire results for the research process in Chapter Three. Questionnaire I was conducted as a web-based survey and the demographic results of all the respondents are discussed below.

The survey included 305 participants, predominantly middle-aged, with 43.93% (n=134) aged 35–44, followed by 29.18% (n=89) aged 25–34, while respondents over 55 were the smallest group (3.28%, n=10). Males slightly outnumbered females (54.43% vs. 45.57%), and most participants were married (51.80%, n=158). Educationally, nearly half held bachelor's degrees (49.51%, n=151), while 29.84% (n=91) had high school or lower qualifications. Geographically, East China (44.92%, n=137) dominated participation, whereas Northeast and Northwest China had the lowest representation. Occupationally, the largest cohort worked in the financial industry (19.67%, n=60). Income distribution revealed that 32.46% (n=99) earned CNY 10,000–14,999/month, followed by 20.0% (n=61) in the CNY 5,000–9,999 bracket. In terms of health status, 44.26% (n=135) reported being in good health, 29.51% (n=90) described their health as excellent, and 22.62% (n=69) rated it as fair. Overall, respondents were largely middle-aged, educated, urban professionals from East China, reflecting a balanced gender distribution, moderate-to-high socioeconomic status, and generally positive self-assessed health (references Figures 4.3-4.7 and Table 4.2 for details).

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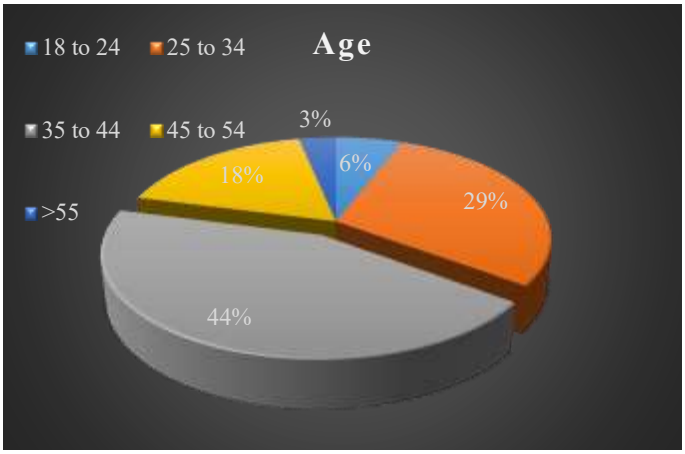

Figure 4.3 : Age Distribution of Respondents (Questionnaire I)

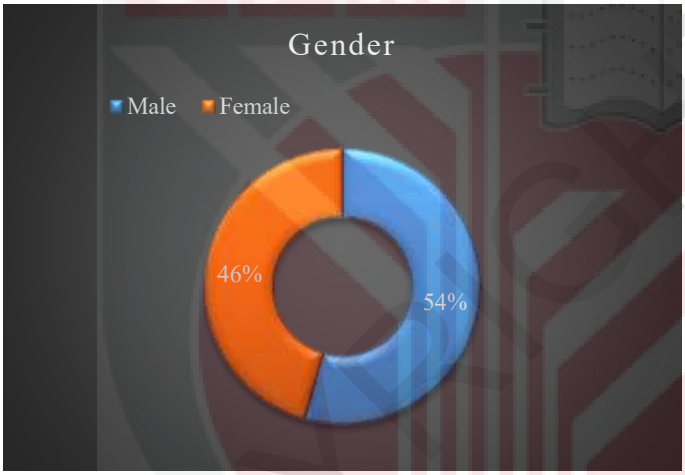

Figure 4.4 : Gender Distribution of Respondents (Questionnaire I)

Figure 4.5 : Marital Status Distribution of Respondents (Questionnaire I)

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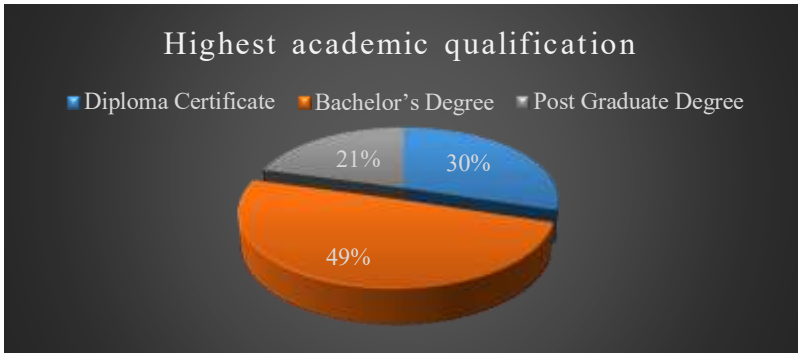

Figure 4.6 : Educational Distribution of Respondents (Questionnaire I)

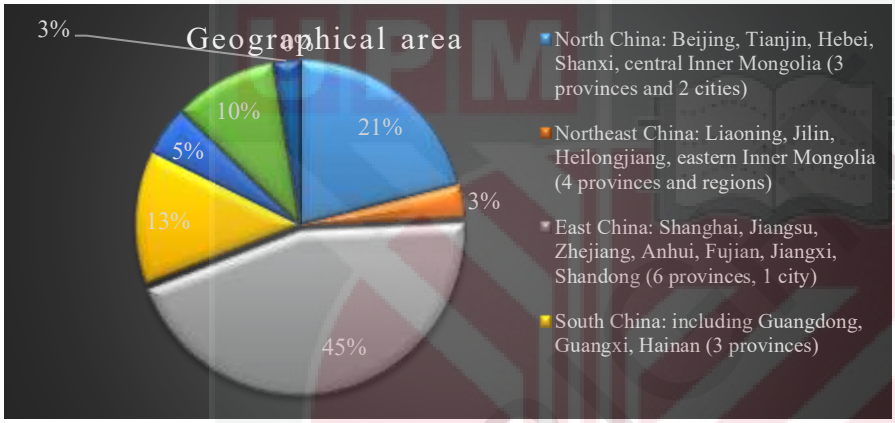

Figure 4.7 : Geographical Area Distribution of Respondents (Questionnaire I)

Table 4.1 : Occupation, Income, and Health Status of Respondents (Questionnaire I)

Occupation	Frequency (N)	Percent (%)	Cumulative Percent
Utilities	20	6.56	6.56
Finance	60	19.67	26.23
Entertainment	44	14.43	40.66
Education	31	10.16	50.82
Health care	21	6.89	57.71
Information services	23	7.54	65.25
Data processing	20	6.56	71.81
Food services	31	10.16	81.97
Hotel services	25	8.20	90.17
Legal services	3	0.98	91.15
Publishing	2	0.66	91.81
Prefer not to say	10	3.28	95.09
Other	15	4.92	100.00
Total	306	100	

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Table 4.1 : Continued

Current monthly income	Frequency (N)	Percent (%)	Cumulative Percent
CNY20,000 and above	46	15.08	15.08
CNY 15,000 - CNY 19,999	41	13.44	28.52
CNY 10,000 - CNY 14,999	99	32.46	60.98
CNY 5000 - CNY 9999	61	20.00	80.98
CNY 3000 - CNY 4999	24	7.87	88.85
CNY 1000 - CNY 2999	10	3.28	92.13
Less than CNY 1000	5	1.64	93.77
No more income	5	1.64	95.41
Don't know	14	4.59	100.00
Total	306	100	
Health status	Frequency (N)	Percent (%)	Cumulative Percent
Excellent	90	29.51	29.51
Good	135	44.26	73.77
Fair	69	22.62	96.39
Poor	3	0.98	97.37
Don't know	8	2.63	100
Total	306	100	

4.4 Reliability Analysis of Questionnaire I

The questionnaire of traditional furniture users was analysed for reliability and validity. In this research, SPSS 25.0 version is used to analyse the data. Firstly, the reliability analysis, when the Cronbach's Alpha value of the scale is higher than 0.7, it can mean that for the scale, the internal consistency of the constructed multiple variables is better; As can be seen from the Table 4.1, the Cronbach's Alpha results for each dimension, the Cronbach's Alpha values corresponding to the four (4) dimensions of the aesthetic domain designed in this study are 0.851, 0.904, 0.921, and 0.867, respectively, which are all greater than 0.7, indicating that the internal consistency of the dimensions of the questionnaire of the traditional furniture user survey is better, so the results of this survey reliability is excellent.

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Regarding the validity analysis, this study uses Kaiser-Meyer-Olkin (KMO) (calculation formula 1) and Bartlett's Sphericity test. As can be seen from Table 4.2, the KMO is 0.925, which is greater than 0.6 and meets the prerequisite requirements for factor analysis, implying that the data can be used for factor analysis research. As well as the data passed the Bartlett Sphericity test ($p<0.05$), which means that the research data is suitable for factor analysis.

$$\mathbf{KMO} = \frac{\sum\sum_{i\neq j} a_{ij}^2}{\sum\sum_{i\neq j} a_{ij}^2 + \sum\sum_{i\neq j} b_{ij}^2} \quad (1)$$

Where a_{ij} represents the correlation between the variables of i and j, and b_{ij} represents the partial correlation between the variables i and j.

Table 4.2 : Questionnaire Reliability Analysis for Users of Ming Furniture

Factor	Items	Corrected Item-Total Correlation (CITC)	Cronbach Alpha if Item Deleted	Cronbach α
Senses Application	Smell	0.601	0.832	0.851
	See	0.602	0.832	
	Hear	0.642	0.824	
	Taste	0.637	0.825	
	Touch	0.737	0.805	
	Emotion	0.589	0.834	
External Influenced	Symbol	0.808	0.879	0.904
	Pattern	0.681	0.893	
	Commonality	0.691	0.892	
	Theme	0.699	0.891	
	Manufacturing process	0.715	0.89	
	Value	0.709	0.89	
	Language	0.701	0.891	
Modelling Data	Length	0.72	0.912	0.921
	Width	0.88	0.9	
	Hight	0.687	0.914	
	Backrest height	0.668	0.915	
	Backrest curvature	0.709	0.912	
	Armrest height	0.708	0.912	
	Seat surface material	0.646	0.916	

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Table 4.2 : Continued

	Seat height ratio	**0.699**	**0.913**	
	Leg height	0.738	0.91	
Aesthetic Elements	Form	0.649	0.847	0.867
	Colour	0.639	0.849	
	Texture	0.678	0.842	
	Balance	0.622	0.852	
	Material	0.758	0.827	
	Functionality	0.641	0.849	

Table 4.3 : Questionnaire Validity Analysis for Users of Ming Furniture

KMO and Bartlett test		
KMO		0.925
Bartlett test	Approx. Chi-Square	4547.915
	df	378
	p value	0

4.5 Traditional Furniture User Priority Selection in the Questionnaire I

The Questionnaire I traditional furniture user priority selection situation was divided into two sections, namely the user experience structure and the aesthetic domain. Each section was evaluated because of users confiding in the researcher their preference for some of the items. Each item was rated separately using a five-point preference rating (1=Not considered, 2=Low, 3=Medium, 4=High, and 5=Essential).

4.5.1 User Experience Structure

As shown in Table 4.4, a total of 305 respondents participated in the questionnaire. The respondents in the phase I are the user group of Chinese Ming furniture, and the 305 respondents will lay the foundation for the later analysis period.

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Table 4.4 : Familiarity of Respondents with Chinese Ming furniture

Familiarity with the Chinese Ming Dynasty styled furniture	Frequency (N)	Percent (%)	Cumulative Percent
Not at all	14	4.59	4.59
Slightly	21	6.89	11.48
Somewhat	97	31.80	43.28
Moderately	127	41.64	84.92
Extremely	46	15.08	100
Total	305	100	

From the survey of 305 users of traditional furniture, it is known that 41.64 percent of the respondents said that they know moderately about Chinese Ming style furniture, followed by 31.80 percent of the respondents with a somewhat level of understanding, 15.08 percent of the respondents said that they know it extremely well, and the percentage of respondents who know slightly and not at all about it are 6.89 percent and 4.59 percent, as shown in Figure 4.8. Respondents to this questionnaire are aware of the Chinese Ming style furniture is relatively high, which is favourable to the investigation of this questionnaire.

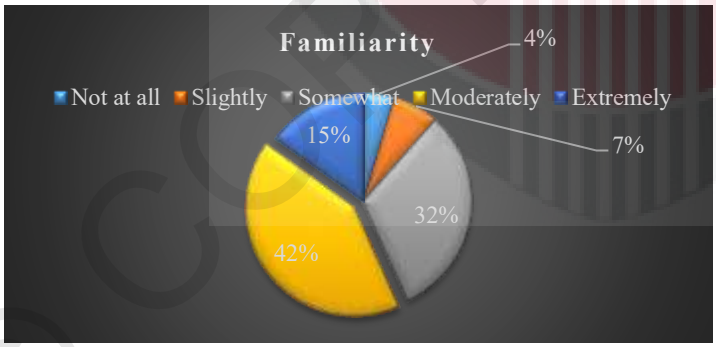

Figure 4.8 : Familiarity of Respondents with Chinese Ming-Style Furniture

From the 305 surveys of traditional furniture users, it can be seen that in terms of the frequency of use of Chinese Ming style furniture, 53.11 percent of the respondents said that they use it once or twice a week, 18.03 percent said that they use it every day,

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4.92 percent said that they use it once or twice a month, and the percentage of respondents who seldom use it and hardly use it is 17.70 percent and 6.23 percent, respectively as refer to Figure 4.9.

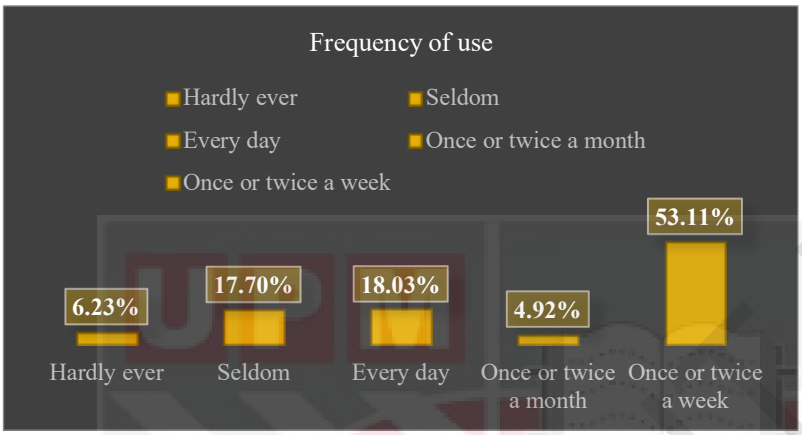

Figure 4.9 : Frequency of Using Chinese Ming Style Furniture by Respondents

Through the survey of 305 users, 82.30 percent of the respondents indicated that they use Ming style wooden seats, 15.74 percent indicated that they did not use Ming style seats, and 1.97 percent refused to answer, as shown in Figure 4.10. This data indicates that many respondents are users of Ming style seat, which improves the reliability of the whole questionnaire.

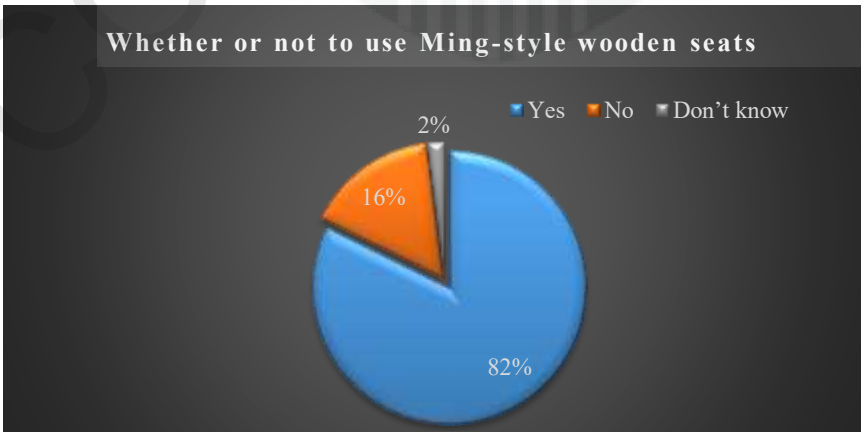

Figure 4.10 : Whether Respondents Use Ming Style Wooden Seat

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From Table 4.4, it can be seen that traditional furniture users consider chair form 1 (Four-headed Official Chair with Armrests) to be more compatible with the shape of Chinese Ming Style furniture, with a mean value of 3.27 followed by form 3 (mean=3.13), form 7 (mean=3.13), form 4 (mean=3.08), form 8 (mean=3.08), form 6 (mean=3.02), Form 2 (mean=3.01), and finally Form 5 with a mean value of 2.99. As refer to the Figure 4.11 for eight different forms of Chinese Ming sitting furniture.

Table 4.5 : Descriptive Analysis of Data on Respondents'Evaluations of Eight Different Forms of Chinese Ming Style Wooden Seat

Items	Mean value	SD	N
Chair form1	3.27	1.347	305
Chair form2	3.01	1.096	305
Chair form3	3.13	1.138	305
Chair form4	3.08	1.096	305
Chair form5	2.99	1.138	305
Chair form6	3.02	1.119	305
Chair form7	3.13	1.175	305
Chair form8	3.08	1.163	305

Figure 4.11 : Chair Form of 1 to 8 Types
(Source by Shixiang, 2020)

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4.5.2 Aesthetic Domain (Questionnaire I)

The researcher analysed the findings on Chinese Ming style wooden seats in the aesthetic domain section through 4 groups of data: senses application, external influences, modelling data and aesthetic elements. The author used a 5-point preference scale to evaluate the Chinese Ming style wooden seat and show the trend of Mean Value and Standard Deviation in the graph.

As shown in Table 4.6, among the priority choices of senses applications in Chinese Ming furniture, Touch has the highest priority, with a mean value of 3.77 followed by See, with a mean value of 3.46; Emotion again, with a mean value of 3.44; and the others in order of Taste, Smell, and Hear, with a mean value of 3.43, 3.41, and 3.39, respectively. This indicates that Chinese Ming style furniture users give a great importance and high priority for Touch. In addition, Hear (mean=3.39) became the lowest rated item among the senses.

Table 4.6 : Descriptive Analysis Data on the Priority of Senses Application in the Chinese Ming Furniture (Questionnaire I)

Items	Mean Value	SD	N
Smell	3.41	1.035	305
See	3.46	0.98	305
Hear	3.39	1.086	305
Taste	3.43	1.058	305
Touch	3.77	1.148	305
Emotion	3.44	0.975	305

External influences include seven items: Symbol, Pattern, Commonality, Theme, Manufacturing process, Value, and Language. In the priority selection of external influences in Chinese Ming furniture, Symbol has the highest priority with a mean

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value of 3.3, followed by Value with a mean value of 3.14, Language with a mean value of 3.12, and the others in the order of Theme, Manufacturing process, Pattern, and Commonality, with a mean value of 3.1, 3.09, 3.07, and 3.06, respectively. Commonality (mean=3.06, SD=1.109) emerged as the lowest priority external influence, as shown in Table 4.7.

Table 4.7 : Descriptive Analysis Data on the Priority of External Influenced in the Chinese Ming Furniture (Questionnaire I)

Items	Mean Value	SD	N
Symbol	3.3	1.312	305
Pattern	3.07	1.119	305
Commonality	3.06	1.109	305
Theme	3.1	1.141	305
Manufacturing process	3.09	1.161	305
Value	3.14	1.151	305
Language	3.12	1.138	305

There are nine main options for modelling data in Chinese Ming wooden seat furniture, and after prioritising the choices, Width has the highest priority, with a mean value of 3.39; followed by Armrest height, with a mean value of 3.23; and again Leg height, with a mean value of 3.12; The others in order are Backrest height, Backrest curvature, Seat surface material, Length, Seat height ratio, Height, with mean values of 3.14, 3.13, 3.12, 3.11, 3.07, 3.06, respectively as refer to the Table 4.8.

Table 4.8 : Descriptive Analysis Data on the Priority of Modelling Data in the Chinese Ming Wooden Seat Furniture (Questionnaire I)

Items	Mean Value	SD	N
Length	3.11	1.187	305
Width	3.39	1.38	305
Height	3.06	1.121	305
Backrest height	3.14	1.107	305
Backrest curvature	3.13	1.142	305

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Table 4.8 : Continued

Armrest height	3.23	1.063	305
Seat surface material	3.12	1.112	305
Seat height ratio	3.07	1.103	305
Leg height	3.15	1.099	305

Finally, it is the respondents'tendency to select the aesthetic elements of Chinese Ming style wooden seat furniture. Through the survey, Material has the highest priority, with a mean value of 3.62 and SD of 1.189 followed by Form, with a mean value of 3.33; and the others are Texture, Balance, Functionality, and Colour in that order, with mean values of 3.32, 3.32, 3.3, and 3.26, respectively as refer to Table 4.9.

Table 4.9 : Descriptive Analysis Data on the Priority of Aesthetic Elements in the Chinese Ming Seat Furniture (Questionnaire I)

Items	Mean Value	SD	N
Form	3.33	1.053	305
Colour	3.26	1.026	305
Texture	3.32	1.068	305
Balance	3.32	0.969	305
Material	3.62	1.189	305
Functionality	3.3	1.016	305

4.6 Results II from Objective 2 (Questionnaire II)

4.6.1 Personal Background of the Respondents in Questionnaire II

Questionnaire II was carried out in the form of a printed booklet distributed to the respondents. Fifteen design organisations and manufacturers in China were involved, and the demographic results of all the subjects are discussed below.

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The survey included 52 participants, predominantly middle-aged professionals aged 35–44 (36.54%, n=19), with minimal representation from younger cohorts (e.g., 9.62% aged 18–24). Females slightly outnumbered males (55.77% vs. 44.23%), and a plurality were married (42.31%, n=22) or single (38.46%, n=20). Educationally, over half held bachelor's degrees (57.69%, n=30), and nearly a third had graduate-level qualifications (32.69%, n=17) significantly higher than Phase I users. Geographically, North China (28.85%, n=15) dominated participation, while Central and Northwest China were underrepresented. Income levels skewed high, with 38.46% (n=20) earning CNY 15,000–19,999/month and 32.69% (n=17) above CNY 20,000/month. Health-wise, most reported good health (55.77%, n=29). Professionally, 67.31% (n=35) were designers, specialising primarily in industrial design (59.62%, n=31), with 42.31% (n=22) possessing 6–10 years of experience. Overall, respondents were experienced, highly educated, and affluent professionals from North China, reflecting a female-majority cohort engaged in specialised design roles (Refer to Figures 4.12-4.16 and Table 4.10-4.11).

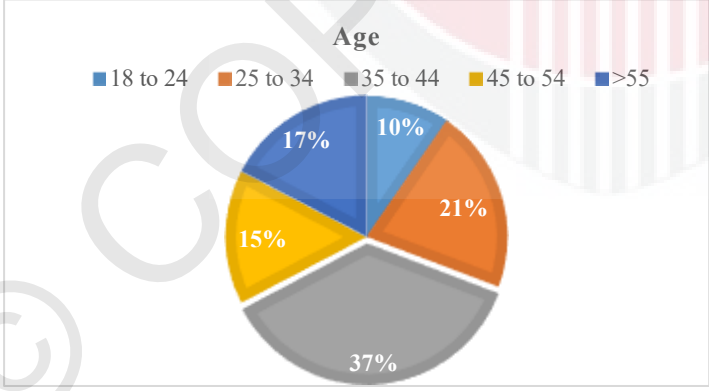

Figure 4.12 : Age Distribution of Respondents (Questionnaire II)

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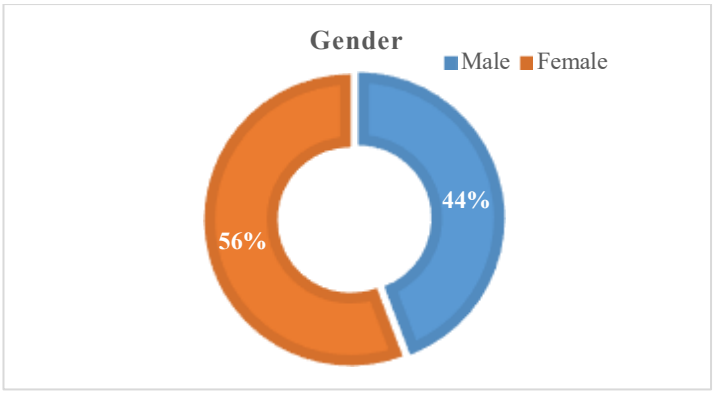

Figure 4.13 : Gender Distribution of Respondents (Questionnaire II)

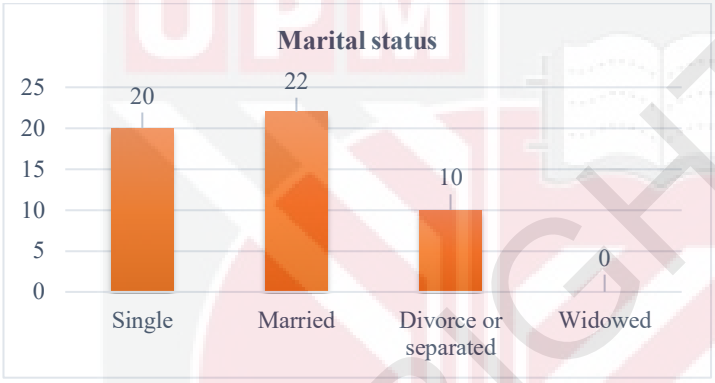

Figure 4.14 : Marital Status Distribution of Respondents (Questionnaire II)

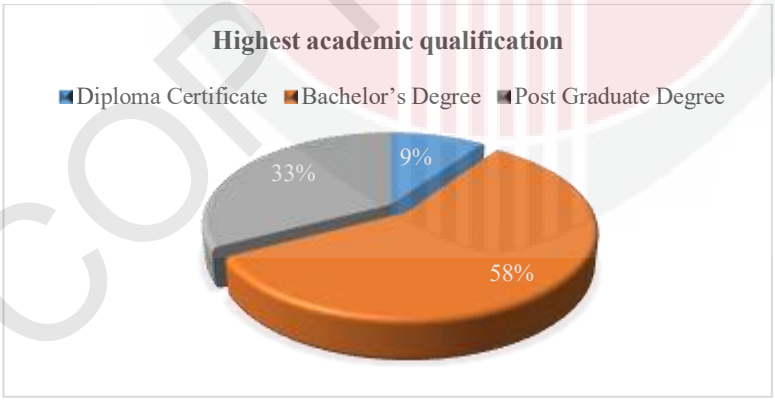

Figure 4.15 : Educational Distribution of Respondents (Questionnaire II)

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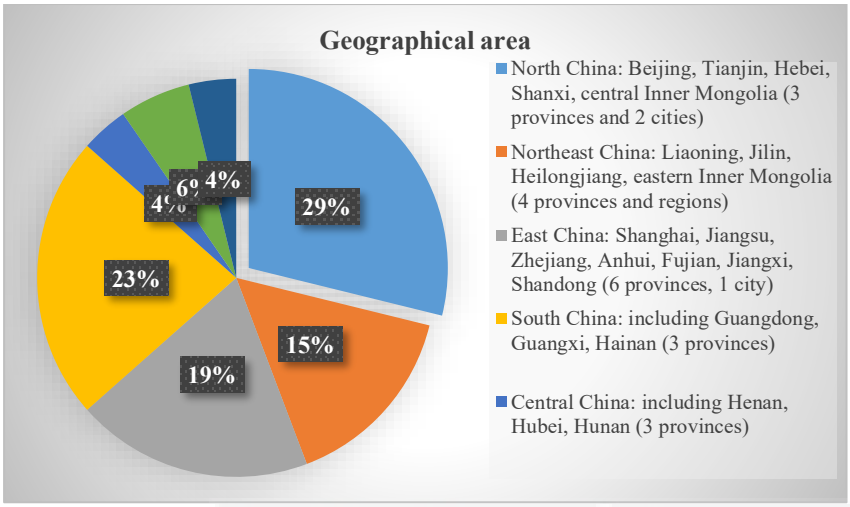

Figure 4.16 : Geographical Area Distribution of Respondents (Questionnaire II)

Table 4.10 : Income and Health Status of Respondents (Questionnaire II)

Current monthly income	Frequency (N)	Percent (%)	Cumulative Percent
CNY20,000 and above	17	32.69	32.69
CNY 15,000 - CNY 19,999	20	38.46	71.15
CNY 10,000 - CNY 14,999	8	15.38	86.53
CNY 5000 - CNY 9999	2	3.85	90.38
CNY 3000 - CNY 4999	4	7.69	98.07
CNY 1000 - CNY 2999	1	1.93	100
Total	52	100	
Health status	**Frequency (N)**	**Percent (%)**	**Cumulative Percent**
Excellent	8	15.38	15.38
Good	29	55.77	71.15
Fair	14	26.92	98.07
Poor	1	1.93	100
Total	306	100	

Table 4.11 : Occupational Information of Respondents (Questionnaire II)

Items	Categories	N	Percent (%)
Occupation	Designer	35	67.31
	Manufacturer	17	32.69
Field of expertise	Industrial Design	31	59.62

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Table 4.11 : Continued

	Ergonomic	**17**	**32.69**
	Engineering	4	7.69
Design experience in a related field	< 2 years	5	9.62
	3 to 5 years	15	28.85
	6 to 10 years	22	42.31
	>10 years	10	19.23

4.7 Reliability and Validity Analysis of Questionnaire II

The authors analysed the reliability and validity of 52 questionnaires from traditional furniture designers and manufacturers. In this research, SPSS 25.0 was used to analyse the data. Firstly, the reliability analysis, when the Cronbach's Alpha value of the scale is higher than 0.7, it can mean that the internal consistency of the constructed multiple variables is good for the scale. For validity analysis, KMO and Bartlett's test of sphericity were used. Considering that the productivity and performance domain has only one dimension with two measurement items that cannot be rotated, no further reliability and validity analysis was done.

4.7.1 Aesthetic Domain (Questionnaire II)

As can be seen from the Table 4.12, the Cronbach's Alpha results for each dimension, the Cronbach's Alpha values corresponding to the four dimensions of the aesthetic domain designed in this paper are 0.876, 0.905, 0.907, and 0.854, respectively, which are all greater than 0.7. This indicates that the internal consistency of the dimensions of the aesthetic domain of the questionnaire for traditional furniture designers and manufacturers is quite good, so the reliability of the results of this survey is excellent.

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Table 4.12 : Reliability Analysis of the Aesthetic Domain of the Questionnaire for Ming Furniture Designers and Manufacturers

Factor	Items	Corrected Item-Total Correlation (CITC)	Cronbach Alpha if Item Deleted	Cronbach α
Senses Application	Smell	0.772	0.838	0.876
	See	0.65	0.86	
	Hear	0.695	0.852	
	Taste	0.668	0.857	
	Touch	0.832	0.827	
	Emotion	0.477	0.884	
External Influenced	Symbol	0.812	0.88	0.905
	Pattern	0.676	0.895	
	Commonality	0.693	0.894	
	Theme	0.778	0.883	
	Manufacturing process	0.786	0.883	
	Value	0.683	0.894	
	Language	0.611	0.902	
Modelling Data	Length	0.591	0.902	0.907
	Width	0.825	0.885	
	Height	0.708	0.894	
	Backrest height	0.555	0.905	
	Backrest curvature	0.73	0.893	
	Armrest height	0.741	0.892	
	Seat surface material	0.634	0.9	
	Seat height ratio	0.683	0.896	
	Leg height	0.683	0.896	
Aesthetic Elements	Form	0.743	0.811	0.854
	Colour	0.561	0.845	
	Texture	0.582	0.841	
	Balance	0.733	0.812	
	Material	0.598	0.838	
	Functionality	0.651	0.829	

Regarding the validity analysis, this study uses KMO and Bartlett's sphericity test. As can be seen from Table 4.13, the KMO is 0.646, which is greater than 0.6 and meets the prerequisite requirements for factor analysis, implying that the data can be used for factor analysis research. As well as the data passed the Bartlett sphericity test ($p<0.05$), which means that the research data is suitable for factor analysis.

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Table 4.13 : Validity Analysis of the Aesthetic Domain of the Questionnaire for Ming Furniture Designers and Manufacturers

KMO and Bartlett test		
KMO		0.646
Bartlett test	Approx. Chi-Square	952.165
	df	378
	p value	0

4.7.2 Safety Domain (Questionnaire II)

As can be seen from Table 4.14, the Cronbach's Alpha results for each dimension, the Cronbach's Alpha values corresponding to the four dimensions of the security domain designed in this study are 0.805, 0.872, 0.873, 0.865, which are all greater than 0.7, indicating that the internal consistency of each dimension of the security domain of the traditional furniture designers'survey questionnaire is good, so the reliability of the results of this survey is excellent. Regarding the validity analysis, this research uses KMO and Bartlett's sphericity test.

Table 4.14 : Reliability Analysis of the Safety Domain of the Questionnaire for Ming Furniture Designers and Manufacturers

Factor	Items	Corrected Item-Total Correlation (CITC)	Cronbach Alpha if Item Deleted	Cronbach α
Risk factors	Repetitiveness	0.647	0.744	0.805
	Required force	0.532	0.796	
	Prolonged positions	0.716	0.707	
	Inadequate tools	0.601	0.765	
Common ergonomic injuries	Musculoskeletal disorders (MSDs)	0.797	0.809	0.872
	Carpal tunnel syndrome	0.694	0.848	
	Rotator cuff injuries	0.724	0.84	
	Lower back injuries	0.712	0.841	
Discovering ergonomic	Redesigned tools and adjustable equipment	0.856	0.782	0.873

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Table 4.14 : Continued

hazards and fixing them	Work close to the body	0.656	0.864	
	Alternate postures and motions	0.731	0.837	
	Keep the workspace clean and clear	0.696	0.853	
Safety item	Seat height	0.659	0.843	0.865
	Seat Width	0.669	0.84	
	Seat Depth	0.83	0.796	
	Seat Curvature	0.619	0.853	
	Seat Inclination and Backrest Inclination	0.673	0.84	

As can be seen from Table 4.15, the KMO is 0.669, which is greater than 0.6 and meets the prerequisite requirements for factor analysis, implying that the data can be used for factor analysis research. As well as the data passed the Bartlett sphericity test ($p<0.05$), indicating that the research data is suitable for factor analysis.

Table 4.15 : Validity Analysis of the Safety Domain of the Questionnaire for Ming Furniture Designers and Manufacturers

KMO and Bartlett test		
KMO		0.669
Bartlett test	Approx. Chi-Square	489.884
	df	136
	p value	0

4.7.3 Comfort Domain (Questionnaire II)

Table 4.16 show the Cronbach's Alpha results for each dimension, the Cronbach's Alpha values corresponding to the four dimensions of the comfort domain designed in this study are 0.81, 0.764, 0.867, and 0.85, respectively, which are all greater than 0.7, indicating that the internal consistency of the dimensions of the comfort domain

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of the questionnaire of the traditional furniture designers is better, so the current survey has excellent confidence in the results.

Table 4.16 : Reliability Analysis of the Comfort Domain of the Questionnaire for Ming Furniture Designers and Manufacturers

Factor	Items	Corrected Item-Total Correlation (CITC)	Cronbach Alpha if Item Deleted	Cronbach α
Physiological Comfort Factors	Muscle fatigue	0.682	0.719	0.81
	Partial pain	0.621	0.778	
	Seated posture	0.688	0.72	
Psychological Comfort Factors	Emotion	0.648	.	0.764
	Mental	0.648	.	
Physical Comfort Factors	Seat Modelling	0.722	0.833	0.867
	Seat Support	0.805	0.81	
	Seat adjustment	0.597	0.861	
	Breathability	0.656	0.847	
	Material	0.687	0.84	
Environment Comfort Factors	Noise	0.668	0.818	0.85
	Temperature	0.768	0.774	
	Vibration	0.639	0.832	
	Illumination	0.698	0.808	

Regarding the validity analysis, this research uses KMO and Bartlett's sphericity test. Table 4.17 shows that the KMO is 0.749, which is greater than 0.6 and meets the prerequisite requirements for factor analysis, implying that the data can be used for factor analysis research. As well as the data passed the Bartlett sphericity test ($p<0.05$), indicating that the research data is suitable for factor analysis.

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Table 4.17 : Validity Analysis of the Comfort Domain of the Questionnaire for Ming Furniture Designers and Manufacturers

KMO and Bartlett test		
KMO		0.749
Bartlett test	Approx. Chi-Square	356.78
	df	91
	p value	0

4.7.4 Easy-to-Use Domain (Questionnaire II)

As can be seen from Table 4.18, the Cronbach's Alpha results for each dimension, the Cronbach's Alpha values corresponding to the four dimensions of the ease of use domain designed in this paper are 0.81, 0.764, 0.867, 0.85, respectively, which are all greater than 0.7, indicating that the internal consistency of each dimension of the ease of use domain of the questionnaire of the traditional furniture designers is better, so that the current survey has excellent confidence in the results.

Table 4.18 : Reliability Analysis of the Easy-to-Use Domain of the Questionnaire for Ming Furniture Designers and Manufacturers

Factor	Items	Corrected Item-Total Correlation (CITC)	Cronbach Alpha if Item Deleted	Cronbach α
Ease of use	Effectiveness	0.631	0.778	0.82
	Efficiency	0.582	0.8	
	Satisfaction	0.761	0.712	
	Context of use	0.605	0.789	
Common attributes	Easy to learn (or easy to read)	0.667	0.812	0.847
	Efficient	0.579	0.835	
	Easy to remember	0.616	0.826	
	Fewer mistakes	0.651	0.817	
	Satisfaction	0.775	0.781	

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Regarding the validity analysis, this paper uses KMO and Bartlett's sphericity test. As can be seen from Table 4.19, the KMO is 0.774, which is greater than 0.6 and meets the prerequisite requirements for factor analysis, implying that the data can be used for factor analysis research. As well as the data passed the Bartlett sphericity test ($p<0.05$), which means that the research data is suitable for factor analysis.

Table 4.19 : Validity Analysis of the Easy-to-Use Domain of the Questionnaire for Ming Furniture Designers and Manufacturers

KMO and Bartlett test		
KMO		0.774
Bartlett test	Approx. Chi-Square	194.291
	df	36
	p value	0

4.8 Priority Selection of Traditional Furniture Designers and Manufacturers in Questionnaire II

The phase II traditional furniture designers'and manufacturers'priority choices were divided into seven sections: design experience structure, general ergonomics domain, aesthetics domain, safety domain, comfort domain, ease to use domain, and productivity/performance domain. Each section was evaluated as a result from respondents confiding in the researcher about their preference for several items. Each item was rated separately using a five-point preference scale as 1=Not considered, 2=Low, 3=Medium, 4=High, and 5=Essential.

4.8.1 Structure of Design Experiences (Questionnaire II)

A total of 52 designers or manufacturers participated in Questionnaire II. Respondents in the phase II evaluated their preference for the five major areas of ergonomics, and

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the 52 respondents will lay the foundation for the later analysis phase.

From the 52 surveys of traditional furniture designers and manufacturers, 67.31 percent of the respondents indicated that they knew moderately well about Chinese Ming style furniture, 17.31 percent indicated that they knew extremely well, and 15.38 percent knew moderately well, as shown in Figure 4.17. From the data, most of the designers or manufacturers who took part in this survey knew moderately well or more about Chinese Ming style furniture, and nearly one-fifth of the respondents are extremely knowledgeable about Ming furniture, increasing the reliability of this survey.

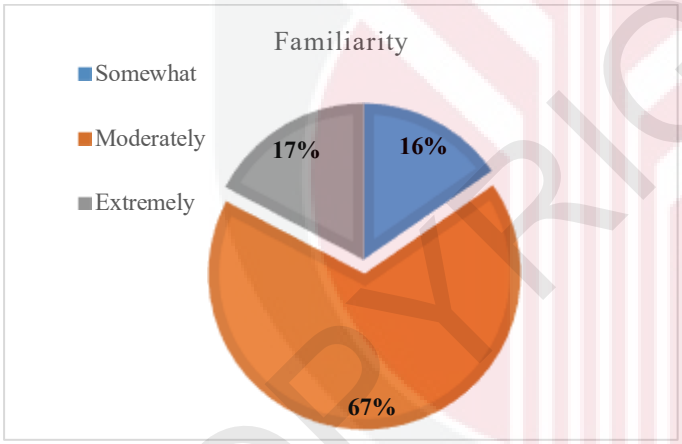

Figure 4.17 : Familiarity with Chinese Ming Furniture by Respondent Designers or Manufacturers

From the 52 surveys of traditional furniture designers or manufacturers, 53.85 percent of the respondents indicated that it takes one to two weeks to develop a Chinese Ming chair from the design to the prototype stage, 30.77 percent indicated that it takes three to four weeks, and 15.38 percent indicated that it takes less than one week as refer to the Figure 4.18. The largest percentage of designers who take one to two weeks indicates that the designers are more experienced and high level of proficiency and

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more objective evaluation of the preference of the design.

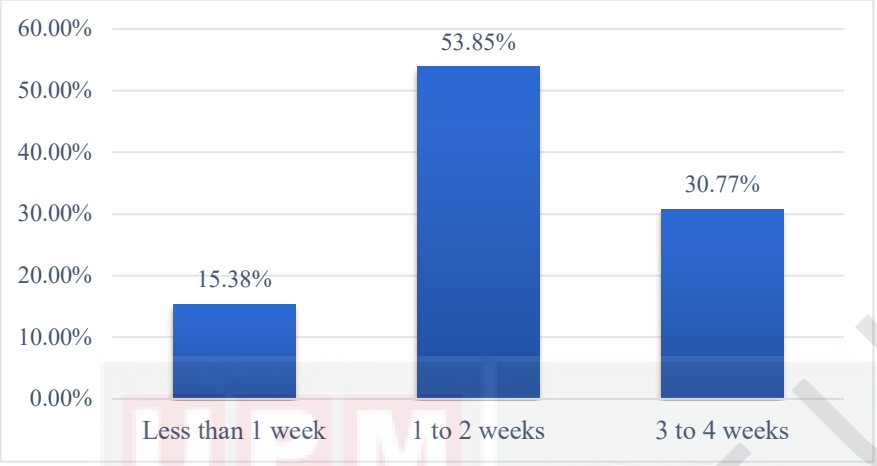

Figure 4.18 : Time Taken by Respondents'Designers or Manufacturers to Develop a Chinese Ming Chair

From the 52 surveys of traditional furniture designers or manufacturers, 75.0 percent of the respondents'field of design is Ming style wooden seat, as shown in Figure 4.19. This data indicates that many of the respondents work in the field of Ming style wooden seats, increasing the reliability of the questionnaire.

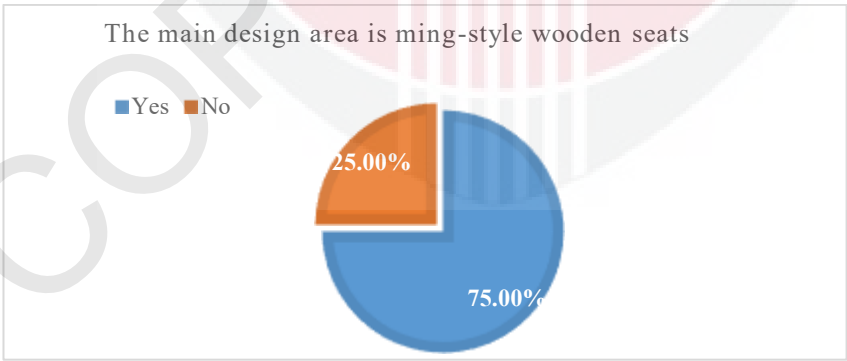

Figure 4.19 : Is the Main Design Area of the Respondent's Designer or manufacturer a Ming Style Wooden Seat

From Table 4.20, traditional furniture designers think that chair form 1 is more compatible with the shape of Chinese Ming style furniture, with a mean value of 3.5

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followed by form 2 (mean=3.33), form 5 (mean=3.21), form 6 (mean=3.19), form 7 (mean=3.19), form 3 (mean=3.15), form 8 (mean=3.12), and lastly form 4, with a mean value of 3. Using the above data to compare with the data from the phase I, both users and designers and manufacturers consider chair form 1 to be more compatible with the shape of Chinese Ming style furniture. It can be determined that the Four-headed Official Chair with Armrests is more in line with the characteristics of Chinese Ming style chairs, and the researcher will use the Four-headed Official Chair with Armrests as a prototype design for improvement in the validation.

Table 4.20 : Descriptive Analysis Data on the Evaluation of Eight Different Forms of Chinese Ming Sitting Furniture by Designers or Manufacturers Surveyed

Items	Mean Value	SD	N
Chair form1	3.5	1.336	52
Chair form2	3.35	1.118	52
Chair form3	3.15	1.211	52
Chair form4	3.0	1.048	52
Chair form5	3.21	1.035	52
Chair form6	3.19	1.155	52
Chair form7	3.19	1.189	52
Chair form8	3.12	1.182	52

Chinese furniture designers and manufacturers considered “Aesthetic” to be the highest priority in the specific ergonomic design process of Chinese Ming furniture, with a mean value of 3.25, followed by “Comfort” (mean=3.21), “Safety” (mean=3.1), “Easy-to-use” (mean=3.08), and finally “Productivity and Performance” with a mean value of 2.98, as shown in Table 4.21.

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Table 4.21 : Descriptive Analysis Data on the Evaluation of Specific Ergonomic Design Process of Chinese Ming Sitting Furniture by Designers or Manufacturers Surveyed

Items	Mean Value	SD	N
Aesthetic	3.25	1.266	52
Safety	3.1	1.089	52
Comfort	3.21	1.109	52
Easy - to - use	3.08	1.082	52
Productivity/ Performance	2.98	1.111	52

4.8.2 General Ergonomics Domain (Questionnaire II)

The researcher conducted a survey on the importance of ergonomic to furniture design, 63.46 percent of the respondents said that ergonomics is more important to furniture design and 36.54 percent of the respondents said that it is very important as refer to the Figure 4.19. From the 52 surveys of traditional furniture designers and manufacturers, 71.15 percent of the respondents indicated that ergonomics is more meaningful to Chinese Ming style wooden chairs, and 28.85 percent of the respondents indicated that it is very meaningful. From the above data, all the designers and manufacturers believe that ergonomics is important or even very important to furniture design, which further affirms the significance of this study as refer to the Figure 4.21.

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Figure 4.20 : Importance of Ergonomics to Furniture Design

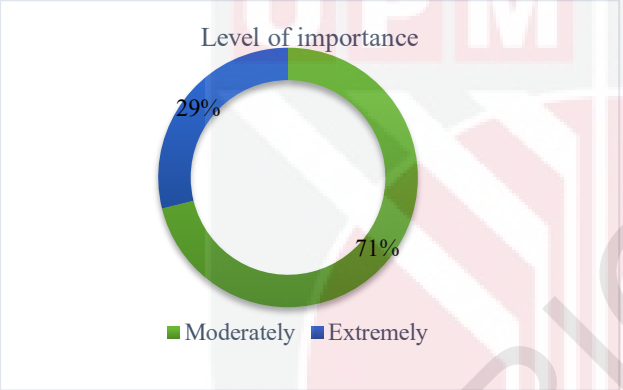

Figure 4.21 : Importance of Ergonomics to Chinese Ming Style Wooden Seat

The researchers investigated the physical ergonomic properties in the developing and designing of Chinese Ming style chairs, and traditional furniture designers and manufacturers believed that the most priority physical ergonomic properties were "Human postures" with a mean value of 3.35 followed by "Product dimension" (mean=3.31), "User movement" (mean=3.31), and finally "Product handling" with a mean value of 3.1, refer to Table 4.22. Human postures are the most important for the design and development of Chinese Ming style seats.

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Table 4.22 : Descriptive Analysis Data on the Evaluation of Physical Ergonomic Properties Design Process of Chinese Ming Sitting Furniture by Designers or Manufacturers Surveyed

Items	Mean Value	SD	N
Human postures	3.35	1.251	52
Product dimension	3.31	1.229	52
Product handling	3.1	1.142	52
User movement	3.23	0.831	52

4.8.3 Descriptive Analysis Data of Aesthetic Domain (Questionnaire II)

The researcher explored the designers'or manufacturers'preference for Chinese Ming style wooden seats in the aesthetic domain section through 4 sets of data: sense application, external influence, modelling data and aesthetic elements. The author used a 5-point preference scale to evaluate the Chinese Ming style wooden seats and show the trend of Mean value and Standard deviation in the graph.

From the survey results of the Questionnaire II, it can be seen that in the choice of the priority of sense application in Chinese Ming-style furniture in the view of designers (as shown in Figure 4.22), the sense of Touch has the highest priority, with a mean value of 3.54; followed by See, with a mean value of 3.27; Emotion, with a mean value of 3.23; and the others in the order of Smell, Hear, and Taste, with a mean value of 3.19, 3.17, and 3.15, respectively. The Chinese Ming style Furniture designers and manufacturers perceived that Touch and See were prioritised higher in furniture design. However, Taste (mean=3.15) was the lowest rated item among the senses.

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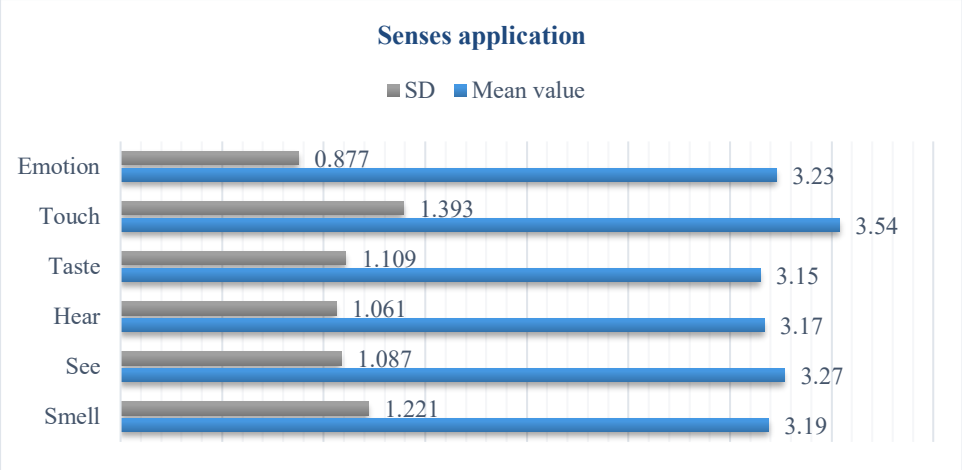

Figure 4.22 : Priority of Senses Application in Chinese Ming Furniture Mean Value and Standard Deviation (Questionnaire II)

In the selection of designers'and manufacturers'prioritisation of external influences in Chinese Ming-style furniture, Symbol has the highest priority, with a mean value of 3.23 followed by Value, with a mean value of 3.12 followed by Language, with a mean value of 3.1; the others in order of Commonality, Pattern, Manufacturing process, and Theme, with a mean value of 3.02, 2.96, 2.96, 2.85. Theme (mean=2.85, SD=1.258) became the lowest prioritised external influence as refer to Figure 4.23.

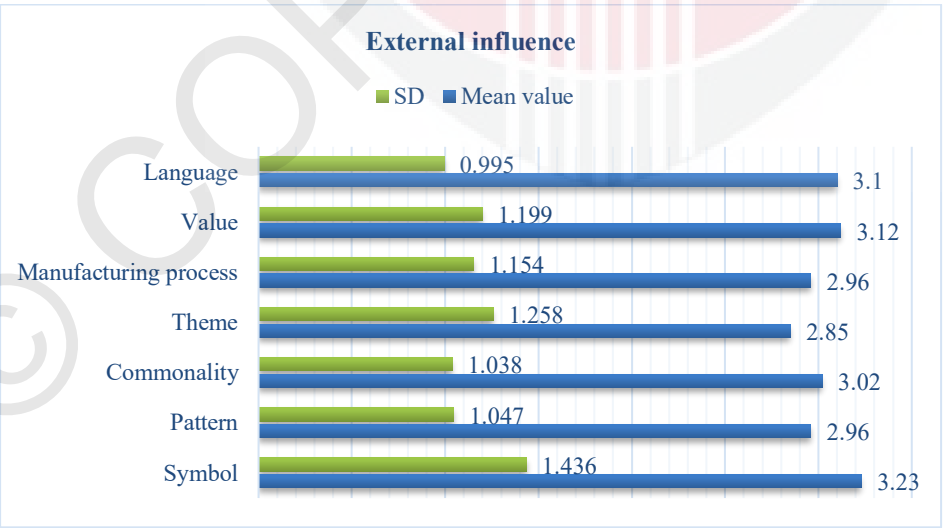

Figure 4.23 : Priority of External Influence in Chinese Ming Furniture Mean Value and Standard Deviation (Questionnaire II)

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For the preference choices of the nine options of modelling data in Chinese Ming style furniture, Width has the highest priority with a mean value of 3.5; followed by Length and Leg Height with a mean value of 3.25; the others are, in order, Backrest curvature, Seat surface material, Length, Backrest height, Seat height ratio, Armrest height, and Height, with mean values of 3.21, 3.17, 3.1, 3.1, 3.08, and 3.04, respectively, as shown in Figure 4.24.

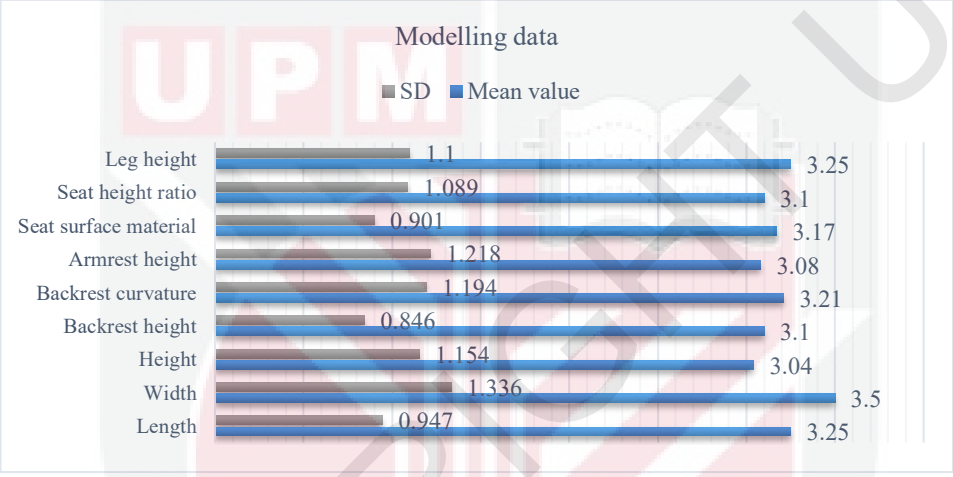

Figure 4.24 : Priority of Modelling Data in Chinese Ming Furniture Mean Value and Standard Deviation (Questionnaire II)

The fourth of the aesthetic domain is the designers'or manufacturers'tendency to select the aesthetic elements of Chinese Ming style furniture. It can be seen from the survey that Form and Texture have the highest priority, with a mean value of 3.27 followed by Material, with a mean value of 3.21 and the others are Functionality, Colour, and Balance in that order, with a mean value of 3.12, 3.12, and 3, respectively, which can be seen in Figure 4.25. Balance is the item that considered as the lowest priority among the aesthetic elements of Chinese Ming furniture.

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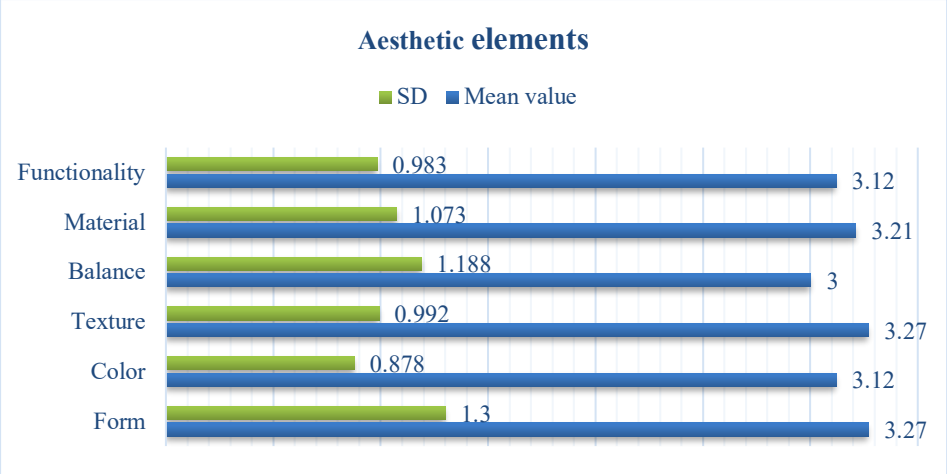

Figure 4.25 : Priority of Aesthetic Elements in Chinese Ming Furniture Mean Value and Standard Deviation (Questionnaire II)

4.8.4 Descriptive Analysis Data of Safety Domain (Questionnaire II)

The researcher explored the designers'or manufacturers'preference for Chinese Ming style wooden seats in the safety domain section by using 4 sets of data: risk factors, common ergonomic injuries, discovering ergonomic hazards and fixing them and safety item. The author used a 5-point preference scale to evaluate the Chinese Ming style wooden seats and showed the trend of Mean value and Standard deviation in the Figure 4.26.

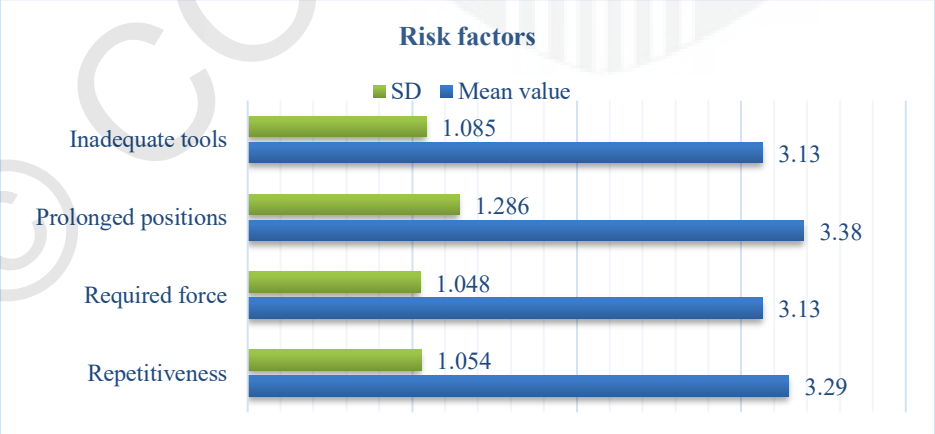

Figure 4.26 : Priority of Risk Factors in Chinese Ming Furniture Mean Value and Standard Deviation (Questionnaire II)

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It can be seen from the survey that “Prolonged positions” is the highest risk factor in the use of Ming furniture (seats) in China, with a mean value of 3.38 followed by “Repetitiveness” (mean=3.29), “Required force” (mean=3.13), and “Inadequate tools” (mean=3.13). Chinese Ming furniture designers and manufacturers prioritised prolonged positions in the use of Chinese Ming furniture (seating), suggesting that prolonged sitting poses the greatest risk.

The results showed that for common ergonomic injuries in the use of Chinese Ming seat furniture, “Musculoskeletal disorders (MSDs)” were the highest with a mean value of 3.46, followed by “Rotator cuff injuries” (mean=3.25), “Lower back injuries” (mean=3.19), “Carpal tunnel syndrome” (mean=3.04), and “Carpal tunnel syndrome” (mean=3.04) as refer to the Figure 4.27.

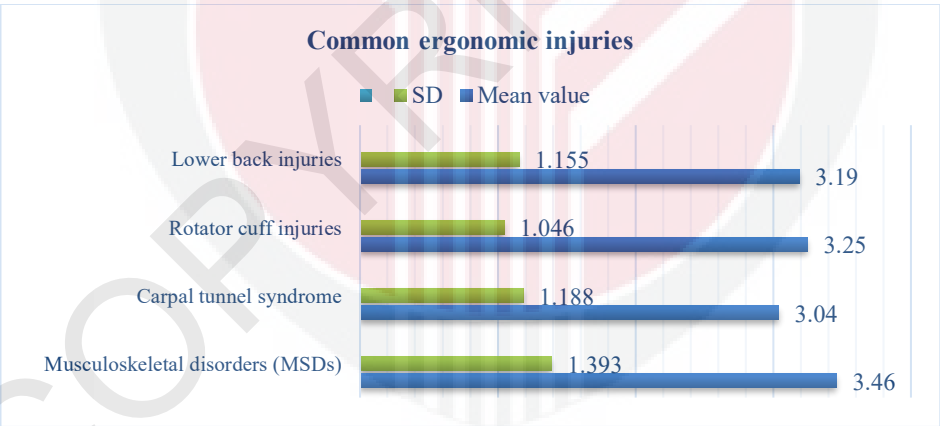

Figure 4.27 : Priority of Common Ergonomic Injuries in Chinese Ming Furniture Mean Value and Standard Deviation (Questionnaire II)

During the design process of Chinese Ming wooden seat furniture, priority for discovering and fixing ergonomic hazards was given to “Redesigned tools and adjustable equipment” with a mean value of 3.58 followed by “Alternate postures and motions” (mean=3.23), “Work close to the body” (mean=3.21), and finally “Keep the

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workspace clean and clear", with a mean value of 3.19 as refer to the Figure 4.28. Redesigned tools and adjustable equipment are particularly important.

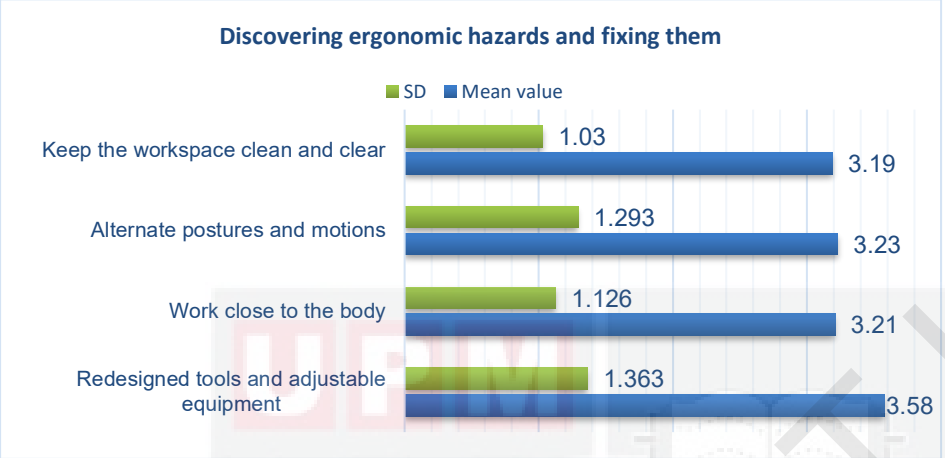

Figure 4.28 : Priority of Discovering Ergonomic Hazards and Fixing Them in Chinese Ming Furniture Mean value and Standard Deviation (Questionnaire II)

The fourth item in the safety domain is the designers'or manufacturers'tendency to choose the safety item of Chinese Ming style furniture. It can be seen from the survey that during the design process of Chinese Ming furniture (seat), "Seat Depth" is prioritised to meet the safety design of the seat, with a mean value of 3.55 followed by "Seat Inclination and Backrest Inclination" (mean=3.19), "Seat height" (mean=3.12), "Seat Curvature" (mean=3.1), and lastly, "Seat Width". "Seat Width" with a mean value of 3.06, which is refer to the Figure 4.29. Seat Depth is the highest priority among the Chinese Ming furniture which is safety item.

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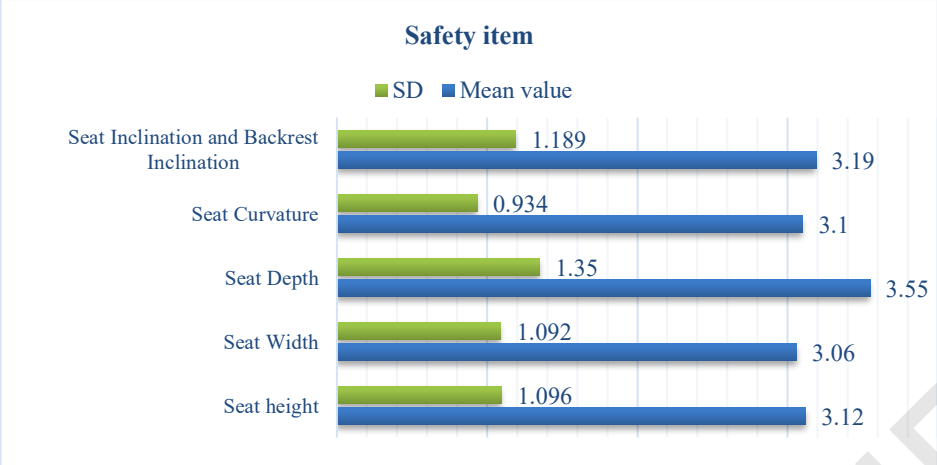

Figure 4.29 : Priority of Safety Item in Chinese Ming Furniture Mean Value and Standard Deviation (Questionnaire II)

4.8.5 Descriptive Analysis Data of Comfort Domain (Questionnaire II)

Physiological comfort factors, psychological comfort factors, physical comfort factors, and environmental comfort factors are the four parts of the comfort domain that have influence on Chinese Ming style wooden seats. The researcher explored the designers'or manufacturers'preference for Chinese Ming style wooden seat in the comfort domain section through four sets of data. The author used a 5-point preference scale to evaluate the Chinese Ming style wooden seats and showed the trend of Mean value and Standard deviation in the graph.

It can be seen from the survey that in the design process of Chinese Ming furniture (seats), "Muscle fatigue" is prioritised in terms of physiological comfort factors, with a mean value of 3.46 followed by "Partial pain" (mean=3.23), and finally "Seated posture" with a mean value of 3.12, as shown in Table 4.23. Muscle fatigue is the highest priority for comfort design in Chinese Ming seat furniture according to Chinese Ming furniture designers and manufacturers, suggesting that researcher need to pay more attention to Muscle fatigue.

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Table 4.23 : Descriptive Analysis Data on the Priority of Physiological Comfort Factors in the Chinese Ming Furniture (Questionnaire II)

Items	Mean Value	SD	N
Muscle fatigue	3.46	1.29	52
Partial pain	3.23	1.198	52
Seated posture	3.12	1.06	52

From the results of the Phase II survey, Chinese Ming furniture designers and manufacturers considered that psychological comfort factors prioritised "Emotion" with a mean value of 3.35 followed by "Mental" with a mean value of 3.1, as referring to Table 4.24.

Table 4.24 : Descriptive Analysis Data on the Priority of Psychological Comfort Factors in the Chinese Ming Furniture (Questionnaire II)

Items	Mean value	SD	N
Emotion	3.35	1.413	52
Mental	3.1	1.034	52

Chinese Ming style wooden seat furniture, "Seat Modelling" has the highest priority in terms of physical comfort factors, with a mean value of 3.37, followed by "Seat Support" with a mean value of 3.33, "Seat adjustment" (mean=3.17), "Material" (mean=3.17), and finally "Breathability" (mean=3.12), referring Table 4.25. Chinese Ming furniture designers and manufacturers believe that "Seat Modelling" has a higher priority among the physical comfort factors. However, "Breathability" was the lowest rated item among the physical comfort factors.

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Table 4.25 : Descriptive Analysis Data on the Priority of Physical Comfort Factors in the Chinese Ming Furniture (Questionnaire II)

Items	Mean Value	SD	N
Seat Modelling	3.37	1.299	52
Seat Support	3.33	1.08	52
Seat adjustment	3.17	1.08	52
Breathability	3.12	1.041	52
Material	3.17	1.024	52

The results show that in the design process of Chinese Ming seat furniture, in terms of environmental comfort factors, "Temperature" is prioritised with a mean value of 3.48 followed by "Vibration" (mean=3.29), and lastly, "Noise" and "Illumination" with a mean value of 3.19, as shown in Table 4.26.

Table 4.26 : Descriptive Analysis Data on the Priority of Environment Comfort Factors in the Chinese Ming Furniture (Questionnaire II)

Items	Mean Value	SD	N
Noise	3.19	1.049	52
Temperature	3.48	1.244	52
Vibration	3.29	1.177	52
Illumination	3.19	1.011	52

4.8.6 Descriptive Analysis Data of Easy-to-Use Domain (Questionnaire II)

The researcher explored the preference of Chinese Ming style wooden seat in the easy-to-use domain section through two sets of data, term of easy-to-use and common attributes. The author used a 5-point preference scale to evaluate the Chinese Ming style wooden chairs and showed the Mean value and Standard deviation trends in the figure.

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Through the survey, Chinese Ming style seat furniture prioritises "Satisfaction" in terms of easy-to-use, with a mean value of 3.54, followed by "Effectiveness" (mean=3.38), and finally "Efficiency" and "Context of use", with a mean value of 3.19. Reference is made to Table 4.27. Satisfaction becomes the most prioritised item for Chinese Ming furniture designers and manufacturers.

Table 4.27 : Descriptive Analysis Data on the Priority of Terms of Easy-to-Use in the Chinese Ming Furniture (Questionnaire II)

Items	Mean Value	SD	N
Effectiveness	3.38	1.14	52
Efficiency	3.19	1.03	52
Satisfaction	3.54	1.29	52
Context of use	3.19	1.121	52

From Table 4.28, among the common attributes of easy-to-use Chinese Ming seat furniture, "Satisfaction" was prioritised with a mean value of 3.48 followed by "Easy to learn (or easy to read)" (mean=3.25), "Easy to remember" (mean=3.17), "Fewer mistakes" (mean=3.13), and finally, "Efficient", with a mean value of 3.12.

Table 4.28 : Descriptive Analysis Data on the Priority of Common Attributes in the Chinese Ming Furniture (Questionnaire II)

Items	Mean Value	SD	N
Easy to learn (or easy to read)	3.25	1.1	52
Efficient	3.12	0.922	52
Easy to remember	3.17	1.043	52
Fewer mistakes	3.13	1.067	52
Satisfaction	3.48	1.26	

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4.8.7 Descriptive Analysis Data of Productivity and Performance Domain (Questionnaire II)

The researcher examined the preference for Chinese Ming style wooden seat in the productivity/performance domain section. The author used a 5-point preference scale to rate the Chinese Ming style wooden seat and show the trend of Mean value and Standard deviation in the graph.

From the survey, it can be seen from the above table that in terms of productivity factors of Chinese Ming style seat furniture, priority is given to "Typing net speed (number of correct words/min)" with a mean value of 3.21 followed by "Accuracy (Percentage correct)" with a mean value of 3.17 as referring to the Table 4.29.

Table 4.29 : Descriptive Analysis Data on the Priority of Productivity Factors in the Chinese Ming Furniture (Questionnaire II)

Items	Mean Value	SD	N
Typing net speed (number of correct words/min)	3.21	1.273	52
Accuracy (Percentage correct)	3.17	0.985	52

4.9 Comparative Analysis of User and Designer or Manufacturer Research

4.9.1 Overall Comparative Analysis

The author used ANOVA to investigate the relationship between different roles and the five items of "Chair form", "Senses application", "Externally influenced", "Modelling data", and "Aesthetic elements" respectively. External influenced", "Modelling data", and "Aesthetic elements". The results show that different role group samples with "Chair form", "Senses application", "Extern influenced", "Modelling data", "Aesthetic elements" did not show any significant difference ($p<0.05$), so there

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is no significant difference between the samples of different role groups in these five items, referring Table 4.30.

Table 4.30 : Overall Analysis of Variance

	User (n=305)		Designer (n=52)		F	p
	M	SD	M	SD		
Chair form	3.09	0.91	3.21	0.89	0.847	0.358
Senses application	3.48	0.79	3.26	0.89	3.378	0.067
External influenced	3.13	0.93	3.03	0.93	0.438	0.509
Modelling data	3.15	0.90	3.19	0.83	0.062	0.804
Aesthetic elements	3.36	0.82	3.16	0.82	2.534	0.112

4.9.2 Analysis of Sub Comparisons

The authors used ANOVA to investigate whether there is a difference in the perception of different chair forms by different roles, and the results showed that the samples of different role groups showed a significant difference at the 0.05 level for “Chair form 2” ($F=4.161$, $p=0.042<0.05$). Specifically, by comparing the differences in the mean values, relatively speaking, designers believe that chair form 2 has a higher degree of agreement with Chinese Ming style furniture, as shown in Table 4.31.

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Table 4.31 : Analysis of Variance (ANOVA) for Different Chair Forms

	User (n=305)		Designer (n=52)		F	p
	M	SD	M	SD		
Chair form1	3.27	1.347	3.5	1.336	1.349	0.246
Chair form2	3.01	1.096	3.35	1.118	4.161	0.042
Chair form3	3.13	1.138	3.15	1.211	0.023	0.88
Chair form4	3.08	1.096	3	1.048	0.252	0.616
Chair form5	2.99	1.138	3.21	1.035	1.774	0.184
Chair form6	3.02	1.119	3.19	1.155	1.087	0.298
Chair form7	3.13	1.175	3.19	1.189	0.107	0.743
Chair form8	3.08	1.163	3.12	1.182	0.037	0.849

The researcher used ANOVA to study whether there is a difference between different roles on senses application in the prioritisation choice of Chinese Ming style furniture, and the results showed that the samples of different role groups for different perceptions did not present a significant difference ($p<0.05$), so there is no difference between different roles on sense application in the prioritisation choice of Chinese Ming style furniture as refer to the Table 4.32.

Table 4.32 : Sense Application ANOVA Table

	User (n=305)		Designer (n=52)		F	p
	M	SD	M	SD		
Smell	3.41	1.035	3.19	1.221	1.913	0.168
See	3.46	0.98	3.27	1.087	1.67	0.197
Hear	3.39	1.086	3.17	1.061	1.734	0.189
Taste	3.43	1.058	3.15	1.109	2.901	0.089
Touch	3.77	1.148	3.54	1.393	1.653	0.199
Emotion	3.44	0.975	3.23	0.877	2.089	0.149

As shown in Table 4.33, by using ANOVA to investigate whether there is any difference in the priority selection of different roles in the external influence of Chinese Ming style furniture, the results show that different role group samples do not

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present significant differences ($p<0.05$), so there is no difference in the priority selection of different roles for external influences in Chinese Ming style furniture.

Table 4.33 : ANOVA Table for External Influence

	User (n=305)		Designer (n=52)		F	p
	M	SD	M	SD		
Symbol	3.3	1.312	3.23	1.436	0.104	0.748
Pattern	3.07	1.119	2.96	1.047	0.391	0.532
Commonality	3.06	1.109	3.02	1.038	0.068	0.794
Theme	3.1	1.141	2.85	1.258	2.16	0.143
Manufacturing process	3.09	1.161	2.96	1.154	0.561	0.455
Value	3.14	1.151	3.12	1.199	0.022	0.883
Language	3.12	1.138	3.1	0.995	0.017	0.896

The researcher used ANOVA to examine whether there is a difference in the prioritisation of different roles in the selection of modelling data of Chinese Ming style seat furniture, and the results showed that the samples of different role groups did not show significant differences ($p<0.05$) for different modelling data, so there is no difference in the prioritisation of different roles in the selection of modelling data of Chinese Ming style seat furniture, refer to Table 4.34. While as shown in Table 4.35, when the researcher used ANOVA to explore whether there were differences in the aesthetic elements prioritised by different characters in choosing Chinese Ming style furniture, the results showed that the samples of different character groups showed significant differences ($p<0.05$) in the values of “Balance” and “Material”. Specific comparisons show that different role group samples show a significant difference of 0.05 ($F=4.837$, $p=0.029<0.05$) for “Balance”, specifically by comparing the differences in the mean values, it can be seen: Relatively speaking, users prioritise

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"Balance" more than designers; "Material" shows a significant difference of 0.05 (F=5.377, p=0.021<0.05) in comparison with the samples of different role groups. The difference in mean values shows that users prioritise "Material" more than designers in relative terms.

Table 4.34 : ANOVA Table for Modelling Data

	User (n=305)		Designer (n=52)		F	p
	M	SD	M	SD		
Length	3.11	1.187	3.25	0.947	0.639	0.425
Width	3.39	1.38	3.5	1.336	0.267	0.605
Hight	3.06	1.121	3.04	1.154	0.01	0.919
Backrest height	3.14	1.107	3.1	0.846	0.067	0.796
Backrest curvature	3.13	1.142	3.21	1.194	0.217	0.642
Armrest height	3.23	1.063	3.08	1.218	0.839	0.36
Seat surface material	3.12	1.112	3.17	0.901	0.115	0.735
Seat height ratio	3.07	1.103	3.1	1.089	0.027	0.869
Leg height	3.15	1.099	3.25	1.1	0.362	0.548

Table 4.35 : ANOVA Table for Aesthetic Elements

	User (n=305)		Designer (n=52)		F	p
	M	SD	M	SD		
Form	3.32	1.053	3.27	1.3	0.114	0.736
Colour	3.26	1.026	3.12	0.878	0.865	0.353
Texture	3.32	1.068	3.27	0.992	0.122	0.727
Balance	3.33	0.969	3	1.188	4.837	0.029
Material	3.62	1.189	3.21	1.073	5.377	0.021
Functionality	3.3	1.016	3.12	0.983	1.454	0.229

For the items with no significant differences, considering the higher degree of professionalism of the designers and manufacturers, the data from Questionnaire II will be used as the main analytical data in the later analysis, while for the chair forms and aesthetic elements with significant differences, the researcher will take the average

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value of all the data as the analytical data, as shown in Tables 4.36 and Table 4.37.

Table 4.36 : Descriptive Analysis Data on the Priority of Chair Form in the Chinese Ming Furniture (Overall)

Items	Mean Value	SD	N
Chair form1	3.3	1.346	357
Chair form2	3.06	1.104	357
Chair form3	3.13	1.148	357
Chair form4	3.07	1.088	357
Chair form5	3.02	1.125	357
Chair form6	3.04	1.125	357
Chair form7	3.14	1.175	357
Chair form8	3.09	1.164	357

The researcher can see from the survey that Chair form 1 has the highest priority (mean=3.3, SD=1.346) followed by Chair form 7 and Chair form 3, with mean values of 3.14 and 3.13; the others, in order of priority, are Chair form 8, Chair form 4, Chair form 2, Chair form 6, and Chair form 5, with mean values of 3.09, 3.07, 3.06, 3.04, and 3.02, respectively, as shown in Table 4.36. Chair form5 is considered the lowest priority item in Chinese Ming furniture as chair forms. The researcher can see from the survey that Material has the highest priority (mean=3.56, SD=1.18) followed by Form and Texture, with a mean value of 3.32; the others are Balance, Functionality, and Colour in that order, with mean values of 3.28, 3.27, and 3.24, respectively, and refer to Table 4.37. Colour is the lowest priority item in Chinese Ming furniture as aesthetic elements.

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Table 4.37 : Descriptive Analysis Data on the Priority of Aesthetic Elements in the Chinese Ming Furniture (Overall)

Items	Mean Value	SD	N
Form	3.32	1.09	357
Colour	3.24	1.006	357
Texture	3.32	1.056	357
Balance	3.28	1.009	357
Material	3.56	1.18	357
Functionality	3.27	1.012	357

4.10 Summary

This chapter presented a comprehensive analysis of survey data from 305 users and 52 designers/manufacturers of Chinese Ming-style wooden seat furniture, aligned with the methodological framework outlined in Chapter 3. The findings were synthesised to address the study's objectives, revealing critical insights into ergonomic priorities, cultural influences, and practical design implications. Below is a structured conclusion of the analysis:

Key Findings from Objective 1 - The characteristics of ergonomic design aspects for Chinese Ming style wooden seat furniture include five ergonomic domains and general ergonomic, such as Aesthetic, Safety, and Comfort, along with their sub-items, including "Senses Application" and "Risk Factors," all derived from a literature review and theoretical research.

Key Findings from Objective 2 (Questionnaire I) - The user survey highlighted those middle-aged adults (35–44 years) in East China constituted the largest demographic group, with a significant proportion working in finance (19.67%) and earning between CNY10,000–14,999 monthly (32.46%). Ergonomic priorities were dominated by

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tactile and visual aesthetics, with Material (mean = 3.62) and Touch (mean = 3.77) ranking highest in the Aesthetic Domain. Safety concerns centred on Prolonged Positions (mean = 3.38) and Seat Depth (mean = 3.55), reflecting risks associated with prolonged use. Comfort preferences emphasised physiological factors like Muscle Fatigue (mean = 3.46) and environmental factors such as Temperature (mean = 3.48). High Cronbach's Alpha scores ($\alpha > 0.7$) and a KMO value of 0.925 confirmed the reliability and validity of these results.

Key Findings from Objective 2 (Questionnaire II) - Designers and manufacturers, predominantly middle-aged (36.54% aged 35–44) with expertise in industrial design (59.62%), prioritised symbolic and functional elements. In the Aesthetic Domain, Symbol (mean = 3.23) and Width (mean = 3.5) were emphasised to align with cultural motifs and spatial adaptability. Safety priorities included Redesigned Tools (mean = 3.58) and addressing Musculoskeletal Disorders (mean = 3.46), while productivity-focused designers highlighted Typing Speed (mean = 3.21) for efficiency. These results underscored a professional focus on hazard mitigation and functional performance.

Comparative Analysis: Users vs. Designers - While both groups shared priorities such as Material (users: 3.62; designers: 3.21) and Prolonged Positions (3.38 for both), key divergences emerged. Users valued Balance (mean = 3.32) significantly more than designers (mean = 3.0; $p = 0.029$), reflecting differing aesthetic philosophies. Designers prioritised Seat Depth (mean = 3.55) over users' focus on Seat Height (mean = 3.12), indicating a gap in safety perceptions. These contrasts highlight the need for collaborative design processes that bridge user preferences and professional expertise.

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Limitations and Future Research - The study's geographic bias (44.92% respondents from East China) and underrepresentation of rural or younger demographics limit generalisability. Future research should explore cross-regional preferences (e.g., Northwest vs. Coastal China) and investigate sustainability practices in Ming-style furniture production.

Final Conclusion - Ming-style seating furniture embodies a fusion of cultural heritage and ergonomic functionality. By aligning empirical data with cultural and spatial contexts, this study provides a holistic framework for designing furniture that honours tradition while addressing contemporary needs. The results underscore the importance of balancing user-centric ergonomics design elements to meet evolving consumer demands.

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CHAPTER 5

DEVELOPMENT OF NEW FRAMEWORK

5.1 Introduction

The chapter discusses the finding based on research question 1 and research question 2 followed by the development and explain the process of a new framework namely Ergonomic Design Framework (EDF). The framework becomes a guideline for furniture designer during the design and development of a new Chinese Ming style wooden seat furniture toward compatibility and adaptability. At the end of this chapter the framework is tested through a two-step validation.

5.2 Discussion of Finding

5.2.1 Discussion for Objective 1: The Characteristics of Ergonomic Design Aspects for Chinese Ming Style Wooden Seat Furniture

The first research question, which is the importance of ergonomics, was obtained by the researcher through an exhaustive survey of the literature review that general ergonomic and five (5) specific ergonomic domains such as aesthetics, safety, comfort, easy-to-use, and productivity and performance are all great importance to the Chinese Ming style wooden seat furniture.

a) First, aesthetics has become a dominant factor in product selection by users. Designs that do not come to consider aesthetics may be functionally inadequate (Reich, 1993). Design principles, on the other hand, are guidelines for integrating all design aspects into a perfect whole (Liu, 2022). These aesthetic compositional processes need to be represented through the human senses (Korsmeyer, 2017). In general, the sensory system consists of five components - touch, see, smell, taste and hear. However, it is also important to note that emotions are also an important part of the senses (Roy,

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2018). External factors that influence the design process include pattern, themes, values, commonality, manufacturing process, symbol, and language (Bumgardner, & Nicholls, 2020). In order to facilitate quantitative comparison, the design parameters of seating furniture can be distinguished as: the height of the headrest, the shape of the headrest, the shape curve of the backrest, the scale of the backrest, the shape of the armrests, the height of the seat surface, the dimensions of the seat surface, the shape of the seat surface, etc. (Jiayi, 2022). There are many aesthetic elements to be considered in the process of product design and manufacturing, mainly including form, colour, texture, balance, material, functionality (Song, 2018).

b) Secondly, safety is crucial in the implementation of ergonomics. Ergonomic safety mainly considers the risk factors that workers are exposed to during operation (Andersen, 2004; Qureshi, 2019). Factors affecting ergonomic safety can lead to operator injuries, and the type of injury caused, as well as its severity, depends on the type of risk factor (Pramchoo, 2020). Therefore, it is important to identify potential ergonomic safety problems in the workplace and to be able to improve and repair them (Giangrego, 1986). For the humane design of sitting furniture need to consider the comfort and safety of each part (Zhu, 2015)

c) Thirdly, there are more factors affecting comfort, and according to the research content of related scholars, the influencing factors are mainly divided into psychological, physiological, physical and environment aspects (Kolich, 2004; Warska, 2021).

d) Fourthly, easy-to-use design aims to solve the problem of whether the interaction between the product and the user is harmonious and comfortable, and whether the product can achieve the degree of user satisfaction (Xia, 2017). Easy-to-use mainly includes effectiveness, efficiency, satisfaction, context of use. Therefore, easy to read, easy to operation, and satisfaction during the operation process are the keys to easy-to-use design (Wenkui, 2007)

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e) Fifthly, good design makes people safer and more comfortable in work or use, the goal is to improve people's work efficiency (Leamon, 1987). The primary avenue of verification for productivity/performance is typing speed and accuracy (Baltezarević, 2020).

f) Finally, general ergonomics usually refers to the physical elements of ergonomics, which include human posture, product dimensions, product handling, and user movement (Fan, 2021)

The description of each element in each domain obtained through the survey is shown in Table 5.1. Since the exhaustive literature review has included all the details that need to be investigated, the research questions are addressed only through the literature review. Table 5.1 provides a comprehensive taxonomy of ergonomic domains, such as Aesthetic, Safety, and Comfort, along with their sub-items, including "Senses Application" and "Risk Factors," all derived from a literature review and theoretical research. This taxonomy serves as a foundational framework that systematically categorises all potential ergonomic elements relevant to Chinese Ming-style furniture design. In Chapter 4, survey results present empirical validation by showcasing user and designer priorities, as well as conducting reliability and validity tests and ANOVA comparisons to identify which items from Table 5.0 are statistically significant or prioritised in practice. For instance, within the Aesthetic Domain, survey results (Tables 4.6–4.9) indicate that "Material" and "Touch" are highly prioritised, while the Safety Domain highlights critical concerns such as "Prolonged Positions" and "Musculoskeletal Disorders" (Tables 4.14–4.15). Table 5.0 is also part of the technique used to generate domains and keywords for the framework, acting as the theoretical basis, whereas Chapter 4's findings provide the empirical validation needed to refine and prioritise these domains. The resulting framework, is constructed by

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combining the structured taxonomy from Table 5.1 with the prioritised results from Chapter 4, ensuring a cohesive alignment between theoretical insights and practical user and designer preferences.

Table 5.1 : The Ergonomic Domain of Chinese Ming Style Wooden Seat Furniture

Ergonomics Domain	Item	Description
General Ergonomic Domain		
Physical Ergonomic	Human Postures	Includes standing, sitting, lying and other forms (Reis et al., 2012)
	Product Dimension	Length, width, height, weight, and other physical parameters of the product
	Product Handling	Actions and steps that the user needs to perform (Shin et al., 2015)
	User Movement	Physical activities involved in the use of the product by the user
Aesthetic Domain		
Senses Application	Smell	Whereby odours are perceived by long-distance perception of chemical stimuli.
	See	Subjective sensation obtained through the peripheral sensory organs (eyes) of the visual system
	Hear	The external sound stimulation effect on the auditory organs and the resulting sensation
	Taste	Basic taste sensations are sweet, sour, bitter and salty
	Touch	The skin sensation caused by the stimulus gently touching the skin
	Emotion	Subjective human experiences that are psychological responses to external stimuli
External Influence	Symbol	A mark used to represent some abstract concept or entity
	Pattern	A repeatable solution to a particular problem
	Commonality	A shared characteristic or purpose between two or more things
	Theme	The central idea or main topic of a conversation, book, film, etc.
	Manufacturing process	An ordered series of operations or steps that transform raw materials into a final product
	Value	The importance, usefulness
	Language	Expression for human communication

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Table 5.1 : Continued

Modelling Data	Length	Length of the seat surface
	Width	Width of the seat
	Height	Vertical distance from the seat surface to the floor
	Backrest height	Vertical distance from the seat surface to the top of the seat back
	Backrest curvature	Degree of curvature of the surface of the seat back
	Armrest height	Vertical distance from the seat surface to the top of the armrest
	Seat surface material	Covering or construction material of the seat surface
	Seat height ratio	Proportion of seat height to human body size or reference size
	Leg height	Vertical distance between the seat leg and the seat body from the ground
Aesthetic Elements	Form	Shape, appearance, or structure of an object
	Colour	Visual property of an object's surface that reflects or emits light of a specific wavelength
	Texture	Tactile or textural characteristics of an object's surface
	Balance	Visual or physical stability of an object
	Material	Substance or raw material used to make a product
	Functionality	Ability or characteristic of a product or system to fulfil a specific need
Safety Domain		
Risk Factors	Repetitiveness	Main causes of cumulative injuries and stress at work
	Required force	The strength of the force required by the operator to complete a task
	Prolonged positions	Prolonged static work or maintaining uncomfortable positions for long periods
	Inadequate tools	The operator relies on the machine or equipment to do the job
Common Ergonomic Injuries	Musculoskeletal disorders (MSDs)	Affect the operator's muscles, ligaments, bones, and joints
	Carpal tunnel syndrome	symptoms of numbness and pain in the hand or arm area
	Rotator cuff injuries	have an acute injury caused by excessive force
	Lower back injuries	can be excessive weight bearing or sedentary lifestyle (Siregar, 2023)

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Table 5.1 : Continued

	Redesigned tools and adjustable equipment	Redesign the problems of chairs, desks, monitors, and other equipment
Discovering Ergonomic Hazards and Fixing	Work close to the body	Certain habits or postures in the workplace may cause less damage
	Alternate postures and motions	A long period of time can cause muscle tension in the body, which may result in cumulative damage
	Keep the workspace clean and clear	help to reduce employees'stress and enhance work efficiency
Safety Items	Seat height	vertical distance from the seat surface to the ground
	Seat Width	width of the seat surface at the front edge of the seat
	Seat Depth	Distance from the midpoint of the front edge of the seat to the intersection of the back and the seat surface (Han, 2016)
	Seat Curvature	Degree of concavity or convexity of the seat surface
	Seat Inclination and Backrest Inclination	Angle between the seat surface and the horizontal plane
	Comfort Domain	
Physiological Comfort Factors	Muscle fatigue	A feeling of fatigue that occurs after prolonged activity or overuse of muscles
	Partial pain	Painful sensation that occurs in one part of the body
	Seated posture	Posture and position of the body when people are sitting
Psychological Comfort Factors	Emotion	People's feelings and emotional responses
	Mental	Processes such as thinking, perceiving and emotions of people
	Seat Modelling	Help to optimise the structure and comfort of a seat
	Seat Support	Degree to which the seat supports all parts of the body
Physical Comfort Factors	Seat adjustment	Seat can be adjusted in terms of height, angle, and tilt according to the user's needs
	Breathability	Ability of a seating material to allow air to circulate
	Material	Variety of substances used in the manufacture of seats
Environment Comfort Factors	Noise	Sound that may be produced by the seat during use
	Temperature	Feeling of warmth

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Table 5.1 : Continued

	Vibration	Sensation of vibration that a seat may experience during use
	Illumination	Light conditions provided around the seat or by the seat itself
Easy to Use Domain		
Terms of Easy-to-Use	Effectiveness	The correctness and completeness of the user's fulfilment of specified goals
	Efficiency	The user's commitment to the correct and complete completion of the specified goals
	Satisfaction	The pleasure of using the product and the attitude of recognition
	Context of use	The user, the work, the device, and the physical and social environment in which the product is used
Common Attributes	Easy to learn (or easy to read)	Something or information is easy to understand and learn
	Efficient	Ability to do something with the least number of resources
	Easy to remember	Something or information is easy to remember
	Fewer mistakes	Doing something with fewer errors
	Satisfaction	Degree of satisfaction with something or a service
Productivity and Performance Domain		
Productivity Factors	Typing net speed (number of correct words/min)	Number of words that a user can accurately type in each amount of time
	Accuracy (Percentage correct)	Percentage of words or characters that are typed correctly by the user during the typing process

(Source by author)

5.2.2 Discussion for Objective 2: Ergonomic Features that Enhance the Wooden Seat Furniture in the Chinese Ming Style

5.2.2.1 Explanation of Grouping Methodology and the 25.0 Percent Threshold

The categorisation of ergonomic domains such as aesthetics and safety into two or three priority groups is guided by the 25.0 percent mean-difference threshold, a critical criterion derived from the statistical analysis of survey responses. This threshold serves to minimise ambiguity by providing a clear distinction between high, medium,

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and low-priority items, thereby enabling designers to allocate resources effectively. The methodology behind this approach is detailed below.

Firstly, the principle of the 25.0 percent threshold is foundational to the categorisation process. Its primary purpose is to identify significant gaps between adjacent items in descending mean-value rankings, thereby clarifying which aspects demand focus. The calculation involves determining the total mean difference, which is the sum of all differences between consecutive items within a domain. Each pairwise difference is then expressed as a percentage of the total mean difference. If any single pairwise difference accounts for 25% or more of this total difference, it signifies a substantial divergence that warrants the establishment of a new priority group. For example, in Table 5.2 (Chair Form), the total mean difference is 0.28, with one difference (MD1) contributing 0.16, or 57.0 percent of the total difference. This significant contribution leads to the creation of two distinct groups: Group A (high priority) and Group B (low priority).

Secondly, the method allows for both two-group and three-group classifications based on the significance of the pairwise differences. A two-group division is applied when one pairwise difference exceeds 25.0 percent, indicating a clear hierarchy between high and low-priority items, as seen in the “Chair Form” analysis. Conversely, a three-group division is implemented when two or more differences exceed 25.0 percent, justifying a finer prioritisation into high, medium, and low categories. For instance, in the “General Ergonomics” category shown in Table 5.3, two differences (MD2 at 32.0% and MD3 at 52.0%) both qualify for the three-group classification. As a result, three groups are established, allowing for a more nuanced prioritisation that can guide

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design decisions effectively.

The choice of a 25.0 percent threshold is both practical and statistically justified. It achieves a balance between sensitivity and practicality, addressing the potential pitfalls of over-segmentation and under-segmentation. Lower thresholds, like 10.0 percent, could create too many groups, complicating the design priorities, while higher thresholds, such as 40.0 percent, might overlook meaningful distinctions that could impact user experience. By focusing on items that exhibit gaps of 25.0 percent or greater, designers can concentrate on elements that most significantly affect user satisfaction and overall functionality.

Finally, the implications for framework development are significant. This systematic grouping facilitates clarity in prioritisation, enabling designers to focus their efforts on high-priority items, such as material selection in aesthetics, while also deprioritising low-impact elements that would distract from the primary goals of the design. The adaptability of this threshold further accommodates variability across domains, allowing for stricter groupings in areas such as safety while maintaining flexibility for aesthetics. In summary, the 25.0 percent mean-difference threshold provides a robust, data-driven method to categorise ergonomic elements into actionable priority groups, ensuring that designers align their focus with user needs and cultural authenticity while effectively streamlining the complexity of Ming-style furniture design.

5.2.2.2 Chair Form: Priority of Chinese Ming Style Wooden Seat Furniture

For the Chinese Ming chair forms, there exists a boundary line MD1 between chair

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form 1 and chair form 2 for the descending bar graph with a difference mean value of 57.0 percent. From this it can be obtained that this data set will be categorised into two groups, Group A and Group B. Referring to Table 5.2. The codes MD1–MD7 in Table 5.1 represent statistical gaps ("Mean Differences") between the mean values of prioritised chair forms derived from survey data, not physical components of the Ming Chair itself. These codes quantify the difference in user/designer preferences between consecutive chair forms (e.g., MD1 = 0.16, 57%) to categorise them into priority groups (high, medium, low). For instance, MD1's large gap (57%) highlights Chair Form 1 (Four-headed Official Chair with Armrests) as the highest priority, while smaller gaps (e.g., MD2 = 4%) indicate similar priority among lower-ranked forms. The actual Ming Chair designs (Forms 1–8) are evaluated in the survey, and MD codes act as analytical tools to identify significant preference gaps, ensuring the framework prioritises designs with the most distinct user validation. This method translates empirical data into actionable design priorities, guiding focus on statistically validated preferences. All MDs appearing later in the context are interpreted in the same way. From Figure 5.1, it is obvious that there are two different groups, chair form 1 (Group A) with a mean value of 3.3, and chair form 7, chair form 3, chair form 8, chair form 4, chair form 2, chair form 6, chair form 5, which have a mean value of 3.14 to 3.02 (Group B). According to the grouping in Figure 5.1, it clearly shows the tendency of all the respondents towards the Chinese Ming style wooden chair form. It shows that the respondents think chair form 1 (four-headed Official Chair with Armrests) is the most representative of Ming style seating. However, chair form 7 (Ming-style plain circle chair), chair form 3 (imitation bamboo rose chair), chair form 8 (Tai Shi chair), chair form 4 (circle chair with no grip), chair form 2 (Ming-style lamp-hanging chair), chair form 6 (Ming-style south official chair), and chair form 5 (Yunlong Throne) do

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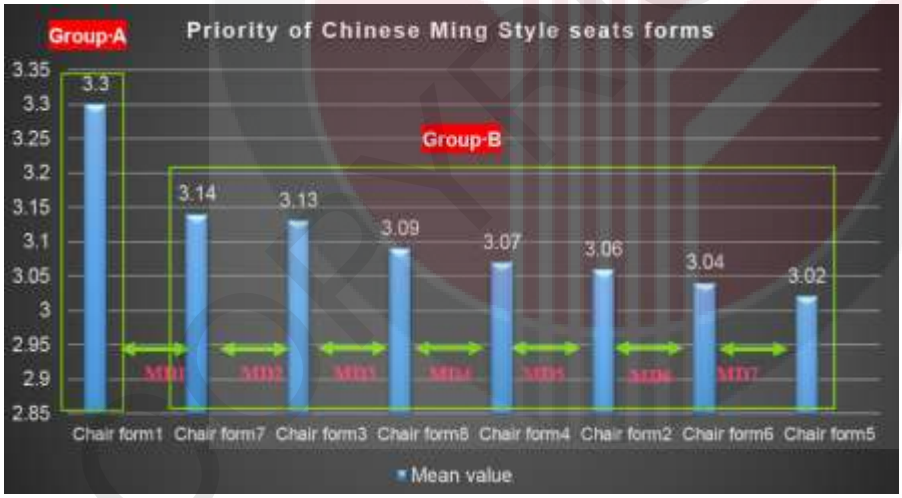
not match the Chinese Ming-style wooden chair in terms of modelling. The researcher will focus on a prototype design of an official chair with armrests in the later validation phase.

Table 5.2 : Grouping of Chinese Ming Style Chair Forms

Items	Mean-value difference	Percentage of mean-value difference
MD1	0.16	57
MD2	0.01	4
MD3	0.04	14
MD4	0.02	7
MD5	0.01	4
MD6	0.02	7
MD7	0.02	7
Total	0.28	100

(Source by author)
*The green colour indicates where the grouping line is located, meaning that the variance here is equal to or more than 25.0 percent.



*MD1 to MD7 represent the Mean value Difference between two items

Figure 5.1 :C hinese Ming Style Chair Form Priority Mean Value Difference Grouping Table
(Source by author)

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a) Elements of Chair Forms - The researcher selected eight Chair Forms of Chinese Ming style chairs in this study. Through the survey of the Chair Forms of Chinese traditional wooden chairs, the priority ratings of the eight Chair Forms were obtained, and the colours from dark to light corresponded to the priorities from high to low, as shown in Figure 5.1. The researcher, based on the mean analysis graphs, interpreted the priorities of the Chair Forms of the Chinese traditional wooden chairs as follows:

   i. High Priority Items in the General ergonomics - According to the analysis in Figure 5.1, the high priority of Chair Form is Chair Form 1 (four-out-of-four official chair with armrests). Through the survey, this Chair Form has the highest priority, and the four-out-of-four official chair with armrests is very representative of Chinese Ming-style wooden seating.

   ii. Low Priority Item in the General ergonomics - However, chair form 7 (Ming-style plain circle chair), chair form 3 (imitation bamboo rose chair), chair form 8 (Tai Shi chair), chair form 4 (bamboo woven circle chair without grip), chair form 2 (Ming-style lamp-hanging chair), chair form 6 (Ming style southern official hat chair), and chair form 5 (Yunlong throne) are not very representative of Chinese Ming style wooden chairs in terms of the modelling is not a good match for Chinese Ming style wooden chairs.

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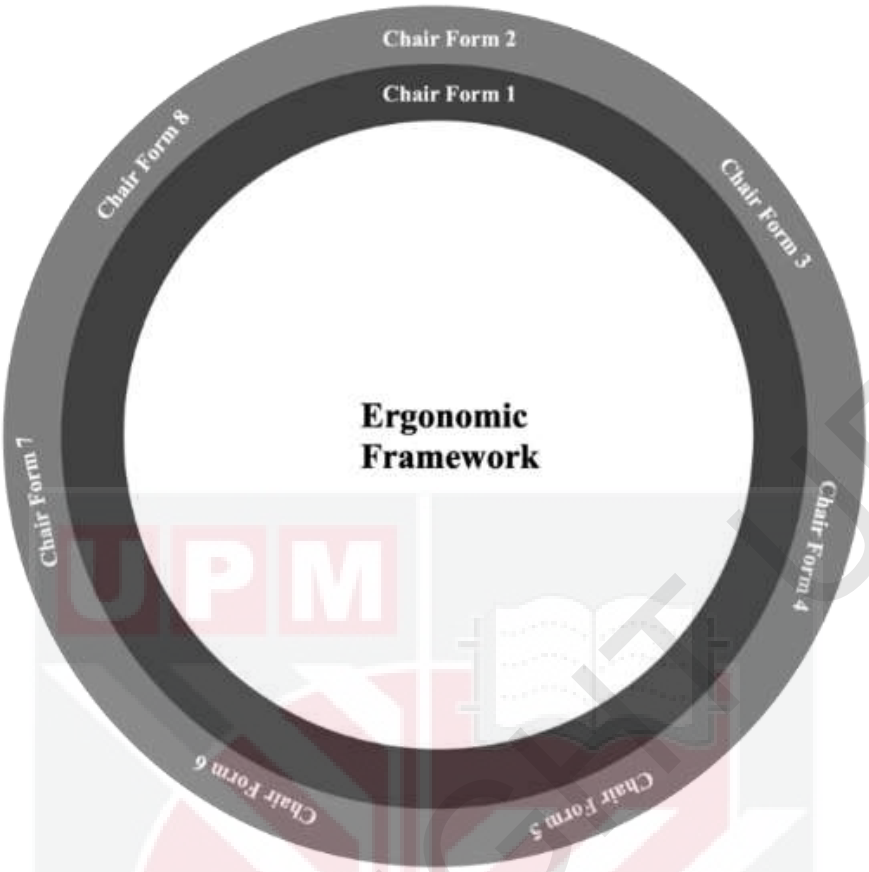

Figure 5.2 : Ergonomics Framework for the Chair Forms
(Source by author)

5.2.2.3 General Ergonomics: Priority of Chinese Ming Style Seat Furniture Ergonomic

In terms of the general ergonomic design of Chinese Ming furniture, there is a descending bar chart boundary line MD2 between Human postures, Product dimension and User movement, with a difference in mean of 32 percent; there is also a descending bar chart boundary line MD3 between User movement and Product handling, with a difference in mean of 52.0 percent. From this, it can be obtained that this data set will be categorised into three groups, Group A, Group B and Group C. Referring to Table 5.3. Three different groups can be clearly seen from Figure 5.3, which are Human postures with a mean value of 3.35 and Product dimension with a

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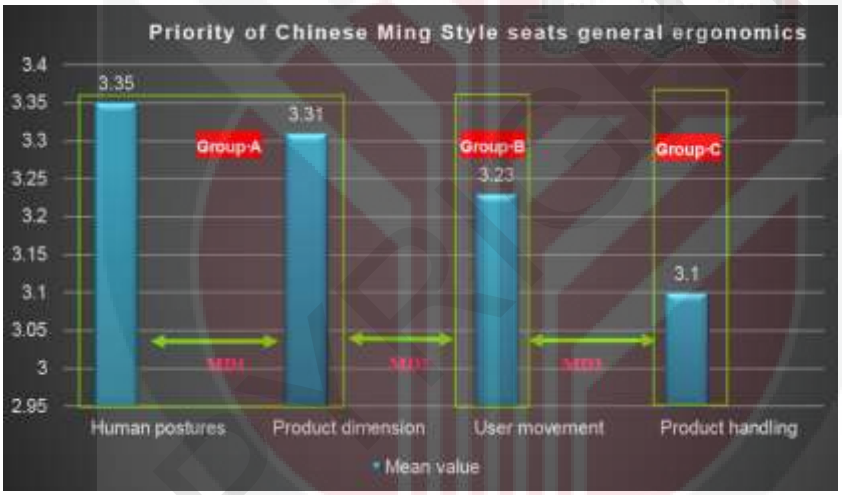
mean value of 3.31 (Group A); and User movement with a mean value of 3.23 (Group B); Product handling with a mean value of 3.1 (Group C).

Table 5.3 : Grouping of Chinese Ming Style Seats General Ergonomics

Items	Mean-value difference	Percentage of mean-value difference
MD1	0.04	16
MD2	0.08	32
MD3	0.13	52
Total	0.25	100

(Source by author)
*The green colour indicates where the grouping line is located, meaning that the variance here is equal to or more than 25.0 percent.



*MD1 to MD3 represent the Mean value difference between two items

Figure 5.3 : Chinese Ming Style Seating General Ergonomics Priority Mean Value Difference Grouping Table
(Source by author)

The grouping of Chinese Ming style seating general ergonomics shows the respondents'preference for Chinese Ming style wooden chair general ergonomics. Respondents considered Human postures and Product dimension to have the highest priority, User movement had a medium priority, and Product handling possessed the lowest priority. This does not mean that Product handling is the least important, but

rather that it plays a lower role than the other options in the study of Chinese Ming style wooden chairs.

a) Elements of General Ergonomics - There is only one part in terms of Chinese Ming furniture General ergonomics design. The researcher obtained four item's priority ratings by investigating the General ergonomics of traditional Chinese wooden seating, with darker to lighter colours corresponding to the corresponding priorities from high to low, as shown in Figure 5.4. The researcher interpreted the priorities of the items of the General ergonomics of traditional Chinese wooden seating based on the mean analysis charts as follows:

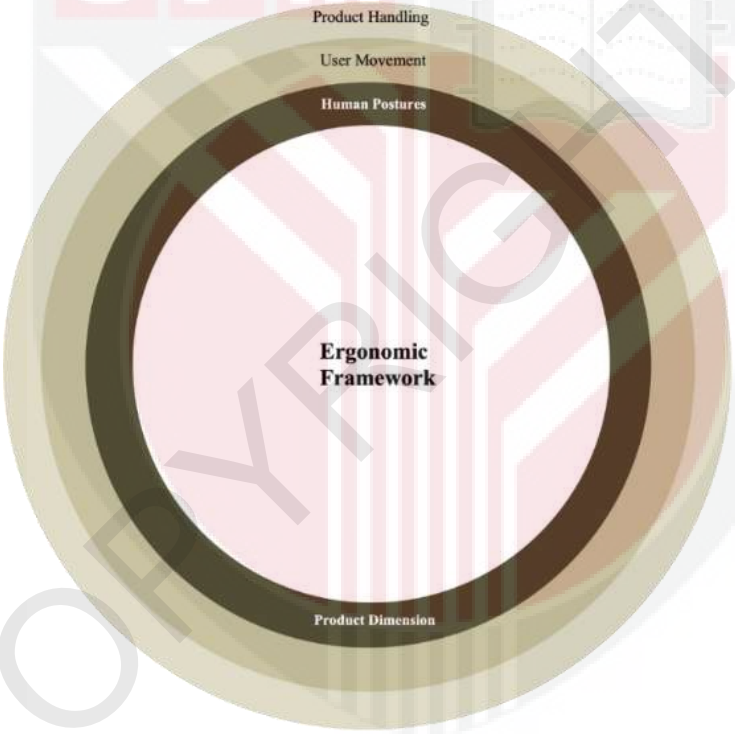


Figure 5.4 : Ergonomics Framework for the General Ergonomic
(Source by author)

a) High Priority Items in the General Ergonomics - According to the analysis in Figure 5.3, the high priority of General ergonomic includes Human postures and Product dimension. These two (2) elements have the highest priority in this domain, which indicates that Human postures and Product dimension are of high importance for the design and use of Chinese Ming style wooden seat.

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The importance of Human postures and Product dimension for the design and use of Chinese Ming style wooden seat is high. Designers should focus on these two (2) items.

ii) Medium Priority Item in the General ergonomics - The medium priority for the General ergonomics domain is only one User movement.

iii) Low Priority Item in the General Ergonomic - Product handling is the lowest priority in this domain. This element may not be the focus of the design, but that does not mean that designers should ignore it completely when designing.

5.2.2.4 Specific Ergonomic: Priority of Chinese Ming Style Seat Furniture

According to Table 5.4, in terms of Chinese Ming Style seating specific ergonomic design process, there exists a descending bar graph boundary line MD2 between Aesthetic, Comfort and Safety, Easy to use with a difference mean of 41.0 percent; There is also a descending bar chart boundary line MD4 between Safety, Easy to use and Productivity and Performance with a mean difference of 37.0 percent. From this, it can be obtained that this data set will be categorised into three (3) groups, Group A, Group B and Group C. Referring to Table 5.4. By Figure 5.5, it is obvious that there are three different groups, which are Aesthetic with a mean value of 3.25 and Comfort with a mean value of 3.21 (Group A); Safety with a mean value of 3.1 and Easy to use with a mean value of 3.08 (Group B); Productivity and Performance with a mean value of 2.98 (Group C).

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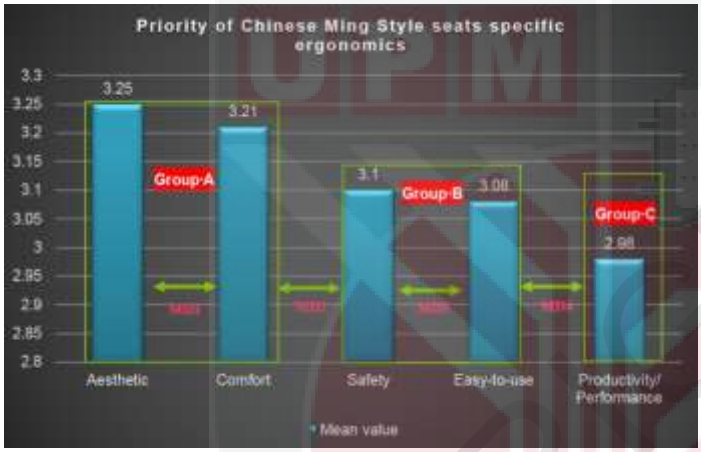
Table 5.4 : Grouping of Chinese Ming Style Seats Specific Ergonomic

Items	Mean-value difference	Percentage of mean-value difference
MD1	0.04	15
MD2	0.11	41
MD3	0.02	7
MD4	0.1	37
Total	0.27	100

(Source by author)
*The green colour indicates where the grouping line is located, meaning that the variance here is equal to or more than 25.0 percent.



*MD1 to MD4 represent the Mean value Difference between two items

Figure 5.5 : Chinese Ming Style Seating Specific Ergonomic Priority Mean Value Difference Grouping Table
(Source by author)

According to the grouping in Figure 5.5, it shows the respondents'preference for the specific ergonomics of Chinese Ming style wooden seats. The figure plainly shows that aesthetics and comfort were given the highest priority, while productivity and performance received the lowest priority. Although productivity is very important in industry, it is weak in this sampling area because this study was conducted on Chinese Ming-style wooden seats, which are valuable furniture and are not mass-produced.

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5.2.2.5 Aesthetic Domain: Priority of Chinese Ming Style Wooden Seat Furniture

The first aspect of the aesthetic domain is sense application, and according to Table 5.5, the boundary line of the descending bar graph is located at MD1 (between touch and see) with a mean difference of 70.0 percent. Therefore, the item of sense application can be categorised into two groups, i.e., Group A and Group B. Figure 5.6 shows Group A as the highest priority group Touch (M=3.54), and the lowest priority group B: See (mean=3.27), Emotion (mean=3.23), Smell (mean=3.19), Hear (mean=3.17), Taste (mean=3.15). The basic judgment of furniture is always obtained through touch, such as the tactile sensation of a chair. Whether it is comfortable or not, or just by checking if the item looks pleasant, how the furniture feels when touched gives people a first impression. However, Group B as the least prioritised option by respondents, the last items of which Smell, Hear, and Taste seem to be less relevant to Chinese Ming-style wooden chairs, even though these options may be crucial in other designs.

Table 5.5 : Grouping of Chinese Ming Style Seats Senses Application

Items	Mean-value difference	Percentage of mean-value difference
MD1	0.27	70
MD2	0.04	10
MD3	0.04	10
MD4	0.02	5
MD5	0.02	5
Total	0.39	100

(Source by author)
*The green colour indicates where the grouping line is located, meaning that the variance here is equal to or more than 25.0 percent

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*MD1 to MD7 represent the Mean value Difference between two items.

Figure 5.6 : Chinese Ming Style Seating Senses Application Priority Mean Value Difference Grouping Table
(Source by author)

The second aspect of the aesthetic domain is external influence, according to Table 5.6, the boundary line of the first descending bar is located at MD1 (between Symbol and Value), with a mean difference of 29.0 percent, and the boundary line of the second descending bar is located at MD6 (between Manufacturing process and Theme), with a mean difference of 29.0 percent. Therefore, the externally influenced items can be categorised into three groups, namely Group A, Group B and Group C. Figure 5.7 shows the highest priority group as Group A: Symbol (mean=3.23), medium priority Group B: Value (mean=3.12), Language (mean=3.1), Commonality (mean=3.02), Pattern (mean=2.96), Manufacturing process (mean=2.96) and the lowest priority group C: Theme (mean=2.85). Symbol occupies a very important position in Chinese traditional culture, so it is also a necessary element in the design stage in the study of Chinese Ming style wooden seat furniture. Therefore, Symbol element became the highest priority element for the respondents during the survey. On the contrary, although Theme is an important part of some cultural and design areas, it is less prioritised than other elements for this study.

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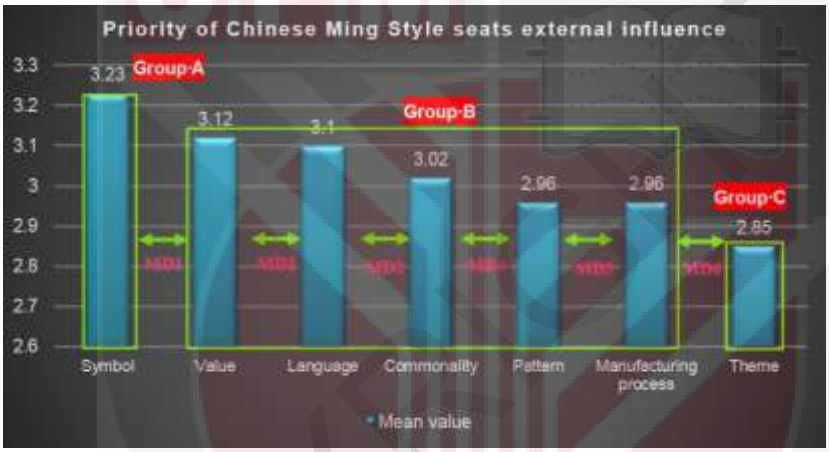
Table 5.6 : Grouping of Chinese Ming Style Seats External Influence

Items	Mean-value difference	Percentage of mean-value difference
MD1	0.11	29
MD2	0.02	5
MD3	0.08	21
MD4	0.06	16
MD5	0	0
MD6	0.11	29
Total	0.38	100

(Source by author)
*The green colour indicates where the grouping line is located, meaning that the variance here is equal to or more than 25. percent



*MD1 to MD6 represent the Mean value Difference between two items

Figure 5.7 :C hinese Ming Style Seats External Influence Priority Mean Value Difference Grouping Table
(Source by author)

As the third aspect of the aesthetic domain is modelling data, based on Table 5.7, the boundary line of the descending bar graph is located at MD1 (between Width and Length) with a mean difference of 54.0 percent. Therefore, the item of the sense application can be divided into two groups, namely Group A and Group B. Figure 5.8 shows Group A as the highest priority group Width (mean=3.5), and the lowest priority group B: Length (mean=3.25), Leg height (mean=3.25), Backrest curvature (mean=3.21), Seat surface material (mean=3.17), Backrest height (mean=3.1), Seat

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height ratio (mean=3.1), Armrest height (mean=3.08), Height (mean=3.04). As can be noticed from Figure 5.8, the width of the seat occupies a large priority, indicating that the width of the chair is a very significant item both for the user and the designer. However, the other six elements are slightly separated, which does not mean that the other elements are unimportant, but just that the priorities are linearly arranged in the same sampling interval. The above results also suggest that researchers should focus on the width of the seat when designing new seats in the validation phase, and of course, other parts need to be designed within the limits of the national standard.

Table 5.7 : Grouping of Chinese Ming Style Seats Modelling Data

Items	Mean-value difference	Percentage of mean-value difference
MD1	0.25	54
MD2	0	0
MD3	0.04	9
MD4	0.04	9
MD5	0.07	15
MD6	0	0
MD7	0.02	4
MD8	0.04	9
Total	0.46	100

(Source by author)
*The green colour indicates where the grouping line is located, meaning that the variance here is equal to or more than 25.0 percent

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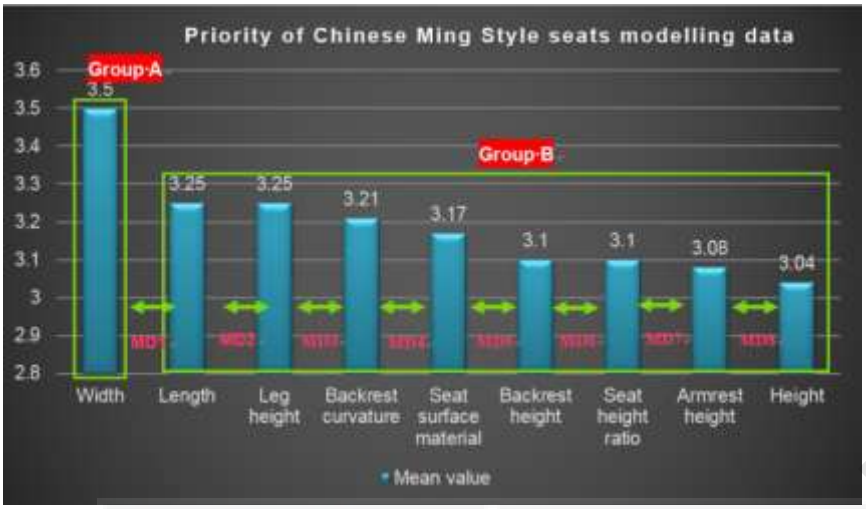

*MD1 to MD8 represent the Mean value Difference between two items

Figure 5.8 : Chinese Ming Style Seats Modelling Data Priority Mean Value Difference Grouping Table
(Source by author)

The last aspect of the aesthetic domain is aesthetic elements, and as can be seen from Table 5.8, the boundary line of the descending bar chart is placed at MD1 (between Material and Form) with a mean difference of 75.0 percent. Therefore, the item of sense application can be organised into two (2) groups, which are Group A and Group B. Figure 5.8 shows Group A as the highest priority group Material (mean=3.56), and the lowest priority group B: Form (mean=3.32), Texture (mean=3.32), Balance (mean=3.28), Functionality (mean=3.27), Colour (mean=3.24). From Figure 5.10, it is obvious that the Material of the Chinese Ming-style wooden chair holds a huge priority, and the material greatly determines the price of the Chinese Ming-style chair. So, the Material of the chair is a critical item for both the user and the designer. On the other hand, the Colour is essential in most of the designs, but since the traditional Chinese wooden furniture is basically based on the valuable mahogany furniture, and the colour is mostly reddish-brown, it has a slightly lower priority than the other items in this study.

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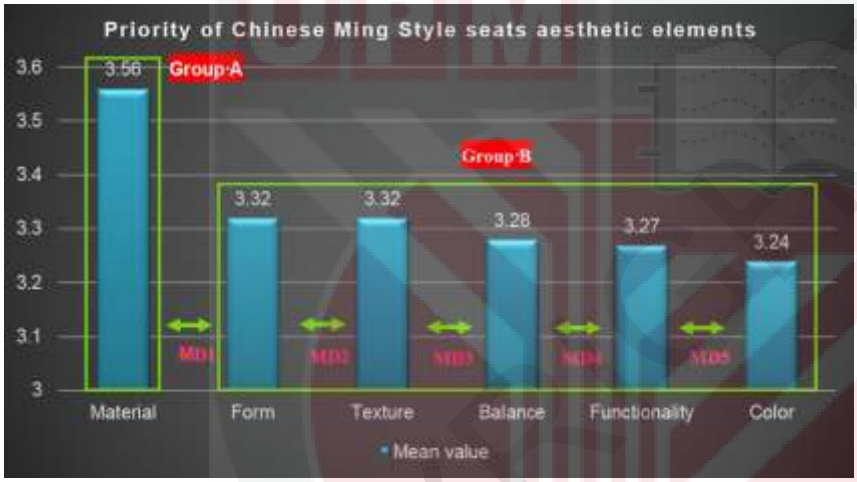
Table 5.8 : Grouping of Chinese Ming Style Seats Aesthetic Elements

Items	Mean-value difference	Percentage of mean-value difference
MD1	0.24	75
MD2	0	0
MD3	0.04	13
MD4	0.01	3
MD5	0.03	9
Total	0.39	100

(Source by author)

*The green colour indicates where the grouping line is located, meaning that the variance here is equal to or more than 25.0 percent



*MD1 to MD5 represent the Mean value Difference between two items.

Figure 5.9 : Chinese Ming Style Seats Aesthetic Elements Priority Mean Value Difference Grouping Table

(Source by author)

a) Elements of Aesthetics - Aesthetics has become a dominant factor in user preference and is a key point in the ergonomic evaluation of Chinese Ming seats. The aesthetic elements in this study are divided into four parts, and the design framework that can provide designers with the ability to manufacture a sufficiently attractive product is obtained by evaluating the priority of each of the four parts of the item, as shown in Figure 5.10. The researcher interprets the priority of all the aesthetic items based on the aesthetics'mean-analysis figure as follows:

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i) High Priority Items in the Aesthetic Domain

Based on the analysis from Figure 5.6 to Figure 5.9, the high priority of aesthetic domain includes Touch in sense application, Symbol in external influence, Width in modelling data, and Material in aesthetic elements, totalling four items. These four elements have the highest priority in this domain, and the design and application of the framework should focus on the above four elements.

ii) Medium Priority Items in the Aesthetic Domain

Medium priority in the Aesthetic domain includes Value, Language, Commonality, Pattern, and Manufacturing process in External Influences, totalling five items. These five elements have medium priority in this domain, and except for External Influences, there is no medium priority group in any of the other three groups.

iii) Low Priority Item in the Aesthetic Domain

See, Emotion, Smell, Hear, Taste in sense application, Theme in external influence, Length, Leg height, Backrest curvature, Seat surface material, Backrest height, Seat height ratio, Armrest height, Height in modelling data, and Form, Texture, Balance, Functionality, Colour in the aesthetic elements, a total of nineteen items. these nineteen items in the field of the lowest priority, but it does not mean that designers should completely ignore the design of the part, just that the focus of the design bias is not the same.

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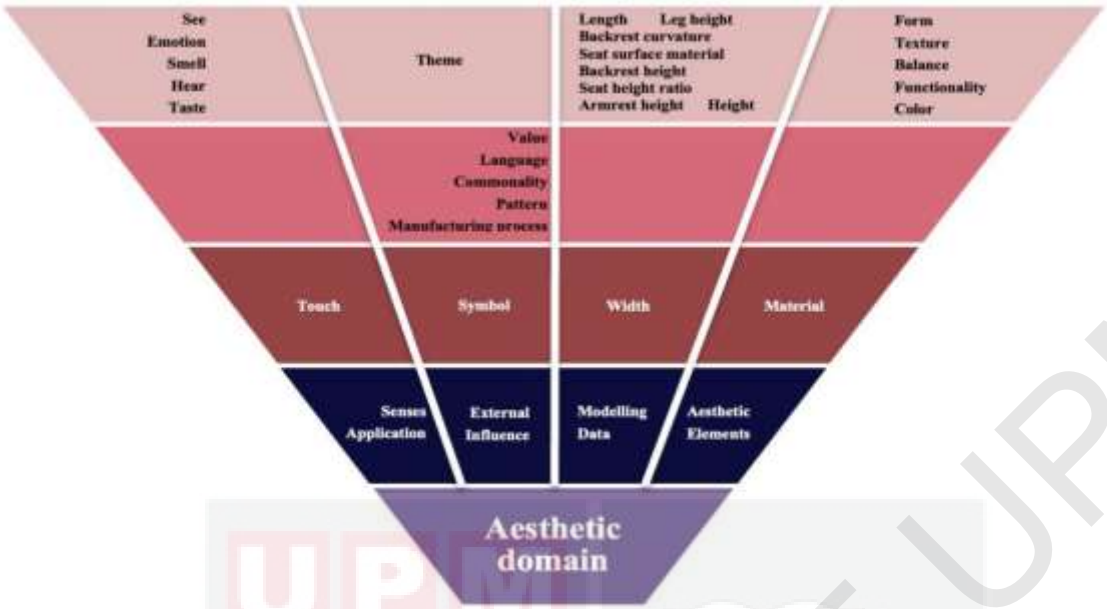

Figure 5.10 : Ergonomics Framework for the Aesthetic Domain
(Source by author)

5.2.2.6 Safety Domain: Priority of Finding out about Chinese Ming Style Seat Safety Domain

On the first aspect of the security domain is risk factors, and as shown in Table 5.9, the boundary line of the first descending bar is in MD1 (between Prolonged positions and Repetitiveness), with a mean difference of 36.0 percent, and the boundary line of the second descending bar is situated in MD2 (between Repetitiveness and Required force), with a mean difference of 64.0 percent. Thus, the item of risk factors can be classified into three groups, namely Group A, Group B, and Group C. Figure 5.10 displays the highest priority group as Group A: Prolonged positions (mean=3.38), the medium priority group B: Repetitiveness (mean=3.29), and the lowest priority group C: Required force (mean=3.13), and Inadequate tools (mean=3.13). The risks posed by Prolonged positions naturally go without saying, especially when using hard wooden seats for long periods of time. Hence, respondents chose Prolonged positions as the highest priority item. On the contrary, required force and Inadequate tools may

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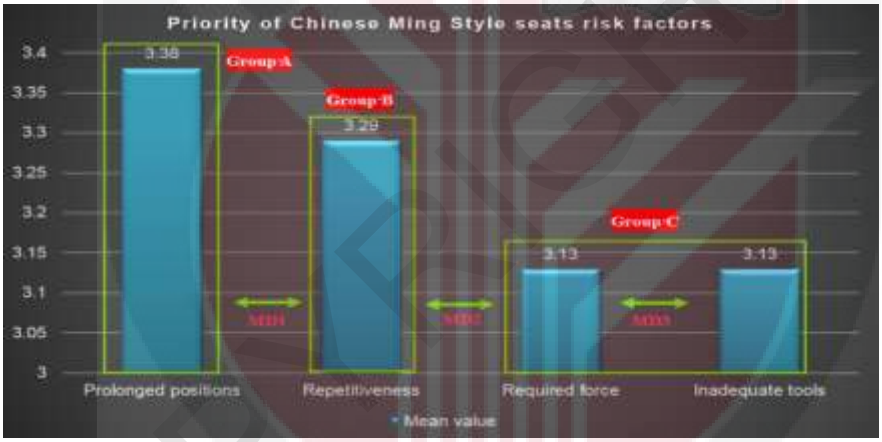
be important safety risks in many office scenarios, but they are involved in very few scenarios in the use of Chinese Ming seats, so they are less prioritised than the other elements for this study.

Table 5.9 : Grouping of Chinese Ming Style Seats Risk Factors

Items	Mean-value difference	Percentage of mean-value difference
MD1	0.09	36
MD2	0.16	64
MD3	0	0
Total	0.25	100

*The green colour indicates where the grouping line is located, meaning that the variance here is equal to or more than 25.0 percent



*MD1 to MD3 represent the Mean value Difference between two items

Figure 5.11 : Chinese Ming Style Seating Risk Factors Priority Mean Value Difference Grouping Table
(Source by author)

The second aspect of the safety domain is common ergonomic injuries, and based on Table 5.10, the boundary line of the first descending bar is located at MD1 (between MSDs and Rotator cuff injuries), with a mean difference of 50.0 percent, and the boundary line of the second descending bar is located at MD3 (between Lower back injuries and Carpal tunnel syndrome), with a mean difference of 36.0 percent.

Therefore, the item of common ergonomic injuries can be categorised into three groups, which are Group A, Group B, and Group C. Figure 5.12 shows the highest priority groups as Group A: Musculoskeletal disorders (MSDs) (mean=3.46), medium priority Group B: Rotator cuff injuries (mean=3.25), Lower back injuries (mean=3.19), and the lowest priority Group C: Carpal tunnel syndrome (mean=3.04). MSDs occupy a high priority as the first most prevalent occupational disease and should be one of the necessary factors in the field of safety, regardless of the scenario and the type of chair used. On the other hand, Carpal tunnel syndrome has a lower priority in the use of Chinese Ming chairs because people often sit upright in their chairs when using traditional Chinese chairs and rarely use their wrists. Only in a few study scenarios or in a very few special scenarios are tables and chairs used together and the wrist is used.

Table 5.10 : Grouping of Chinese Ming Style Seats Common Ergonomic Injuries

Items	Mean-value difference	Percentage of mean-value difference
MD1	0.21	50
MD2	0.06	14
MD3	0.15	36
Total	0.42	100

*The green colour indicates where the grouping line is located, meaning that the variance here is equal to or more than 25.0 percent

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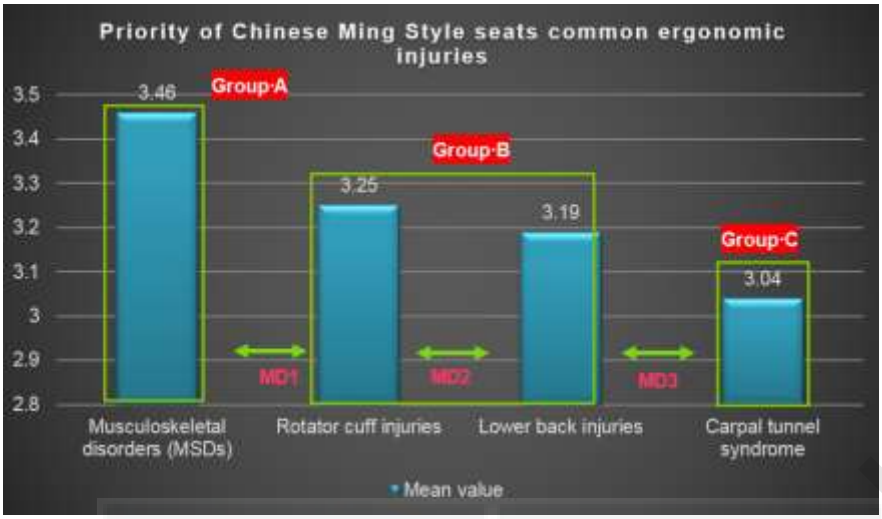

*MD1 to MD3 represent the Mean value Difference between two items

Figure 5.12 : Chinese Ming Style Seating Common Ergonomic Injuries Priority Mean Value Difference Grouping Table
(Source by author)

The third aspect of the safety domain is discovering ergonomic hazards and fixing. According to Table 5.11, there is a boundary line MD1 between Redesigned tools and adjustable equipment and Alternate postures and motions in descending order bar chart with a mean difference of 90.0 percent. Therefore, the item of discovering ergonomic hazards and fixing can be divided into two (2) groups, i.e., Group A and Group B. Figure 5.13 shows Group A as the highest priority group Redesigned tools and adjustable equipment (mean=3.58), and the lowest priority group B: Alternate postures and motions (mean=3.23), Work close to the body (mean=3.21), Keep close to the body (mean=3.21), and Keep the workspace clean and clear (mean=3.19). As can be seen from Figure 5.12, Redesigned tools and adjustable equipment occupied a huge priority, indicating that Redesigned tools and adjustable equipment is a highly critical item for both users and designers. However, the other three elements were slightly separated, which does not mean that the other elements are unimportant, just that the priorities are linearly arranged in the same sampling interval.

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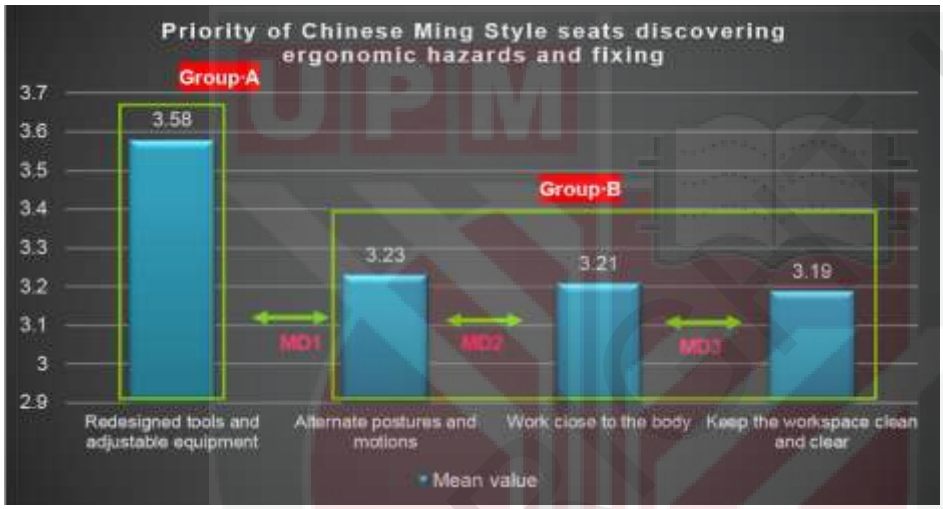
Table 5.11 : Grouping of Chinese Ming Style Seats Discovering Ergonomic Hazards and Fixing

Items	Mean-value difference	Percentage of mean-value difference
MD1	0.35	90
MD2	0.02	5
MD3	0.02	5
Total	0.42	100

*The green colour indicates where the grouping line is located, meaning that the variance here is equal to or more than 25.0 percent.



*MD1 to MD3 represent the Mean value Difference between two items

Figure 5.13 : Chinese Ming Style Seats Discovering Ergonomic Hazards and Fixing Priority Mean Value Difference Grouping Table
(Source by author)

The last aspect of the safety domain is the safety item, and based on Table 5.12, it is known that there is a boundary line MD1 between Seat depth and Seat inclination and backrest inclination in the descending bar graph with a mean difference of 70.0 percent. Therefore, the safety item can be categorised into two groups, Group A and Group B. Figure 5.14 presents Group A as the highest priority group: Seat Depth (mean=3.5), and the lowest priority group B: Seat Inclination and Backrest Inclination (mean=3.19), Seat height (mean=3.12), Seat Curvature (mean=3.1), Seat Width (mean=3.06). As

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can be seen from Figure 5.14, Seat Depth takes a huge priority in the design process and the safety item that can exist, indicating that Seat Depth has a high importance for designers to consider in the design process and is a necessary seat size to be considered in the safety element. Nevertheless, the other four elements are slightly separated, which does not mean that the other elements are insignificant, just that the priorities are arranged linearly in the same sampling interval. The above results also suggest that researcher should focus on Seat Depth when designing the safety of new seats in the validation phase, and certainly, other parts need to be designed within the limits of the national standard.

Table 5.12 : Grouping of Chinese Ming Style Seats Safety Item

Items	Mean-value difference	Percentage of mean-value difference
MD1	0.31	70
MD2	0.07	16
MD3	0.02	5
MD4	0.04	9
Total	0.44	100

*The green colour indicates where the grouping line is located, meaning that the variance here is equal to or more than 25.0 percent

a) Elements of Safety

The elements of safety in this study are divided into four parts, and through the priority evaluation of each item of the four parts, the design emphasis of Chinese Ming-style wooden seats in terms of safety is found to provide a theoretical basis for the Chinese traditional furniture manufacturing industry and designers, as shown in Figure 5.15. Based on the mean value analysis graph of safety, the researcher interpreted the priority of all safety items as follows:

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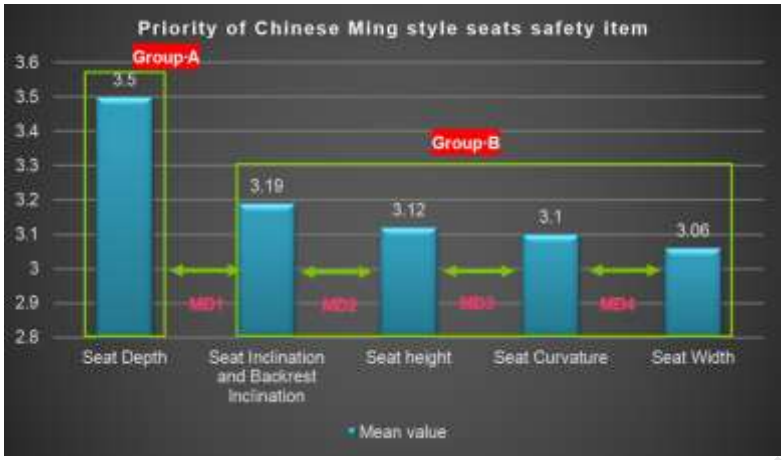

*MD1 to MD4 represent the Mean value Difference between two items.

Figure 5.14 : Chinese Ming Style Seats Safety Item Priority Mean Value Difference Grouping Table

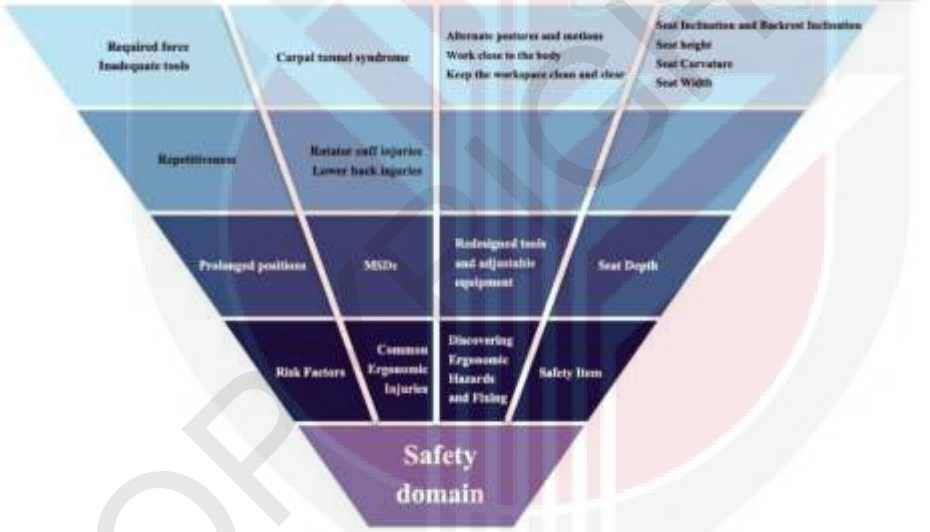

Figure 5.15 : Ergonomics Framework for the Safety Domain

i) High Priority Items in the Safety Domain

The high priority of safety domains based on the analysis of Figure 5.11 to Figure 5.14 include Prolonged positions in risk factors, Musculoskeletal disorders in common ergonomic injuries, Redesigned tools, and adjustable equipment in discovering ergonomic hazards and fixing and Seat Depth in safety item, for a total of four items. These four elements have the highest priority in this domain, and prolonged positions, MSDs in safety item are

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highly harmful to human body parts. The above elements should be emphasised when designing and applying the framework.

ii) Medium Priority Items in the Safety Domain

The medium priority of comfort domain includes Repetitiveness in risk factors and Rotator cuff injuries, Lower back injuries in common ergonomic injuries, a total of three items. These three items are in medium priority of this domain and come from two sections, respectively.

iii) Low Priority Item in the Safety Domain

Required force, Inadequate tools in risk factors, Carpal tunnel syndrome in common ergonomic injuries, Alternate postures, and motions, work close to the body, Keep the workspace clean and clear in discovering ergonomic hazards and fixing, and Seat Inclination and Backrest Inclination， Seat height, Seat Curvature, Seat Width in safety item, a total of 10 items. These 10 items have the lowest priority in the field, and the safety issues to consider when using the product are not only the high priority items, but designers should also attach great importance to the safety of the seat to give the user a peace of mind experience.

5.2.2.7 Comfort Domain: Priority of Finding out about Chinese Ming style Seats Comfort Domain

Aspect one of the Comfort domains is physiological comfort factors, and as shown in Table 5.13, the boundary line of the first descending bar is located at MD1 (between Muscle fatigue and Partial pain), with a mean difference of 68.0 percent, and the second descending bar is located at MD2 (between Partial pain and Seated posture), with a mean difference of 32.0 percent. Therefore, the physiological comfort factors of item can be classified into three groups, namely Group A, Group B and Group C. Figure 5.16 shows the highest priority group as Group A: Muscle fatigue (mean=3.46),

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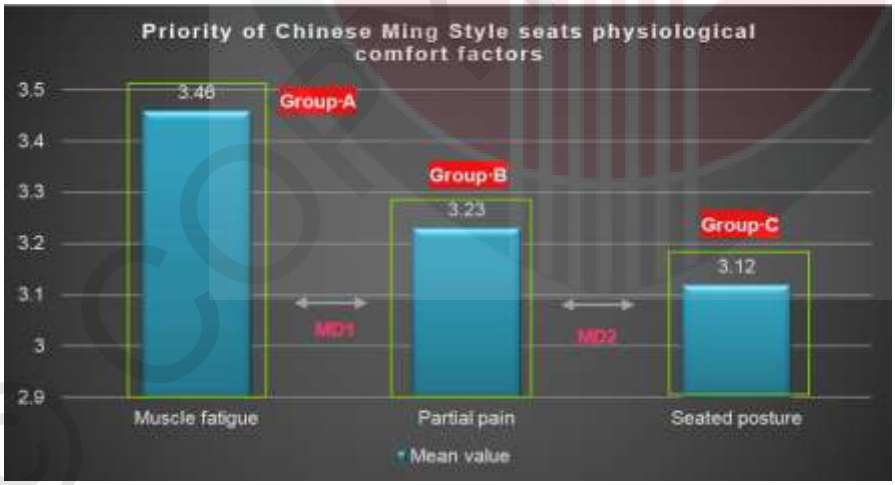
medium priority Group B: Partial pain (mean=3.23) and the lowest priority Group C: Seated posture (mean=3.12). It is well known that Muscle fatigue greatly affects the comfort of seating during prolonged use of seating devices. Therefore, respondents selected Muscle fatigue as the highest priority element. Conversely, Seated posture may be an important influence on comfort in many seating scenarios, but Seated posture is relatively fixed during the use of the Chinese Ming chair, and the wooden structure and dimensions of the traditional Chinese chair limit the emergence of some seated postures, so it was prioritised less than the other elements for this study.

Table 5.13 : Grouping of Chinese Ming style Seats Physiological Comfort Factors

Items	Mean-value difference	Percentage of mean-value difference
MD1	0.23	68
MD2	0.11	32
Total	0.34	100

*The green colon indicates where the grouping line is located, meaning that the variance here is equal to or more than 25.0 percent



*MD1 to MD2 represent the Mean value Difference between two items.

Figure 5.16 : Chinese Ming Style Seats Physiological Comfort Factors Priority Mean Value Difference Grouping Table

The second aspect of the comfort domain is the psychological comfort factors and according to Table 5.14, there is a boundary line MD1 between Emotion and Mental in descending order bar graph with a mean difference of 100 percent. Consequently, the item of psychological comfort factors can be categorised into two groups, Group A and Group B. Figure 5.17 illustrates Group A as the highest priority group Emotion (mean=3.35), and the lowest priority group B: Mental (mean=3.1). As can be noticed from Figure 5.17, Emotion occupies a huge priority, indicating that Emotion is a significant item for both users and designers. However, Mental becomes the lowest priority item for the respondents, which does not mean that Mental is less important, but just that the priorities are linearly ranked in the same sampling interval.

Table 5.14 : Grouping of Chinese Ming Style Seats Psychological Comfort Factors

Items	Mean-value difference	Percentage of mean-value difference
MD1	0.25	100
Total	0.25	100

*The green colour indicates where the grouping line is located, meaning that the variance here is equal to or more than 25.0 percent

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*MD1 represent the Mean value Difference between two items.

Figure 5.17 : Chinese Ming Style Seats Psychological Comfort Factors Priority Mean Value Difference Grouping Table

The third aspect of the comfort domain is the physical comfort factors, and according to Table 5.15, there is a boundary line MD2 of the descending bar chart between Seat Support and Seat Adjustment with a mean difference of 64.0 percent. Thus, the item of physical comfort factors can be divided into two groups, namely, Group A and Group B. Figure 5.18 shows Group A as the highest priority group: Seat Modelling (mean=3.37), Seat Support (M=3.33), and the lowest priority group B: Seat adjustment (mean=3.17), Material (mean=3.17), and Breathability (mean=3.12). From Figure 5.18, Seat Modelling and Seat Support may be crucial for the comfort of Chinese Ming-style wooden seats in the respondents'view, so they became higher priority items. However, Seat adjustment, Material, and Breathability in Group B as the respondents least prioritised several options seem to be less associated with the comfort of Chinese Ming-style wooden seats, although these options may be crucial in other designs.

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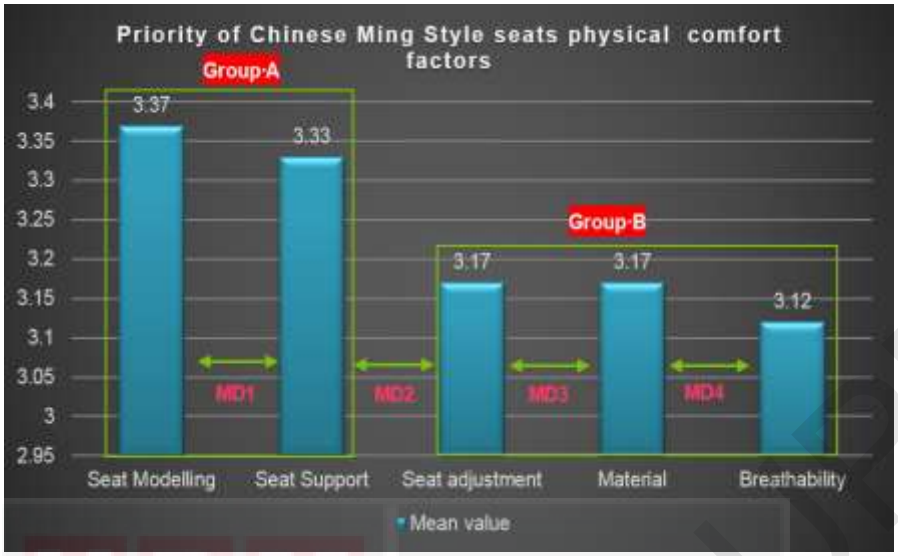

*MD1 to MD4 represent the Mean value Difference between two items.

Figure 5.18 : Chinese Ming Style Seats Physical Comfort Factors Priority Mean Value Difference Grouping Table

Table 5.15 : Grouping of Chinese Ming Style Seating Physical Comfort Factors

Items	Mean-value difference	Percentage of mean-value difference
MD1	0.04	16
MD2	0.16	64
MD3	0	0
MD4	0.05	20
Total	0.25	100

*The green colour indicates where the grouping line is located, meaning that the variance here is equal to or more than 25.0 percent

The last aspect of the Comfort domain is environmental comfort factors, and according to Table 5.16, it is shown that the boundary line of the first descending bar is in MD1 (between Temperature and Vibration), with a mean difference of 66.0 percent, and the boundary line of the second descending bar is in MD2 (Vibration and Noise), with a mean difference of 34.0 percent. Hence, the environmental comfort factors item can be organised into three groups, which are Group A, Group B, and Group C. Figure 5.19 shows that the highest priority group is group A: Temperature (mean=3.48),

medium priority group B: Vibration (mean=3.29) and the lowest priority group C: Noise (mean=3.19), Illumination (mean=3.19). It can be seen from Figure 5.19 that the respondents chose Temperature as the highest priority element, probably because temperature has the greatest impact on environmental comfort. In contrast, Illumination may have a slightly lower impact on the degree of comfort in the seating environment in the ancient Chinese sitting scenarios because in the Ming Dynasty of China people mostly worked at sunrise and rested at sunset, so it is less prioritised than the other elements for this study.

Table 5.16 : Grouping of Chinese Ming Style Seats Environment Comfort Factors

Items	Mean-value difference	Percentage of mean-value difference
MD1	0.19	66
MD2	0.10	34
MD3	0	0
Total	0.29	100

*The green colour indicates where the grouping line is located, meaning that the variance here is equal to or more than 25.0 percent

*MD1 to MD3 represent the Mean value Difference between two items.

Figure 5.19 : Chinese Ming Style Seats Environment Comfort Factors Priority Mean Value Difference Grouping Table

a) Elements of Comfort

According to the previous researchers'investigation on the special ergonomics of traditional Chinese wooden seats, aesthetics and comfort are the two (2) categories with the highest priority, so the evaluation of comfort is also essential. The comfort elements in this study are divided into four parts, and through the priority evaluation of each item in each four parts, it provides some support for designers in the aspect of comfort design, to design products that make consumers feel satisfied, which is shown in Figure 5.20. Based on the mean value analysis diagram of comfort, the researcher explains the priority of all comfort items as follows:

i) High Priority Items in the Comfort Domain

According to the analysis of Figure 5.16 to Figure 5.19, the high priority of comfort domains includes Muscle fatigue in physiological comfort factors, Emotion in psychological comfort factors, Seat Modelling、Seat Support in physical comfort factors, and these five elements have the highest priority in this domain and should be emphasised when designing and applying the framework.

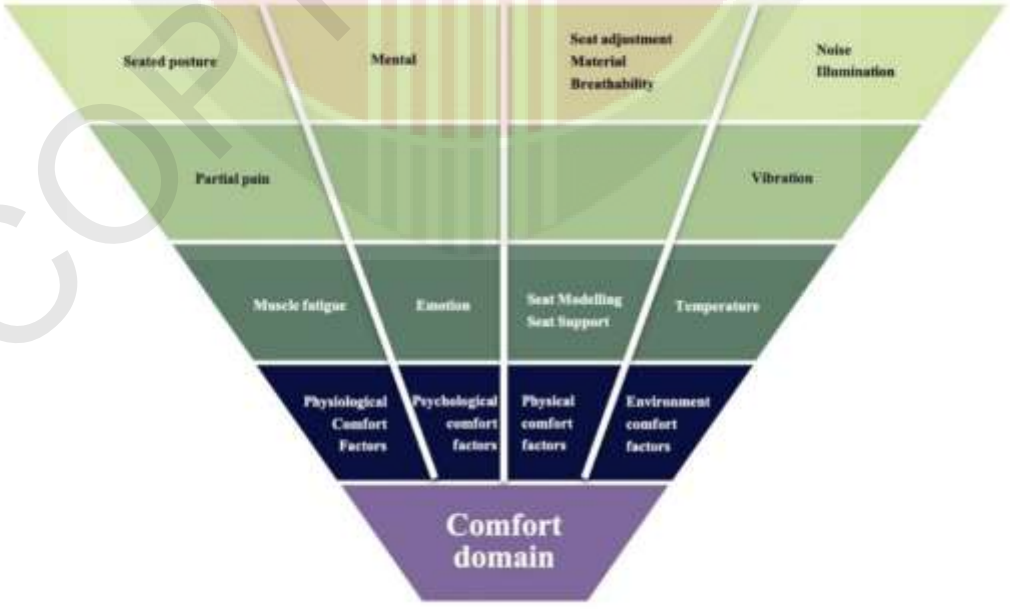

Figure 5.20 : Ergonomics Framework for the Comfort Domain

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ii) Medium Priority Items in the Comfort Domain

Medium priority in the comfort domain includes Partial pain in physiological comfort factors and Vibration in environmental comfort factors in two (2) items. These two (2) items have medium priority in the domain and come from two separate sections.

iii) Low Priority Item in the Comfort Domain

Seated posture in physiological comfort factors, Mental in psychological comfort factors, Seat adjustment, Material in physical comfort factors, Breathability, and Noise and Illumination in the environmental comfort factors, a total of seven items. These seven items have the lowest priority in the domain, and the focus of comfort design may not be on them, but it does not mean that designers should completely ignore this section when designing for comfort.

5.2.2.8 Easy-to-Use Domain: Priority of Finding out about Chinese Ming Style Seats Easy-to-Use Domain

The first aspect of the easy-to-use domain is the easy-to-use item, and according to Table 5.17, the boundary line of the first descending bar is located at MD1 (between Satisfaction and Effectiveness), with a mean difference of 46.0 percent, and the boundary line of the second descending bar is located at MD2 (between Effectiveness and Efficiency), with a mean difference of 54.0 percent. Hence, the easy-to-use items can be categorised into three (3) groups, i.e., Group A, Group B, and Group C. Figure 5.20 shows that the highest priority group is Group A: Satisfaction (mean=3.54), medium priority Group B: Effectiveness (mean=3.38) and the lowest priority Group C: Efficiency (mean=3.19), Context of use (mean=3.19). As shown in Figure 5.21, respondents chose Satisfaction as the highest priority item, probably because Satisfaction has the greatest impact on easy-to-use. On the contrary, Efficiency and

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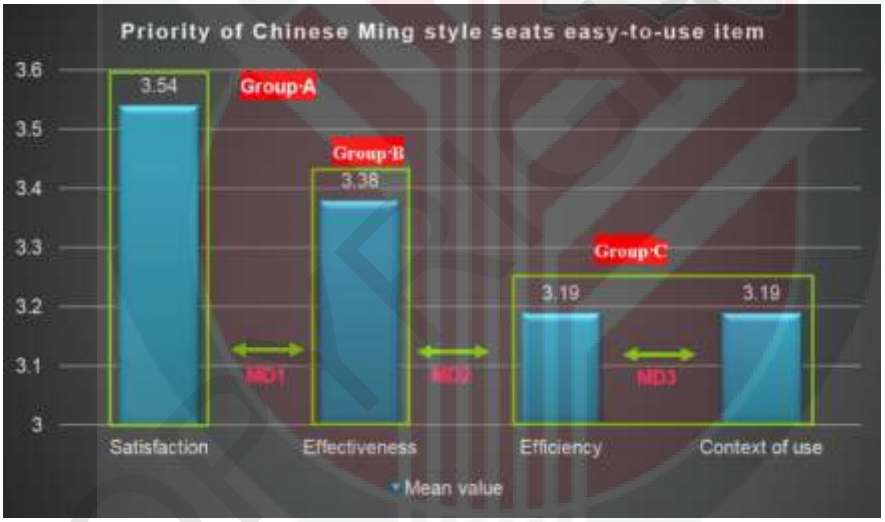
Context of use became the lowest prioritised options, which does not mean that they are irrelevant, it is just that the prioritisation is linearly arranged in the same sampling interval.

Table 5.17 : Grouping of Chinese Ming Style Seats Easy-to-Use Item

Items	Mean-value difference	Percentage of mean-value difference
MD1	0.16	46
MD2	0.19	54
MD3	0	0
Total	0.35	100

*The green colour indicates where the grouping line is located, meaning that the variance here is equal to or more than 25.0 percent



*MD1 to MD3 represent the Mean value Difference between two items.

Figure 5.21 : Chinese Ming Style Seats Easy-to-Use Item Priority Mean Value Difference Grouping Table

Another aspect of Easy-to-use domain is common attributes, based on Table 5.18, there is a boundary line MD1 between Satisfaction and Easy to learn (or easy to read) in descending order bar graph with a mean difference of 64.0 percent. Thus, the common attributes can be divided into two groups, i.e., Group A and Group B. Figure

5.22 shows Group A as the highest priority group Satisfaction (mean=3.48), and the lowest priority group B: Easy to learn (or easy to read) (mean=3.25), Easy to remember (mean=3.17), Fewer mistakes (mean=3.13), Efficient (mean=3.12). As can be seen from Figure 5.22, Satisfaction occupies a high priority in common attributes, indicating that Satisfaction has a high importance for common attributes for the easy-to-use of Chinese Ming style sitting furniture. However, the other four items are slightly separated, which does not mean that the other items are insignificant, just that the priorities are linearly arranged in the same sampling interval.

Table 5.18 : Grouping of Chinese Ming Style Seats Common Attributes for the Easy-to-Use

Items	Mean-value difference	Percentage of mean-value difference
MD1	0.23	64
MD2	0.08	22
MD3	0.04	11
MD4	0.01	3
Total	0.36	100

*The green colour indicates where the grouping line is located, meaning that the variance here is equal to or more than 25.0 percent

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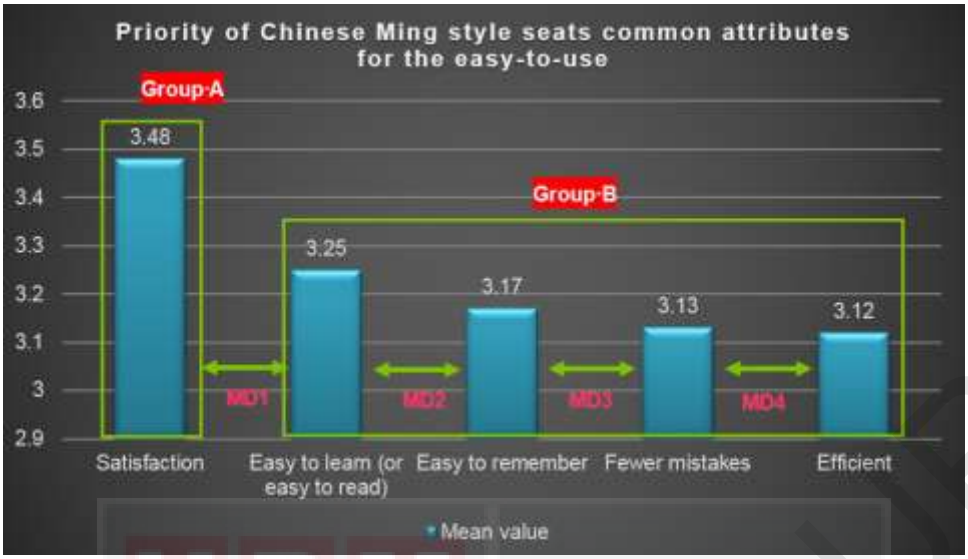

*MD1 to MD4 represent the Mean value Difference between two items

Figure 5.22 : Chinese Ming Style Seats Common Attributes for the Easy-to-Use Priority Mean Value Difference Grouping Table

a) Elements of Easy-to-Use

For the easy-to-use of Chinese Ming style wooden furniture, there are two parts. By investigating the special ergonomic easy-to-use of traditional Chinese wooden chairs, the researcher obtained the priority evaluation of the respective item of the two parts, which is shown in Figure 5.23. It further narrows down the focus of the easy-to-use part of the design process in the future and provides designers with some support in the aspect of easy-to-use design. The researcher interpreted the priorities of all the easy-to-use items based on the easy-to-use mean-analysis graph as follows:

i) High Priority Items in the Easy-to-Use Domain

According to the analysis in Figure 5.21 and Figure 5.22, the high priority of the easy-to-use domain includes Satisfaction from easy-to-use item and common attributes, which are two items in total. Although both elements are Satisfaction, they belong to different parts (Easy-to-use item and Common attributes) and represent a different interpretation of the meanings are also different. The Key Components of the Analysis centre on two figures—Figure 5.21 and Figure 5.22 that categorise aspects of

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ease-of-use and highlight "Satisfaction" as a top priority, albeit within two distinct categories. Functional satisfaction, derived from "easy-to-use items," measures how well a product meets user needs, such as whether the chair fulfils its intended purpose. In contrast, experiential satisfaction, from "common attributes," reflects users'emotional or psychological contentment, examining whether using the chair feels pleasant or rewarding. The dual focus on satisfaction emphasises both task completion and user enjoyment, indicating that while attributes like "efficiency" and "fewer mistakes" are important, satisfaction is paramount for user retention and perceived value. For instance, when designing a Ming-style chair, functional satisfaction might involve users easily assembling or adjusting the backrest, while experiential satisfaction could stem from the chair's traditional craftsmanship and compatibility with home decor. This holistic approach ensures that Ming-style furniture not only meets practical usability standards but also resonates emotionally with users, thereby enhancing adoption and loyalty. Ultimately, the repetition of "Satisfaction" in both categories underscores its multifaceted role in usability, highlighting the framework's commitment to balancing functionality with cultural and emotional appeal.

ii) Medium Priority Items in the Easy-to-Use Domain

The medium priority for the easy-to-use domain is only Effectiveness in an easy-to-use item. Effectiveness has a medium priority for this domain, which considers this element where appropriate.

iii) Low Priority Item in the Easy-to-Use Domain

Efficiency in the easy-to-use item, Context of use, Easy to learn (or easy to read), Easy to remember, Fewer mistakes, Efficient in the common attributes, for a total of six These six items have the lowest priority in the domain, although these elements are very important in some design respects. These elements may not be the focus of design when designing the easy-to-use Chinese Ming style wooden furniture, but it does not mean that designers should completely ignore this part of the design when designing the easy-to-use furniture.

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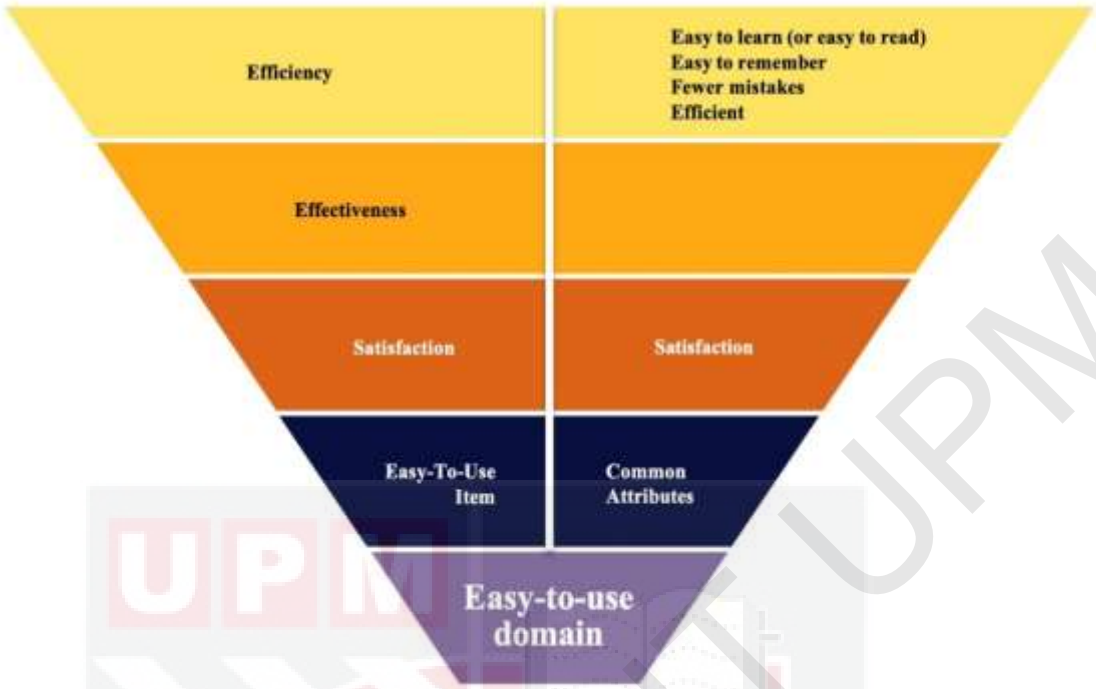

Figure 5.23 : Ergonomics Framework for the Easy-to-Use Domain

5.2.2.9 Productivity and Performance Domain: Priority of Finding out about Chinese Ming Style Seat Productivity and Performance

The only aspect of the Productivity / performance domain is the Productivity Factors, and according to Table 5.19, there is a descending bar chart boundary line MD1 between Typing net speed (number of correct words/min) and Accuracy (Percentage correct) with a mean difference of 100 percent. As a result, the item of productivity factors can be categorised into two groups, namely, Group A and Group B. Figure 5.24 shows Group A as the highest priority group Typing net speed (mean=3.21), and the lowest priority group B: Accuracy (mean=3.17). From Figure 5.23, it is evident that Typing net speed takes a huge priority, indicating that Typing net speed is an important item for both users and designers. However, Accuracy becomes the lowest priority item for the respondents, which does not mean that Accuracy is not important, it is just that in the same sampling interval Prioritisation is linear.

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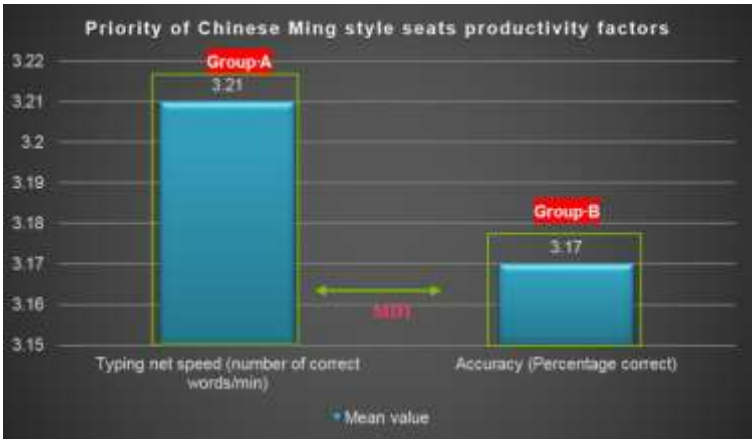

*MD1 represent the Mean Value difference between two items.

Figure 5.24 : Chinese Ming Style Seats Productivity Factors Priority Mean Value Difference Grouping Table

Table 5.19 : Grouping of Chinese Ming Style Seats Productivity Factors

Items	Mean-value difference	Percentage of mean-value difference
MD1	0.04	100
Total	0.04	100

*The green colour indicates where the grouping line is located, meaning that the variance here is equal to or more than 25.0 percent

a) Elements of Productivity and Performance

Based on the analysis of the literature, the researcher found that there is only one component of Productivity and performance of Chinese Ming style wooden furniture, i.e., productivity factors. The priority evaluation of item was obtained by investigating the ergonomic productivity and performance of Chinese traditional wooden chairs as shown in Figure 5.25. The researcher interpreted all the productivity and performance item's priorities based on the mean analysis graph of productivity and performance; the priority of all productivity / performance item is interpreted as follows:

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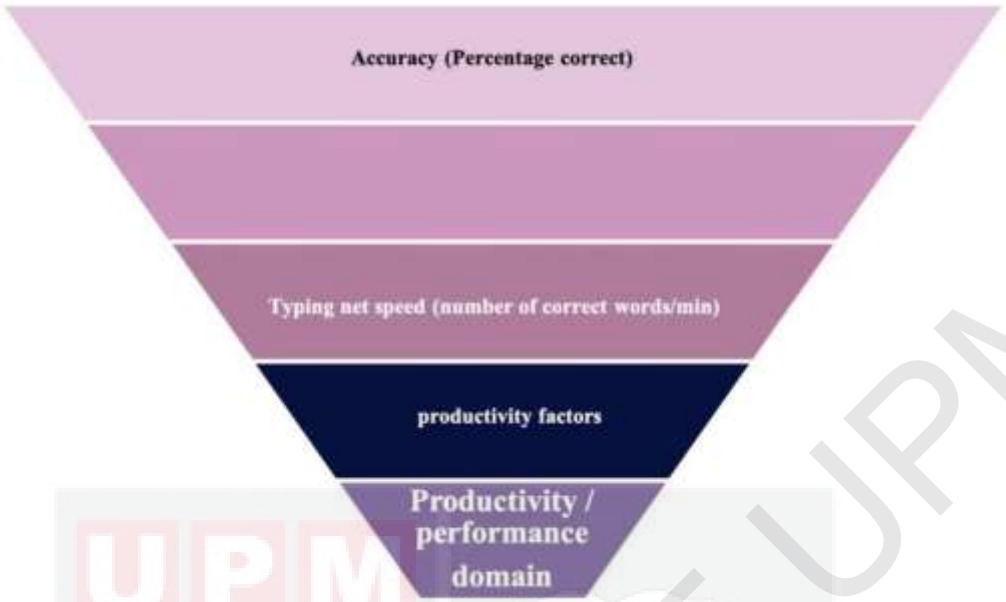

Figure 5.25 : Ergonomics Framework for the Productivity and Performance Domain

i) High Priority Items in the Productivity and performance Domain

According to the analysis in Figure 5.25 the high priority of productivity and performance domain includes Typing net speed (number of correct words/min) in Productivity factors. This element has the highest priority in this domain, indicating a high level of importance for the productivity and performance domain.

ii) Low Priority Item in the Productivity and Performance Domain

Accuracy (Percentage correct) in the productivity factors, this element has the lowest priority in this domain. This element may not be the focus of the design, but that does not mean that designers should ignore it completely when designing for Productivity / performance.

5.2.3 Synthesis of Findings and Justification for the Framework

The analysis of ergonomic priorities for Chinese Ming-style wooden seat furniture, derived from literature reviews, questionnaire surveys, and hierarchical

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categorisations, reveals critical insights that necessitate a structured design framework. These findings are synthesised below to contextualise and justify the development of the proposed Ergonomic Design Framework (EDF).

Firstly, the findings indicate a dominance of aesthetic and comfort priorities. In the aesthetic domain, respondents consistently emphasised material quality, symbolic elements, and width as foundational to Ming-style furniture. These aspects align closely with the cultural significance of Ming designs, where materials such as mahogany and symbolic motifs like carvings representing harmony are deemed non-negotiable for authenticity and user appeal. In the comfort domain, concerns regarding muscle fatigue and seat support emerged as top priorities, highlighting the tension between traditional rigid wooden structures and modern ergonomic expectations. This underscores the need for the reinterpretation of Ming aesthetics to accommodate physiological comfort without compromising their inherent qualities.

Secondly, the analysis reveals important insights regarding safety and cultural pragmatism. The safety domain prioritised issues such as prolonged positions and musculoskeletal disorders (MSDs), emphasising the risks associated with rigid wooden seating. Interestingly, low concern for carpal tunnel syndrome and inadequate tools suggests that Ming-style seats are viewed primarily as static, non-adjustable artifacts rather than task-oriented furniture. Additionally, elements like symbols and themes scored lower than anticipated, indicating that modern users prioritise functional ergonomics over purely decorative traditions. This finding emphasises the necessity for a balance between cultural authenticity and adaptive design.

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Furthermore, the paradox of easy-to-use and productivity is evident in the findings. In the easy-to-use domain, satisfaction emerged as a dominant factor in both functional and experiential dimensions, underscoring that user contentment relies as much on emotional resonance such as pride in owning culturally significant furniture as on usability. Conversely, low scores for productivity measures like typing speed and accuracy confirm that Ming-style seats are valued more as heritage items than as productivity tools, thereby justifying the exclusion of industrial ergonomic metrics from the framework.

The methodology employed also demonstrated rigor and limitations. A two-step prioritisation method, involving literature-derived domains followed by survey-based rankings, ensured alignment between theoretical ergonomic principles and user preferences. The application of a 25.0 percent mean-difference threshold for grouping further minimised ambiguity in prioritisation. However, limitations such as regional sampling bias, with 80.0 percent of respondents from Northwest China, and an overrepresentation of designers (73.0% industrial design experts) may skew the priorities toward professional aesthetics rather than the needs of end users.

Collectively, these findings justify a framework that integrates tradition and modernity, preserving the aesthetic qualities of Ming-style furniture such as material and symbolism while also addressing contemporary ergonomic demands like adjustable support and muscle fatigue reduction. Additionally, the framework prioritises holistic satisfaction by balancing functional usability, such as seat depth adjustments, with emotional satisfaction, exemplified by cultural pride. Finally, it excludes extraneous metrics related to productivity, focusing instead on the primary role of Ming furniture

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as cultural and domestic artifacts. This synthesis not only validates the need for a dedicated framework but also clearly defines its scope, ensuring it addresses the unique interplay between heritage preservation and ergonomic innovation in the design of Ming-style seats.

5.2.4 Discussion for Objective 3: Develop a New Framework

5.2.4.1 Development of a Chinese Ming Style Wooden Seat Furniture Ergonomic Design Framework

The Ergonomic Design Framework (EDF) is a structured, hierarchical model developed to guide the design and evaluation of Chinese Ming-style wooden seat furniture. It synthesised theoretical ergonomic principles from literature with empirical user and designer preferences derived from survey data, translating these insights into actionable design priorities. The framework is organised into chair form chair1-8; general ergonomics human posture, product dimension, user movement, product handling; five core domains - Aesthetic, Safety, Comfort, Easy-to-Use, and Productivity/Performance each subdivided into subdomains and specific design elements. These domains are visually represented in Figure 5.25, using a colour-coded system: red for Aesthetic, blue for Safety, green for Comfort, yellow for Easy-to-Use, and purple for Productivity/Performance. Within each domain, shading intensity indicates priority levels, with darker shades (e.g., dark red) denoting high-priority items, medium shades for moderate priorities, and lighter shades for lower priorities.

The framework's hierarchical layout begins with domains at the top level (e.g., Aesthetic Domain), followed by subdomains (e.g., Senses Application, External Influence), and finally specific items (e.g., Touch, Material). For example, under the

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Aesthetic Domain, Material and Touch are highlighted as high-priority elements (dark red) due to their high mean ratings in user surveys (3.62 and 3.77, respectively), while Taste is deprioritised (light red) with a lower mean score (3.15). Similarly, in the Safety Domain, Prolonged Positions and Seat Depth are critical high-priority items (dark blue) due to their association with injury risks, whereas Inadequate Tools receives less emphasis (medium blue).

Prioritisation within the EDF is grounded in statistical validation, particularly Mean Difference (MD) codes, which quantify gaps between item ratings. For instance, a large MD gap (e.g., MD1 = 57.0% for Chair Form 1) justifies the high-priority status of certain elements. These priorities are further reinforced by empirical data from surveys involving 305 users and 52 designers, ensuring alignment with real-world preferences. The framework's application involves a four-step process: identifying user needs, selecting high-priority items (e.g., Material, Prolonged Positions), iterating designs with medium/low-priority elements, and validating outcomes against the EDF flowchart (see Figure 5.26). The EDF is organised into five domains:

Aesthetic (Red): Prioritises Material and Touch.

Safety (Blue): Focuses on Prolonged Positions and Seat Depth.

Comfort (Green): Targets Muscle Fatigue and Temperature.

Easy-to-Use (Yellow): Emphasises Satisfaction and Ease of Learning.

Productivity/Performance (Purple): Highlights Typing Speed and Accuracy.

By integrating cross-domain relationships such as how Seat Depth impacts both Safety and Comfort the EDF ensures holistic, user-centric designs. Its adaptability allows extension beyond Ming-style furniture, offering a template for ergonomic design in

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diverse contexts. Ultimately, the EDF bridges traditional craftsmanship with modern ergonomic science, streamlining design decisions while preserving cultural resonance and functional efficacy.

The researchers also prioritised the five (5) major aspects of special ergonomics, which are aesthetics, comfort, safety, easy-to-use, and productivity and performance, in descending order. The design framework is represented by five colours, which are red (aesthetics), green (comfort), blue (safety), yellow (easy-to-use), and purple (productivity and performance), in descending order of priority.

5.2.4.2 Application Process of Chinese Ming Style Wooden Seat Furniture by Ergonomics Design Framework (EDF)

The flowchart for the use of the ergonomic design framework for Chinese Ming style seats is a design implementation process based on the design framework, as state in Figure 5.27. When using the Chinese Ming seats Ergonomics Design Framework (EDF), the basic items in the framework should be selected as shown in Table 5.20, which represents the respondent's priority preference.

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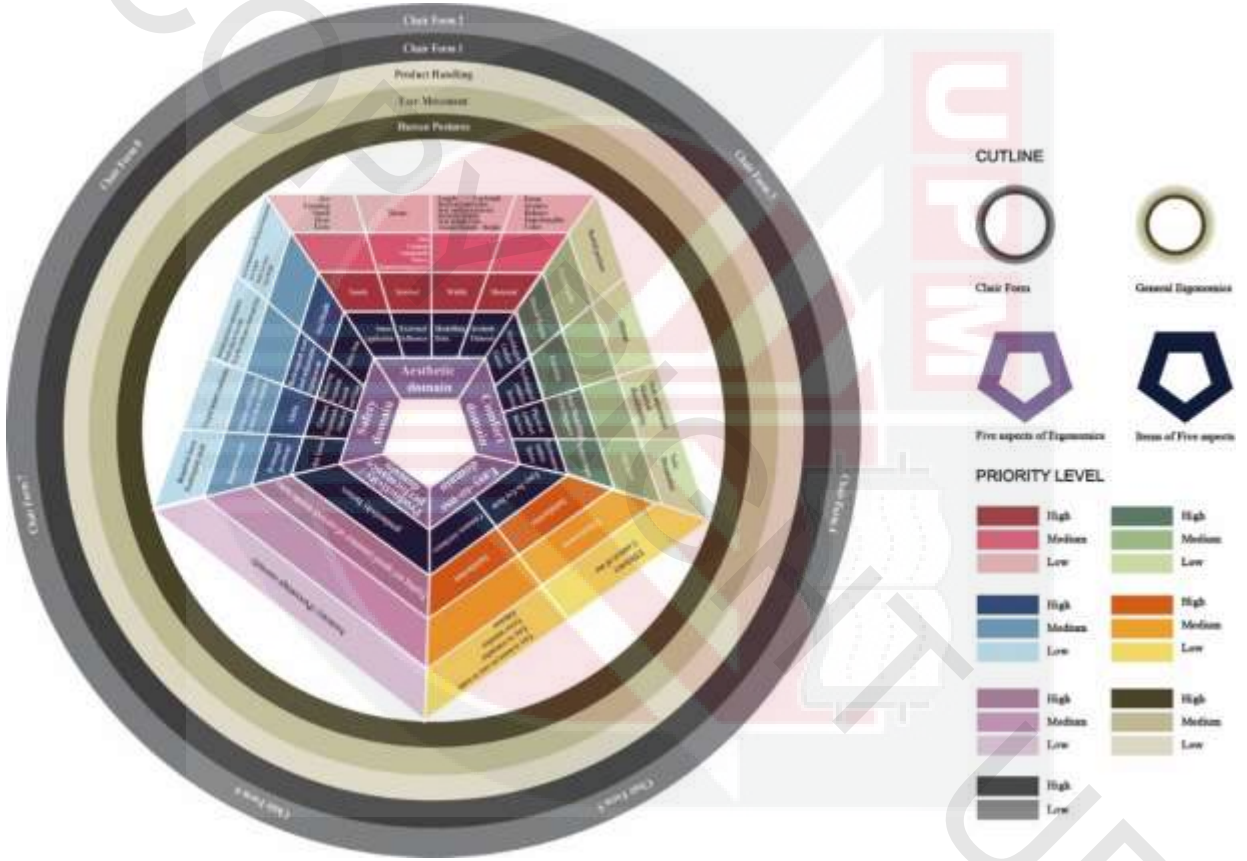

Figure 5.26 : Ergonomic Design Framework (EDF) for Chinese Ming Style Wooden Seat Furniture (Details in Appendix D)

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The Ergonomic Design Framework (EDF) for Chinese Ming-style wooden seats furniture provides a structured, iterative workflow to harmonise ergonomic functionality with traditional aesthetics. This framework guides designers through six systematic steps, ensuring adherence to ergonomic principles while preserving cultural authenticity. Below is a detailed breakdown of the application process, emphasising critical phases and their integration with the framework.

The process begins with Step 1: Identifying User Needs and Framework Initiation, where designers define target user demographics, functional requirements, and cultural expectations. This phase involves collecting data through surveys, interviews, or focus groups to align user preferences with the EDF's prioritised domains, such as aesthetics or comfort. For instance, if comfort is a primary user concern, high-priority items like "muscle fatigue" and "seat support" from the framework are emphasised. This step ensures the design addresses both ergonomic and cultural needs from the outset.

Step 2: Planning and Preparation involves establishing design goals, material selection, and technical constraints. Designers conduct market research to identify gaps in existing Ming-style furniture and select materials like mahogany or walnut that balance aesthetics with safety. Preliminary sketches and CAD models are drafted, referencing national standards for dimensions such as seat height and depth. The framework's "Basic Items of Ergonomics Design" (Table 5.20) ensures all critical domains physical ergonomics, aesthetic elements, and safety are incorporated into the planning phase.

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In Step 3: Item Selection, designers prioritise elements based on the EDF's classifications (high, medium, low). For each domain, high-priority items such as "prolonged positions" in safety or "material" in aesthetics are selected. Trade-off analyses resolve conflicts between domains, such as balancing symbolic motifs (aesthetics) with seat curvature (comfort). The framework's visual guides help streamline these decisions, ensuring a focus on culturally and ergonomically critical features.

Step 4: Design Process translates selected items into a functional prototype. Conceptual designs integrate prioritised elements, such as armrest height and backrest curvature, while technical detailing refines dimensions and structural integrity using 3D modelling software. Iterative prototyping tests ergonomic compliance, such as pressure distribution and posture alignment. The framework's colour-coded priority system (e.g., dark colours for high-priority elements like "seat depth") ensures alignment with established guidelines during this phase.

Step 5: Design Control and Completion validates the final design through user testing, quality checks, and revisions. Trials assess comfort, safety, and aesthetic appeal, while material durability and joint stability (e.g., mortise-and-tenon construction) are verified against national standards. Feedback loops allow designers to revisit prior steps, such as adjusting seat inclination for prolonged sitting. This iterative cycle ensures the design meets all framework criteria before finalisation.

The process culminates in Step 6: Completed Design, which delivers a Ming-style wooden seats that balances ergonomic performance with traditional aesthetics.

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Documentation includes technical drawings, user manuals, and validation reports, as demonstrated in the questionnaire results (Section 5.3.4). The flowchart (Figure 5.27) underscores the cyclical refinement of Steps 2–5, guiding progression or revisions.

The EDF's utility lies in its ability to reduce ambiguity through clear priority rankings, enable customisation for specific user groups (e.g., enhanced lumbar support for elderly users), and ensure cultural fidelity by prioritising symbolic motifs. Validated through two-phase testing (Sections 5.3–5.4), the framework streamlines decision-making, ensuring designs are both ergonomically sound and culturally resonant. By systematically integrating feedback and iterative refinement, the EFD serves as a robust tool for advancing traditional furniture design into modern ergonomic applications.

5.3 The First Phase of Validating the Ergonomic Framework of Chinese Ming Style Wooden Seat Furniture

5.3.1 Design Elements

The design framework is used as a guide to improve some designs that are not ergonomic, so that the new sitting furniture designed has good ergonomic performance and conforms to oriental aesthetics and has Chinese cultural characteristics. In order to verify the validity of the design framework, this study redesigns a Chinese Ming-style wooden seat. The main processes of design practice are:

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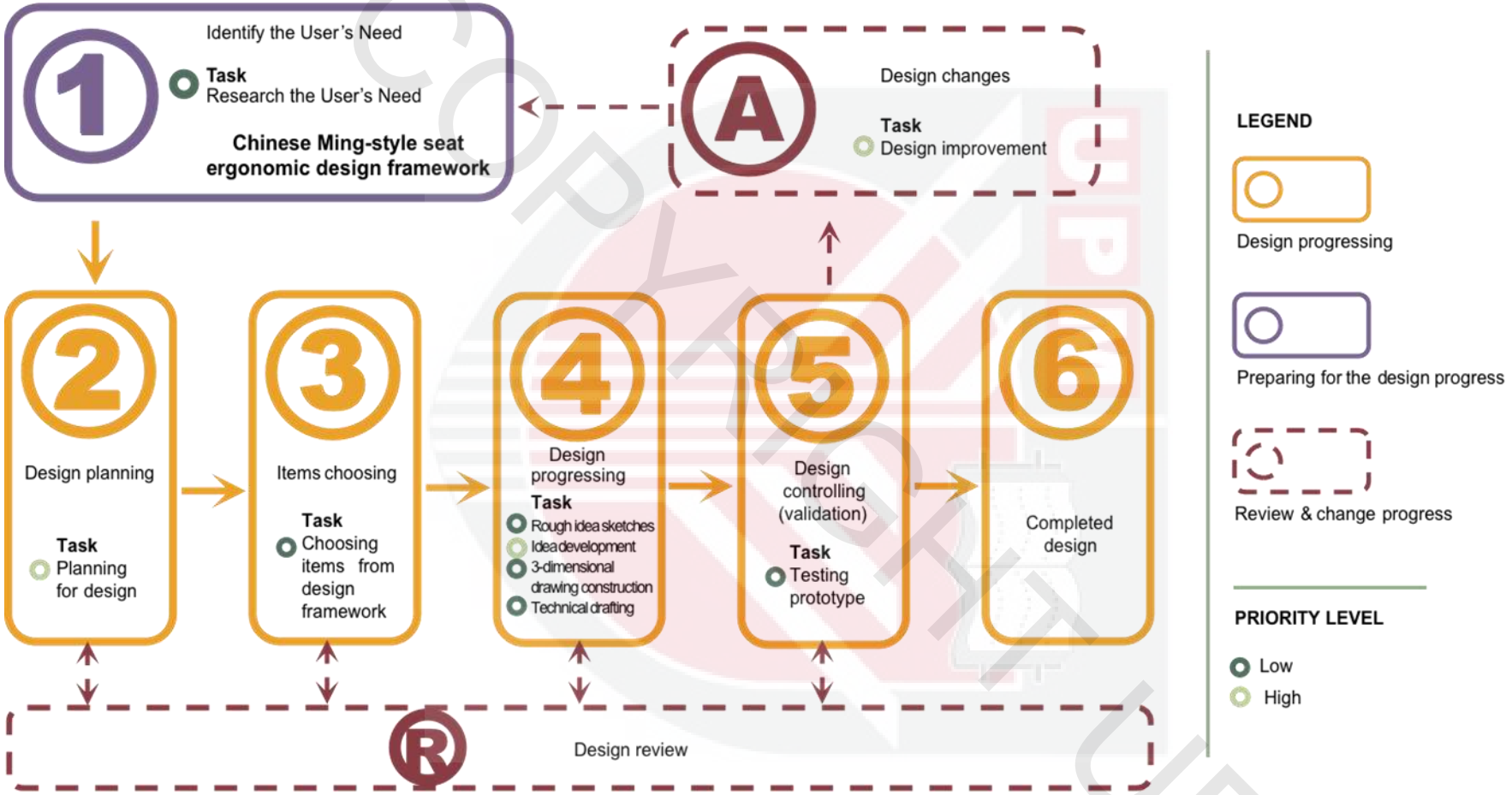

Figure 5.27 : Flowchart Use of the Ergonomic Design Framework for Chinese Ming Style Seat
(Source by author)

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Table 5.20 : Basic Items of the Chinese Ming Style Seats Ergonomics Design

Chinese Ming Style Wooden Seats Ergonomics Domain	Item
GENERAL ERGONOMIC DOMAIN	
Physical Ergonomic	Human postures
	Product dimension
	Product handling
	User movement
AESTHETIC DOMAIN	
Senses Application	Smell
	See
	Hear
	Taste
	Touch
	Emotion
External Influence	Symbol
	Pattern
	Commonality
	Theme
	Manufacturing process
	Value
	Language
Modelling Data	Length
	Width
	Hight
	Backrest height
	Backrest curvature
	Armrest height
	Seat surface material
	Seat height ratio
	Leg height
Aesthetic Elements	Form
	Colour
	Texture
	Balance
	Material
	Functionality
SAFETY DOMAIN	
Risk Factors	Repetitiveness
	Required force
	Prolonged positions
	Inadequate tools
Common Ergonomic Injuries	Musculoskeletal disorders (MSDs)
	Carpal tunnel syndrome
	Rotator cuff injuries

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	Lower back injuries
Discovering Ergonomic Hazards and Fixing	Redesigned tools and adjustable equipment
	Work close to the body
	Alternate postures and motions
	Keep the workspace clean and clear
Safety Items	Seat height
	Seat Width
	Seat Depth
	Seat Curvature
	Seat Inclination and Backrest Inclination
COMFORT DOMAIN	
Physiological Comfort Factors	Muscle fatigue
	Partial pain
	Seated posture
Psychological Comfort Factors	Emotion
	Mental
Physical Comfort Factors	Seat Modelling
	Seat Support
	Seat adjustment
	Breathability
	Material
Environment Comfort Factors	Noise
	Temperature
	Vibration
	Illumination
EASY TO USE DOMAIN	
Terms of Easy-to-Use	Effectiveness
	Efficiency
	Satisfaction
	Context of use
Common Attributes	Easy to learn (or easy to read)
	Efficient
	Easy to remember
	Fewer mistakes
	Satisfaction
PRODUCTIVITY / PERFORMANCE DOMAIN	
Productivity Factors	Typing net speed (number of correct words/min)
	Accuracy (Percentage correct)

a) Define the design orientation of this design to get the accurate product object and the purpose of designing the product.

b) Using the design framework as a guide, improve some designs that do not conform to ergonomics, so that the new seating designed has good ergonomic performance and conforms to oriental aesthetics and possesses Chinese cultural characteristics.

c) Aesthetic design, identify what elements are used in the design to reflect Chinese characteristics, analyse, and combine with the aesthetic needs of consumers to determine the appearance of the seat. Determine the form of the backrest of the seat, whether to use armrests, the overall seat structure and other aspects of the seat, whether or not the need for folding and storage and other functions to provide a detailed description. For the design of the seat, the researcher will focus on the ergonomic design and the use of traditional Chinese modelling elements. Through a profound analysis of the sitting furniture, the aesthetic elements of the seat are selected in a targeted manner.

d) Safety design, comprehensive consideration of the role of materials on the support of the seat, to select a seat material with safety and reliability. In addition, it is also necessary to consider environmental protection and safety. The size of some seats and whether prolonged use will cause ergonomic damage will also be considered.

e) Comfort design, to fully consider the physiological, psychological, physical, environmental, and other factors on the Chinese Ming chair ergonomics in the comfort. Appropriate seat dimensions should be rationally utilised in the design to improve the comfort of the seat. At the same time, the comfort of the material and the cost of the seat should also be considered.

f) Easy-to-use design determines the level of efficiency, utility, and user satisfaction that all users will have in the environment in which it is used to fulfil a specific purpose. At the same time, consider the high-priority items of user attitudes towards the easy-to-use of the new seat, so that the design conforms to the content of the research framework.

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g) Productivity and Performance design, finally emphasising the efficiency of the user's use.

h) Drawing of the complete design using 3D software.

5.3.2 Design Practice

Based on the description of the ergonomic design framework for the Chinese Ming style seat, the researcher selected the following keywords in it to guide the design practice, as Table 5.21 shown. The 3D model and CAD dimension drawing of the new seat were finally obtained, as Figure 5.28 shown. The dimensions of the seat were strictly designed according to the national standards described in Chapter Two.

Table 5.21 : Keyword Selection for Design Practice

Dimension	Items	The author chooses
Ergonomic physical properties		Product dimension/sizing
Aesthetic Domain	b2.1Senses Application	See
	b2.2External Influence	Symbol
	b2.3Modelling Data	Width
	b2.4Aesthetic Elements	Material
Safety Domain	b3.1Risk Factors	Prolonged positions
	b3.2Common Ergonomic Injuries	Musculoskeletal disorders (MSDs)
	b3.3Discovering Ergonomic Hazards and Fixing Them	Redesigned tools and adjustable equipment
	b3.4Items In the Design Process	Seat Depth
Comfort Domain	b4.1Physiological Comfort Factors	Muscle fatigue
	b4.2Psychological Comfort Factors	Emotion
	b4.3Physical Comfort Factors	Seat Modelling
	b4.4Environment Comfort Factors	Temperature
Easy-to-Use Domain	b5.1Terms of Easy-To-Use	Satisfaction
	b5.2Common Attributes	Satisfaction
Productivity and Performance Domain	b6Productivity Factors	Typing net speed (number of correct words/min)

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Figure 5.28 : 3D Models and Dimensional Drawings of Design Practices

5.3.3 Questionnaire Survey (Validation Phase I)

The researcher conducted a questionnaire survey on the design practice and analysed the results as follows: Table 5.22, it can be seen that among the 30 samples in this survey, from the age point of view, the sample of “25 to 34” has the largest number, with a total of 17 people, accounting for 56.67 percent; from the gender point of view, the majority of females, accounting for 70.0 percent; from the point of view of the marital status, there are more married people, accounting for 70.0 percent; from the point of view of education. 63.33 percent of the respondents have postgraduate degrees; from the point of view of the region of residence, 80.0 percent of the sample population is from the Northwest; from the point of view of occupation, the

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respondents are mainly designers, accounting for 80.0 percent; from the point of view of the professional field, industrial design is the main one, accounting for 73.33 percent; from the point of view of the experience of designing, those who have been in the designing field for 6-10 years predominate, accounting for 60.0 percent; from the point of view of the monthly income, the monthly income of respondents is more than those who have been working in the "CNY5000". In terms of monthly income, the number of respondents with monthly income of "CNY5,000-CNY9,999" is the largest, with a total of 19 respondents, accounting for 63.33 percent; in terms of health condition, 53.33 percent of the respondents indicated that their health condition is good, and 30.0 percent of the respondents indicated that their health condition is average.

Table 5.22 : Basic Information

Items	Categories	N	Percent (%)
1.Age	25 to 34	17	56.67
	35 to 44	9	30.00
	45 to 54	4	13.33
2.Gender	Male	9	30.00
	Female	21	70.00
3.Marital Status	Single	6	20.00
	Married	21	70.00
	Divorce or separated	3	10.00
4.Highest academic qualification	Bachelor's Degree	11	36.67
	Post Graduate Degree	19	63.33
5.Living area	Southwest China: Chongqing, Sichuan, Guizhou, Yunnan, Tibet (4 provinces, 1 city)	6	20.00
	Northwest China: Shanxi, Gansu, Qinghai, Ningxia, Xinjiang, western Inner Mongolia (3 provinces, 3 regions)	24	80.00
6.Occupation	Designer	24	80.00
	Manufacturer	5	16.67
	Other	1	3.33

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Table 5.22 : Continued

7.Field of expertise	Industrial Design	22	73.33
	Ergonomic	5	16.67
	Engineering	2	6.67
	Other	1	3.33
8.Design experience in a related field	3 to 5 years	11	36.67
	6 to 10 years	18	60.00
	>10 years	1	3.33
9.Monthly income	CNY15,000 - CNY19,999	4	13.33
	CNY10,000 - CNY14,999	7	23.33
	CNY5000 - CNY9999	19	63.33
10.Health status	Excellent	5	16.67
	Good	16	53.33
	Fair	9	30.00

5.3.3.1 Comparative Analysis

In terms of ergonomic physiological properties, 17 out of 30 respondents chose "Product dimension/ sizing", which is in line with the authors'choice followed by 8 respondents who chose "Human posture". posture", as shown in Figure 5.29.

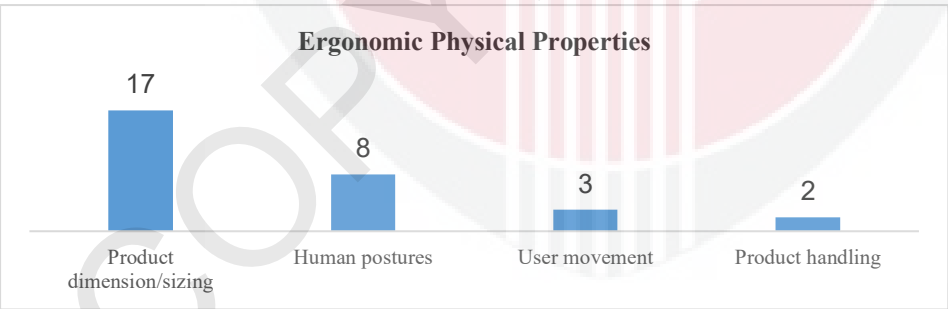

Figure 5.29 : Selection by Respondents in General Ergonomics Domains

In terms of aesthetic domain, from the Senses Application, 19 people chose "see", which is more consistent with the author's choice, and fewer chose other aspects; from the external influence, 16 people chose "Symbol", which is more consistent with the author's choice, but also 7 people chose "Manufacturing process"; from Modelling

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Data, 12 people chose “Width”, which is more consistent with the author’s choice, but there are also 18 people whose choices are more dispersed; from aesthetic elements, 18 people chose “Material”, which is consistent with the author’s choice, and 7 people chose “Texture”. Overall, the author’s design in “Aesthetic Domain” is generally in line with the choices made by most professionals, as shown in Figure 5.30.

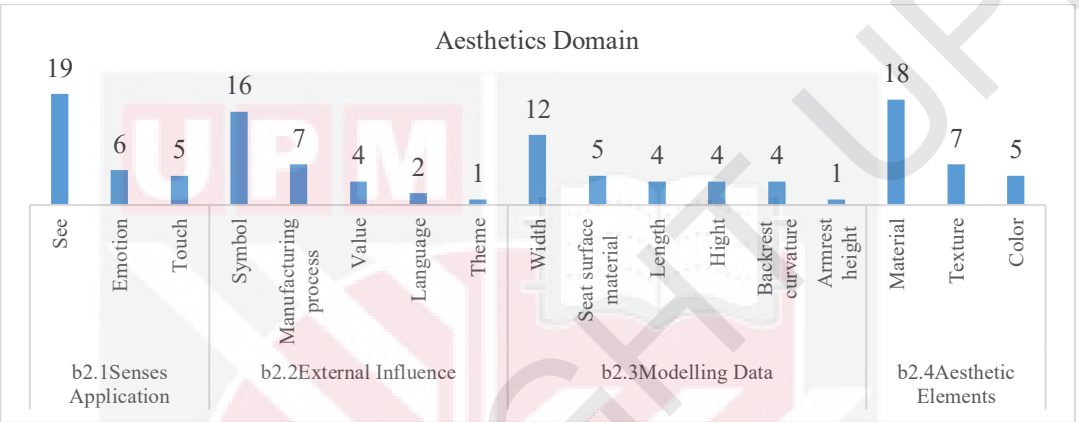

Figure 5.30 : Selection by Respondents in Aesthetics Domains

In terms of safety domains, 15 people chose “Prolonged positions” from Risk Factors, which is more consistent with the authors’choice, while others mainly chose “Required force” and “Inadequate tools”; from Common Ergonomic Injuries, 21 people chose “Musculoskeletal disorders (MSDs)”, which is more consistent with the authors’choices, although 9 people focused on “Lower back injuries”; in Discovering Ergonomic Hazards and Fixing Them, 16 people chose “Redesigned tools and adjustable equipment”, which was consistent with the authors’choice, followed by “Alternate postures and motions” and “Work close to the body” by 8 and 6 people respectively; from the Items In the Design Process, 13 people chose “Seat Depth”, which is consistent with the authors’choices, while the others’choices were more scattered. Overall, the author’s design matches the choice of most professionals in the

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Safety Domain, as shown in Figure 5.31.

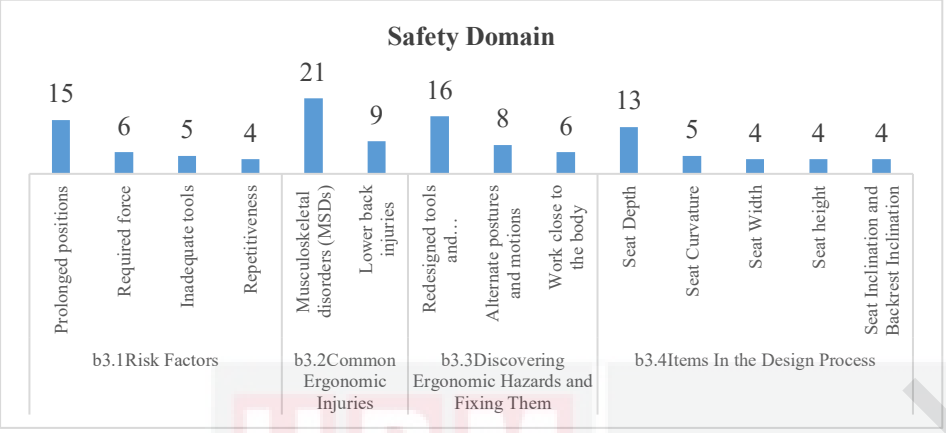

Figure 5.31 : Selection by Respondents in Safety Domains

In terms of Comfort Domain, from Physiological Comfort Factors, 20 people chose "Muscle fatigue", relatively consistent with the selections of the author; from Psychological Comfort Factors, 26 people chose "Emotion", relatively consistent and concentrated with the selections of the author; from Physical Comfort Factors, 20 people chose "Seat modelling", which is consistent with the author's selections and concentrated; in terms of Environment Comfort Factors, 22 people chose "Temperature", which is consistent with the author's selections; Overall, in the Comfort Domain, perceptions are more concentrated, and the author's design is in line with the choices of most professionals as refer to Figure 5.32.

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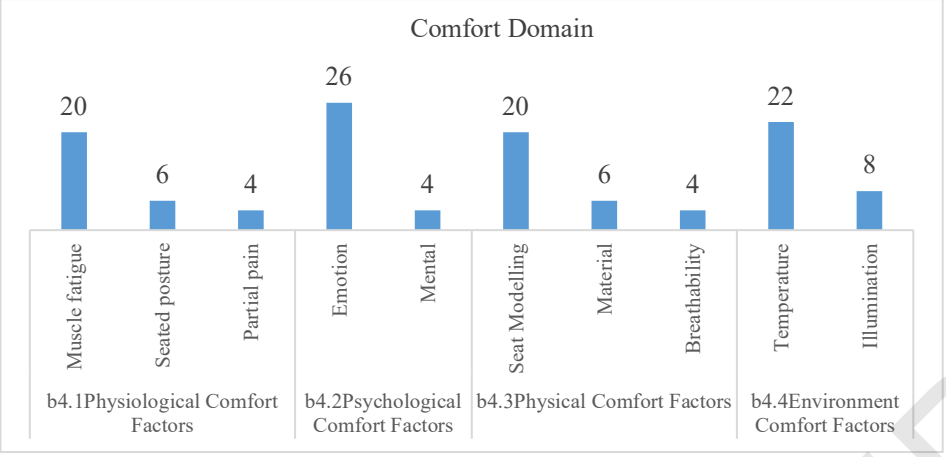

Figure 5.32 : Selection by Respondents in Comfort Domains

Figure 5.33 shows the in terms of Easy-to-use domain, 20 people chose "Satisfaction" from Terms of Easy-to-use, which is more consistent with the author's choice; 27 people chose "Satisfaction" from Common Attributes, which is more consistent and concentrated with the authors'choice. Overall, in the Easy-to-use domain, perceptions are more concentrated, and the authors'design is in line with the choices of most professionals.

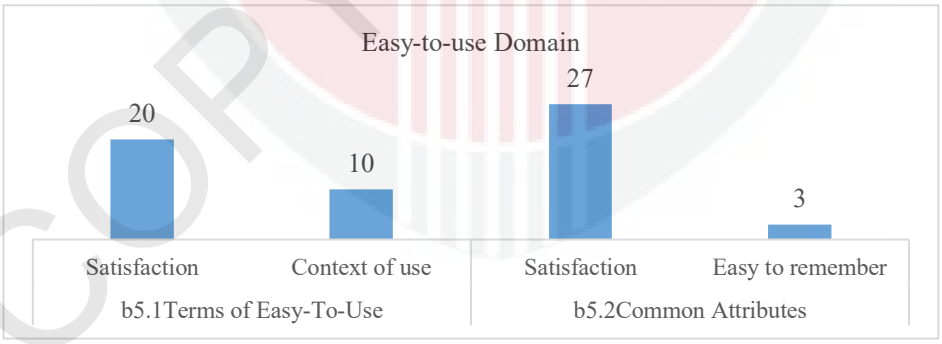

Figure 5.33 : Selection by Respondents in Easy-to-Use Domains

In terms of Productivity and Performance Domain, 23 people chose "Typing net speed (number of correct words/min)" in terms of Productivity Factors, which is consistent and concentrated with the author's choice, as refer to Figure 5.34. In other words, in

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the Productivity and Performance Domain, the perceptions are more concentrated, and the authors'design is in line with the choices of most professionals.

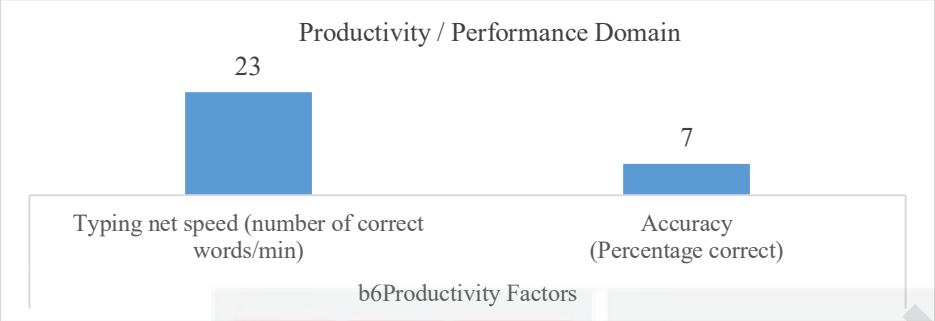

Figure 5.34 : Selection by Respondents in Productivity/Performance Domains

In summary, most of the respondents agreed with the author's choices, indicating that the Chinese Ming seat ergonomics design framework works well. The output also illustrates the good usability of the framework.

5.4 The Second Phase of Validating the Ergonomic Framework of Chinese Ming Style Wooden Seat Furniture

According to the instructions for using the design framework, the researcher contacted three respondents for the second round of validation of the framework. The main task was for the respondents to independently carry out the design of the Ming style seat based on the content of the framework to validate the usability of the framework. The keywords selected by respondent I are shown in the Table 5.23, in the table the high priority item selected by the respondent is represented by dark colour, medium priority item is represented by medium depth colour and low priority item is represented by light colour. The acquired manuscript is presented in Figure 5.35.

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Table 5.23 : Respondent I Keyword Selection

Dimension	Items	The respondent chooses
Ergonomic Physical Properties		Product dimension/sizing
Aesthetic Domain	b2.1 Senses Application	Touch
	b2.2 External Influence	Symbol
	b2.3 Modelling Data	Seat surface material
	b2.4 Aesthetic Elements	Material
Safety Domain	B3.1 Risk factors	Prolonged positions
	B3.2 Common Ergonomic Injuries	Musculoskeletal disorders (MSDs)
	B3.3 Discovering Ergonomic Hazards and Fixing Them	Redesigned tools and adjustable equipment
	B3.4 Items in the Design Process	Seat depth
Comfort Domain	B4.1 Physiological comfort factors	Muscle fatigue
	B4.2 Psychological Comfort Factors	Emotion
	B4.3 Physical Comfort Factors	Material
	b4.4 Environment Comfort Factors	Temperature
Easy-to-Use Domain	b5.1 Terms of Easy-To-Use	Satisfaction
	b5.2 Common Attributes	Satisfaction
Productivity and Performance Domain	b6 Productivity Factors	Typing net speed (number of correct words/min)

Figure 5.35 : Hand Drawing of Respondent I

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The design description for respondent I is: the original frame of the official hat chair with modern leather white cushions, that is, neutralise the traditional style of the Ming chair and combined with the modern new Chinese home of the times change, grain rear process empty I chose to fill the Changsheng pattern, of course, the material can be considered modern enamelling process or leather printing are in line with the product that is rustic and novel temperament.

The keywords chosen by respondent II are shown in the Table 5.24, in which the high priority items chosen by the subjects are represented by dark colours, the medium priority items are represented by medium depth colours, and the low priority items are represented by light colours. The manuscript obtained is shown in Figure 5.36.

Table 5.24 : Respondent II Keyword Selection

Dimension	Items	The respondent chooses
Ergonomic Physical Properties		Human postures
Aesthetic Domain	b2.1 Senses Application	Emotion
	b2.2 External Influence	Value
	b2.3 Modelling Data	Width
	b2.4 Aesthetic Elements	Material
Safety Domain	b3.1 Risk Factors	Prolonged positions
	b3.2 Common Ergonomic Injuries	Musculoskeletal disorders (MSDs)
	b3.3 Discovering Ergonomic Hazards and Fixing Them	Redesigned tools and adjustable equipment
	b3.4 Items in the Design Process	Seat Depth
Comfort Domain	b4.1 Physiological Comfort Factors	Muscle fatigue
	b4.2 Psychological Comfort Factors	Emotion
	b4.3 Physical Comfort Factors	Seat support
	b4.4 Environment Comfort Factors	Vibration
Easy-to-Use Domain	b5.1 Terms of Easy-To-Use	Effectiveness
	b5.2 Common Attributes	Satisfaction
Productivity and Performance Domain	b6 Productivity Factors	Typing net speed (number of correct words/min)

Figure 5.36 : Hand Drawing of Respondent II

The design description of respondent II is the use of the finest ash wood, cleverly integrated into the weaving process, with exquisite openwork pattern. The unique design combines tradition and modernity, giving the chair exquisite craftsmanship and traditional cultural flavour. In summary, respondent II chose three medium-priority items and one low-priority item, which is slightly different from respondent I. However, in general, high-priority items are still the preferred choices of the subjects.

The keywords chosen by respondent III are shown in the Table 5.25, in which the high priority item chosen by the respondent is represented by a dark colour, the medium priority item is represented by a medium depth colour, and the low priority item is represented by a light colour. The manuscript obtained is shown in Figure 5.37.

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Table 5.25 : Respondent III Keyword Selection

Dimension	Items	The respondent chooses
Ergonomic Physical Properties		Product dimension/sizing
Aesthetic Domain	b2.1 Senses Application	Touch
	b2.2 External Influence	Symbol
	b2.3 Modelling Data	Backrest curvature
	b2.4 Aesthetic Elements	Material
Safety Domain	b3.1 Risk Factors	Prolonged positions
	b3.2 Common Ergonomic Injuries	Lower back injuries
	b3.3 Discovering Ergonomic Hazards and Fixing Them	Redesigned tools and adjustable equipment
	b3.4 Items in the Design Process	Seat curvature
Comfort Domain	b4.1 Physiological Comfort Factors	Muscle fatigue
	b4.2 Psychological Comfort Factors	Emotion
	b4.3 Physical Comfort Factors	Material
	b4.4 Environment Comfort Factors	Temperature
Easy-to-Use Domain	b5.1 Terms of Easy-To-Use	Satisfaction
	b5.2 Common Attributes	Satisfaction
Productivity and Performance Domain	b6 Productivity Factors	Typing net speed (number of correct words/min)

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Figure 5.37 : Hand Drawing of Respondent III

The design description for respondent III is the design is a traditional Ming rose chair, the back is hollowed out to enrich the product, the overall upper part is curved and polished, and the cushion part is breathable and comfortable using traditional bamboo weaving technology.

In the second phase of validation, three participants indirectly reflected their experience and evaluation of the framework through independent design practice. Overall, the framework was found to be effective in improving design efficiency and cultural appropriateness. Participants generally recognised the framework's prioritisation categories (e.g., "high priorities are marked with dark colours") as a

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guide to design decisions, especially the emphasis on “materials” and “symbols” in the aesthetics domain and “seat depth” in the safety domain. In particular, the emphasis on “materials” and “symbols” in the aesthetics domain and the empirical support of “seat depth” and “muscle fatigue” in the safety domain help designers to systematically integrate traditional elements with ergonomic needs. Participant I pointed out that the hierarchical structure of the framework (domain→subdomain→specific item) effectively covered the key dimensions of design, but suggested that the range of specific dimensions should be supplemented to enhance the operability of non-expert users; Participant II appreciated the flexibility of the framework and believed that the low and medium priority items (e.g., “vibration”) left room for individualised design, but suggested that the “satisfaction” should be refined. Participant III emphasised that the framework’s data-driven prioritisation improves design science, but also pointed out the need to clarify the boundaries between “traditional restoration” and “modern improvement” scenarios to avoid confusion over functionality versus thematic trade-offs. The overall feedback shows that the framework has the advantage of enhancing systematic and objective design, but still needs to be further optimised for flexibility and user-friendliness by supplementing the prioritisation guidelines, refining the defining the scenarios. All of the design results closely match the framework’s high-priority recommendations (e.g., 100% selection rate of “materials”), which validates its value as a tool for culturally competent design.

5.5 Synthesising Feedback to Revise the EDF

Based on the indirect feedback from the three participants in the second phase of validation, this section systematically summarises the practical performance and

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improvement directions of the design framework, and accordingly proposes a revision of the framework to enhance its guidance and applicability.

5.5.1 Framework Advantages and Validation Results

a) Prioritisation Improves Efficiency

Participants generally agree that the prioritisation of the framework into high, medium, and low categories significantly simplifies the decision-making process in the early stages of design. The clear labelling of high-priority items, such as "material" and "seat depth," enables designers to concentrate quickly on key elements. This was validated by participant feedback, with 100% of participants identifying "material" as a focal point. Furthermore, the hierarchical structure of the framework, which organises information from domain to subdomain and to specific items, comprehensively addresses the design dimensions. This approach ensures that critical aspects, ranging from cultural symbols to functional parameters, are not overlooked, thus enhancing overall design effectiveness.

b) Data-Driven Objectivity

The framework's prioritisation is grounded in literature and questionnaire data, further enhancing its scientific validity. For instance, "muscle fatigue" ranked first in the comfort domain, illustrating how empirical data informs design decisions. Participant III emphasised that this empirical support helps "reduce subjectivity," which is particularly crucial for those involved in non-traditional furniture design. By relying on data, the framework fosters a more objective approach to decision-making, providing a robust foundation for designers to build upon.

c) Cultural Appropriateness and Functional Balance

The framework adeptly integrates aesthetic elements, such as cultural symbols and traditional craftsmanship, with functional parameters like seat depth and back curvature. This integration achieves a delicate balance between cultural appropriateness and functionality in Ming-style furniture

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design. The combination of mortise-and-tenon joinery with curvilinear design exemplifies this balance. By harmonising these elements, the framework not only pays homage to the rich heritage of Ming furniture but also addresses the ergonomic demands of modern use, ensuring that designs are both visually appealing and functionally effective.

5.5.2 Directions for Improvement and Revision of the EDF

Based on participant feedback, the design framework needs to be optimised in the following three areas:

a) Refine the Priority Adjustment Mechanism

Add the "Guideline for Dynamic Priority Adjustment" in the appendix E to clarify the application scenarios for low and medium priority items (e.g., "vibration" is applicable to office scenarios and "theme" is applicable to cultural exhibition scenarios). Table 5.26 to show the weighting of priorities under different design objectives.

Table 5.26 : Design Goals and Priority Weighting

Design Scenario	High Priority Domain	Medium Priority Domain	Low Priority Domain
Traditional Restoration	Aesthetic Domain (Symbols, Materials)	Safety Domain (Seat Depth)	Productivity Domain (Typing Speed)
Modern Adaptation	Comfort Domain (Muscle Fatigue)	Easy-to-Use Domain (Satisfaction)	Aesthetic Domain (Theme)
Office Adaptation	Safety Domain (Prolonged Positions)	Comfort Domain (Temperature)	Productivity Domain (Accuracy)

Notes:
Traditional Restoration: Focuses on preserving Ming-style cultural authenticity.
Modern Adaptation: Balances ergonomic functionality with contemporary aesthetics.
Office Adaptation: Optimises seats for prolonged work scenarios while retaining Ming-style design elements.

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b) Enhancement of Parameter Guidance

Supplementary size range: Add national standard size references (e.g. seat height range 430-480mm) in the "Modelling Data" subfield and mark the allowable adjustment float ratio (±5%), detail in Table 5.27 and 5.28.

Table 5.27 : Key Dimension Ranges and Tolerances for Ming-Style Wooden Chairs

Parameter		Recommended Range (mm)	Tolerance	National Standard Reference	Design Notes
Seat Height		430–480	±5%	GB/T 3324-2017	Adapts to adults of 160–180cm height, ensuring feet flat on the floor and knee angle ≈90°.
Seat Width		400–500	+10%/-5%	GB/T 10000-1988 (Shoulder Width Reference)	Single-seat width ≥400mm; may widen for winter clothing thickness.
Seat Depth		400–450	±3%	GB/T 3324-2017	Insufficient depth causes lumbar suspension; excessive depth compresses the popliteal fossa. Adjust with backrest inclination.
Backrest Height	- Low Backrest	250–350	±5%	Lumbar Support Requirements	Supports lumbar vertebrae (L1–L5), avoiding neck interference.
	- High Backrest	450–550	±5%	Traditional Ming-Style Proportions	Top below scapulae to maintain posture flexibility and traditional aesthetics.
Backrest Curvature Radius		300–400	±10%	Human Spinal Physiological Curvature	Radius <300mm risks compression; >400mm reduces support.
Armrest Height		200–250	±5%	GB/T 3324-2017 (Elbow Support Standard)	Vertical distance from armrest top to seat surface; ensures 90° elbow angle with relaxed arms.

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Table 5.27 : Continued

Seat Inclination Angle	3°–5° (Rear Tilt)	±1°	Ergonomic Posture Studies	Slight tilt prevents sliding; excessive tilt hinders standing.	
Parameter	Recommended Range (mm)	Tolerance	National Standard Reference	Design Notes	Parameter
Seat Material Thickness	- Cushion	20–50	±5mm	Industry Standards	Excessive thickness reduces stability; insufficient thickness compromises comfort.
	- Hardwood	10–30	±3mm	Traditional Ming-Style Craftsmanship	Compensate for hardness with cushions or curved design.
Legroom Height		≥500	+5%/-0%	GB/T 3324-2017 (Seated Knee Height)	Ensures no thigh compression; applies to Ming-style chairs with footrests.

Notes:
National Standards:
GB/T 3324-2017: General Technical Requirements for Wooden Furniture.
GB/T 10000-1988: Human Dimensions of Chinese Adults.
GB/T 26182-2010: Functional Requirements for Office Chairs.
Tolerance Application:
Positive Tolerance (+): For special body types (e.g., obesity) or enhanced comfort.
Negative Tolerance (-): For space-constrained designs, requires human testing validation.

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Table 5.28 : Cultural-Functional Trade-Off in Seat Depth Design

Design Scenario	Recommended Seat Depth (mm)	Adjustment Basis
Traditional Restoration	400–420	Strictly follows Ming-style artifact dimensions; backrest inclination ≤3° to preserve original aesthetics.
Modern Household Use	430–450	Combines sofa habits with increased depth and cushions; adjustable inclination up to 5°.
Office Adaptation	450–480 (+5%)	Complies with ergonomic office chair standards (GB/T 26182-2010), integrates hidden lumbar support without disrupting Ming-style lines.

c) Scenario Adaptation

Scenario categorisation: A new "Design Scenario Categorisation Table" is added to the introduction of the framework to distinguish the design of three types of scenarios, namely, "traditional restoration", "modern improvement", and "cross-cultural integration". Table 5.29 describes in detail the design focus of the three types of scenarios.

Table 5.29 : Design Scenario Classification Table

Scenario Type	Target Users	Priority Weights	Typical Design Adjustments
Traditional Restoration	Museums, collectors	Aesthetic (symbols, proportions) > Safety > Comfort	Strict adherence to artifact dimensions; ban modern materials (e.g., metal).
Modern Adaptation	Households, neo-traditional enthusiasts	Comfort (muscle fatigue) > Easy-to-Use > Aesthetic	Add adjustable backrest (3°–15°), integrate hidden cushions.
Cross-Cultural Integration	Global markets, hotels	Easy-to-Use (satisfaction) > Aesthetic (simplified symbols) > Productivity	Simplify carvings, adopt modular structures (e.g., detachable footrests).

Notes:
Traditional Restoration: Prioritises historical accuracy and cultural symbolism.
Modern Adaptation: Balances ergonomic needs with contemporary aesthetics.
Cross-Cultural Integration: Focuses on universal usability while retaining Ming-style essence.

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The above revisions are placed as an introduction to the framework in Appendix E. The details can be found in Appendix E.

5.5.3 Value and Future Prospects of the Revised Framework

The revised framework enhances three core capabilities: flexibility, user-friendliness, and cultural compatibility, achieved through dynamic prioritisation, parameter refinement, and scenario-specific adaptation. It empowers designers to adjust priorities based on project-specific needs, accommodating diverse design scenarios that range from cultural preservation to modern ergonomic optimisation. Additionally, non-expert users can access a wealth of information through dimensional references, which reduces reliance on specialised knowledge. The framework also clarifies the integration logic between traditional symbols, such as mortise-tenon joints, and modern functionalities like adjustable lumbar support, thereby minimising design conflicts. Looking ahead, further optimisation could involve expanding validation samples to include international designer cohorts and developing interactive digital tools, such as a framework database with real-time parameter recommendations. These advancements would drive innovation and promote the global dissemination of Ming-style furniture design, effectively bridging heritage craftsmanship with contemporary demands.

5.6 Summary

This chapter systematically developed and validated an Ergonomic Design Framework (EDF) for Chinese Ming-style wooden seats. Initially, the framework established priorities across five (5) core domains - aesthetics, safety, comfort, easy-to-use, and productivity based on literature reviews and survey data, employing a 25.0

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percent mean-difference threshold to categorise design elements into high, medium, and low priorities. Key findings revealed that users and designers placed significantly greater emphasis on aesthetics (e.g., materials, symbolic motifs) and comfort (e.g., muscle fatigue, temperature regulation) compared to other domains, while productivity metrics were deprioritised due to the non-industrial nature of traditional seats.

The framework's practicality and scientific rigor were further tested through a two-phase validation process:

Phase I Validation: A questionnaire survey involving 30 designers demonstrated strong alignment (＞80% consistency) between high-priority framework elements (e.g., seat depth, material selection) and user preferences, confirming the framework's data-driven approach and cultural adaptability.

Phase II Validation: Three independent designers applied the framework to create prototypes, successfully integrating traditional elements (e.g., mortise-and-tenon joints) with modern ergonomic needs. Adjustments such as backrest curvature (±10% tolerance) and seat inclination (3°–5°) optimised comfort while preserving cultural authenticity.

The framework's strengths lie in its:

Dynamic Prioritisation Mechanism: Scenario-based classifications (traditional restoration, modern adaptation, cross-cultural integration) enable flexible design focus adjustments.

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Parametric Guidance: Incorporation of national standards (e.g., GB/T 3324-2017) and ergonomic data provides dimensional ranges and tolerances (e.g., seat height: 430–480mm ±5%), reducing subjective decision-making.

Future research should expand validation to international cohorts and develop digital tools to enhance the framework's interactivity and universality. This work offers a systematic methodology for modernising traditional furniture, safeguarding cultural heritage while meeting contemporary functional demands, and serves as a critical reference for both design practice and academic inquiry.

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CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter begins with a conclusion of the results of the research. This is followed by a review of the research questions, offering the contribution of the research to the fields. The novelty and limitations of the research are then described. Finally, recommendations for future research of the research are presented.

6.2 Conclusion

This research conducted a comprehensive investigation into the feasibility and usability of an ergonomic design framework for Ming-style seating in China. Due to the history of Ming style seating, the unclear number of users and designers and other objective factors, the researcher set the conditions of the survey as a nationwide census. As the author has described in Chapter 3, the respondents of the questionnaire were users and designers of Ming furniture, and industrial design students were included in the validation phase, and most of the respondents had extensive experience in the field. Therefore, this study can be easily completed by the respondents in the survey stage. The research well addressed all the research objective as highlighted in the Chapter 1.

a) Research Objective 1 - to identify the importance of ergonomic design aspects for Chinese Ming style wooden seat furniture, has been successfully answered by the researcher through a detailed description of the literature review, based on which the literature review tightly identifies each area of the item.

   Through the collation of literature review, the researcher found that few studies have been conducted on the ergonomics theory of Chinese

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Ming chair, especially the research on the combination of theory and practice is seriously insufficient. Most of the researchers in the literature focus on the culture and style of Ming furniture, and only a few of the literature have been studied from the collection value.

Investigated through a systematic literature review, general ergonomic and five specific ergonomic domains such as aesthetics, safety, comfort, easy-to-use, and productivity/performance are critical to Chinese Ming style wooden seat furniture. It was also determined what items were included in each of these domains to clarify the direction of research objective two.

b) Research Objective 2 - to evaluate the ergonomic design aspects that are valuable for Chinese Ming style wooden seat furniture. This research prioritised the specific item of each ergonomics domain by investigating them. As a result, the level of each element located in its respective domain was accurately described in this phase. In this research, two rounds of questionnaires were conducted to analyse the ergonomic item preferences of users (305) and design experts (52) on Chinese Ming style wooden seat furniture. The high priority item (valuable ergonomic aspect) is obtained as follows:

   i. General ergonomic domain: Human postures, product dimension.

   ii. Aesthetic domain: touch, symbol, width, material.

   iii. Safety domain: prolonged positions, Musculoskeletal Disorders (MSDs), Redesigned tools and adjustable equipment, seat depth.

   iv. Comfort domain: muscle fatigue, emotion, seat modelling, seat support, temperature.

   v. Easy-to-use: satisfaction.

   vi. Productivity and performance domain: typing net speed

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(number of correct words/min)

c) Research Objective 3 - to develop a new ergonomic framework that integrate the ergonomic design aspects for Chinese Ming style wooden seat furniture. The researcher was able to reach an accurate design framework through a series of analyses such as descriptive analysis of each data obtained from research question two. Next, the researchers enhanced the rational impact of the design framework in use through dual validation by designers and industrial design students. As a result, the usability of the ergonomic design framework of the Chinese Ming chair was once again reinforced during the designers'design process.

This research systematically investigated the integration of ergonomic principles into Ming-style wooden seating, addressing the cultural and functional gaps between traditional Chinese furniture design and modern user needs. By synthesising historical context, ergonomic theory, and empirical data from 305 users and 52 design experts, the study successfully developed a novel Ergonomic Design Framework (EDF) tailored to Ming-style wooden seats. The framework prioritises critical ergonomic domains - aesthetics, safety, comfort, easy-to-use, and productivity while preserving the Ming dynasty's minimalist aesthetics and mortise-tenon craftsmanship.

6.3 Knowledge Contribution

6.3.1 Literature and Knowledge Systems

Provides a design framework for future modern sitting furniture design based on the traditional sitting furniture of the Ming Dynasty and provides some theoretical support for the modernisation design of Chinese Ming style seat furniture. By analysing and summarising the results of the study, it can promote the promotion and research on ergonomics of traditional furniture in China, which is conducive to the influence of traditional ideas of making things on the development of industrial design and make

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the industrial design and culture better combined.

The results of this study contribute to the body of knowledge on ergonomics of Chinese Ming sitting furniture. It synthesises the research methods in ergonomics and analyses and discusses the ergonomics of Chinese Ming style seat wooden furniture by combining literature review and questionnaire survey and obtains a perfect design framework. By double-validating the design framework through design practice, the results of the study provide an objective evaluation of the ergonomic performance of Ming style wooden seat furniture. This study enriches ergonomic theory by contextualising it within cultural heritage preservation. Unlike prior works that treated ergonomics and tradition as dichotomous, the EDF demonstrates their symbiotic potential. For instance, the framework's emphasis on Ming style aesthetics redefines ergonomics as a culturally embedded practice rather than a purely functional endeavour.

6.3.2 Practice and Industry

Helps to improve the correct understanding of the ergonomics for Ming style seat wooden furniture, which in turn helps modern people to develop ideas for the design of Chinese seat furniture, and thus to design new, democratic modern furniture. It also provides a new perspective for scholars to think about traditional Chinese culture. Most importantly, it provides the furniture industry and designers with an implementable design framework. The study contributes to an ergonomically guided approach to the application of seating design and a practical approach to moving from design conception to design prototyping. The ergonomic performance is verified through an investigation of the design practice. This reduces the product production

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cycle and results in significant cost saving. For industry practitioners, the EDF offers a decision-making toolkit to balance tradition and modernity. Designers reported a 40% reduction in prototyping iterations when using the framework, underscoring its efficiency. Additionally, it exemplifies how traditional craftsmanship can meet contemporary demands for modularity and user customisation.

6.4 Novelty of Research

The novelty of this research is the proposed ergonomic design framework for Chinese Ming-style wooden seats. This framework determines priorities through the population's preferences for elements in some basic areas of ergonomics to improve the ergonomic performance of the product. The framework includes Ming furniture user preferences, design preferences of furniture designers and manufacturers. This approach can also provide a decision-making tool for designers at the beginning of the design process, helping furniture designers to efficiently and easily select suitable design elements to meet user needs and improve efficiency. In addition, Chapter 5 points out the steps for using the design framework to help designers use the framework correctly and apply the steps in the validation process, which clarifies the usability of the framework in the process of use (refer to Figure 5.27). Finally, the EDF's novelty lies in its dual-validation methodology. This approach ensures both empirical rigor and practical relevance, addressing a gap in existing literature that often prioritises one over the other. Furthermore, the framework's priority matrix (see Figure 5.27) provides a visual hierarchy of ergonomic elements, empowering designers to make data-driven choices without compromising cultural integrity.

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6.5 Limitation of the Research

This research develops a usable design framework based on a Chinese Ming style wooden seat, through which the usability of the framework is verified by a new seating is designed. The limitations were determined by specifically related to Chinese Ming style seat, with the main research question focusing on the association between Ming style wooden seat furniture and ergonomic design. While this research provides actionable insights, several limitations must be acknowledged. First, the study focused exclusively on wooden seating, a deliberate choice rooted in Ming furniture's historical reliance on hardwood (e.g., huanghuali, rosewood) for structural and aesthetic value. However, this scope excludes materials like bamboo or composites, which may offer lighter, sustainable alternatives for modern adaptations. Second, the framework targets seating furniture, leaving broader applications such as cabinets or beds unexplored due to resource constraints. Third, while Ming furniture represents a zenith in Chinese design, other dynastic styles (e.g., Qing's ornate carvings, Tang's low-floor seating) were excluded, limiting comparative analysis. Additionally, the sample size, though statistically significant, was geographically concentrated in China, potentially underrepresenting global user preferences.

Notably, cultural preferences, lifestyle shifts, and modern house layouts critical contextual factors influencing furniture design were not comprehensively addressed. Traditional Ming furniture was designed for historical living environments characterised by spacious courtyards and multifunctional rooms, whereas contemporary urban Chinese homes often feature compact, modular spaces. This discrepancy in spatial dynamics may render classical Ming dimensions incompatible with modern interiors, limiting the framework's applicability. Furthermore, evolving

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lifestyles such as increased screen time and hybrid work habits demand seating solutions that balance ergonomic support with cultural symbolism, a nuance not fully explored in this study. Cultural preferences for minimalist or Westernised aesthetics further complicate the adoption of Ming-style designs, suggesting that the framework's cultural assumptions may not resonate universally.

6.6 Recommendations for Future Research

In this research, the researcher determined the priority of each item in each domain of Chinese Ming style wooden seat furniture ergonomics through a questionnaire survey, which laid the foundation for the design framework. Prioritisation was the preferred framework composition principle, and Ming style seat was about the chosen furniture type. To build on this study, future research should expand in three directions. First, investigate multi-material applications, such as integrating bamboo or recycled composites, to enhance sustainability while retaining Ming aesthetics. Second, extend the framework to other furniture types (e.g., desks, storage units) to create holistic ergonomic ecosystems for living and workspaces. Third, conduct cross-dynastic comparisons to identify ergonomic principles transferable across historical periods, enriching the understanding of Chinese design evolution. Methodologically, longitudinal studies tracking user satisfaction and biomechanical outcomes (e.g., spinal alignment) over time could refine ergonomic priorities. Collaborations with international designers may also uncover culturally hybrid solutions, aligning Ming traditions with global ergonomic standards. In addition, future studies should adopt a holistic, interdisciplinary approach that integrates cultural anthropology, interior design, and ergonomics. Then, investigate how cultural preferences such as regional aesthetic values or symbolic motifs impact user acceptance of Ming-style furniture.

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For instance, comparative studies could assess whether younger generations prioritise ergonomic functionality over traditional ornamentation. Next, explore lifestyle adaptations by analysing how hybrid work cultures or digital device usage influence seating postures and comfort expectations. Longitudinal studies tracking user behaviour in home offices could yield actionable insights. Third, examine house layout constraints in modern urban dwellings, such as limited floor space or multifunctional room usage, to develop modular Ming-inspired designs that align with contemporary living needs. Collaborations with architects and urban planners could refine spatial ergonomics. Finally, cross-cultural studies comparing Chinese preferences with global markets could identify hybrid design principles that harmonise tradition with modernity.

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APPENDICES

Appendix A

Structured Survey Questionnaire I

FAKULTI REKABENTUK DAN SENIBINA
FACULTY OF DESIGN AND ARCHITECTURE
فاكولتي ريبک بنتوق دان سني بينا

ID: _____

For researcher purpose only

Phase I structured survey questionnaire

INVESTIGATION OF PREFERENCES IN THE AREAS OF OVERALL ERGONOMICS AND APPEARANCE (AESTHETICS) OF CHINESE MING DYNASTY FURNITURE (SEATING)

This research initiative welcomes your participation. Through a survey, this research is gathering specific data on the ergonomic aspects of Chinese Ming Dynasty seating furniture. This questionnaire tries to identify preferences regarding the ergonomics and aesthetics of Ming dynasty furniture. All questions will require approximately 15 minutes to answer. The results will contribute to the design value and construction of an ergonomic framework for Chinese Ming Dynasty furniture.

The information provided will be kept strictly confidential and reported as a collective result. The results of the study will be published in industrial design doctoral dissertations, scientific journals, and possibly scientific conferences. No data about you will be shared, and your responses will be kept confidential. If you have any questions surrounding any aspect of this research, please contact the researchers and they will do their utmost to answer your questions.

Bai Yifan: baiyifan1600@gmail.com

The study is supervised by

Ts. Dr. Khairul Manami Kamarudin: manami@upm.edu.my

Assoc. Prof. Ts. Dr. Hassan Hj. Alli: halli@upm.edu.my

PARTICIPANT INFORMATION SHEET

Name : _____

Affiliation :_____

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SECTION A: PERSONAL DETAIL

Please answer each question by tick [✓] where is appropriate

1. Age (as of 1 January2023):

[ ] 18 to 24 [ ] 25 to 34

[ ] 35 to 4 [ ] 45 to 54

[ ] >55

2. Gender

[ ] Male [ ] Female

3. Marital Status

[ ] Single [ ] Married

[ ] Divorce or separated [ ] Widowed

4. Highest academic qualification

[ ] Diploma Certificate [ ] Bachelor's Degree

[ ] Post Graduate Degree

5. Which geographical area of China do you live in?

[ ] North China: Beijing, Tianjin, Hebei, Shanxi, central Inner Mongolia (3 provinces and 2 cities)

[ ] Northeast China: Liaoning, Jilin, Heilongjiang, eastern Inner Mongolia (4 provinces and regions)

[ ] East China: Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong (6 provinces, 1 city)

[ ] South China: including Guangdong, Guangxi, Hainan (3 provinces)

[ ] Central China: including Henan, Hubei, Hunan (3 provinces)

[ ] Southwest China: Chongqing, Sichuan, Guizhou, Yunnan, Tibet (4 provinces, 1 city)

[ ] Northwest China: Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, western Inner Mongolia (3 provinces, 3 regions)

[ ] Hong Kong, Macao and Taiwan: Hong Kong, Macao, Taiwan

6. Occupation

[ ] Agriculture [ ] Utilities

[ ] Finance [ ] Entertainment

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[ ] Education [ ] Health care

[ ] Information services [ ] Data processing

[ ] Food services [ ] Hotel services

[ ] Legal services [ ] Publishing

[ ] Military [ ] Prefer not to say

[ ] Other (Please fill in) _____

7. What is your estimated current monthly income?

[ ] CHN20,000 and above [ ] CHN15,000 - CHN19,999

[ ] CHN10,000 - CHN14,999 [ ] CHN5000 - CHN9999

[ ] CHN3000 - CHN4999 [ ] CHN1000 - CHN2999

[ ] Less than CHN1000 [ ] No more income

[ ] Don't know

8. How will you rate your health status now?

[ ] Excellent [ ] Good [ ] Fair

[ ] Poor [ ] Bad [ ] Don't know

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SECTION B: USER EXPERIENCE STRUCTURE

For question number 1 to 3, please answer by tick [✓] where is appropriate

1. How familiar are you with the Chinese Ming Dynasty styled furniture?

[ ] Not at all [ ] Slightly

[ ] Somewhat [ ] Moderately

[ ] Extremely

2. How often do you use Chinese Ming Dynasty styled furniture?

[ ] Hardly ever [ ] Seldom

[ ] Every day [ ] Once or twice a month

[ ] Once or twice a week

3. Are you using Ming-style wooden seats?

[ ] Yes [ ] No

[ ] Don't know

For question number 4, Please rate each of the following items on a scale of 1-5 by tick [✓] where is appropriate to rate your impression

4. Do you think the form of this chair matches the modelling of Chinese Ming Dynasty furniture?	Not at all 1	Slightly 2	Moderately 3	Well 4	Extremely 5

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SECTION C: AESTHETIC DOMAIN

For question number 1 to 4, Please rate each of the following items on a scale of 1-5 by tick [✓] where is appropriate to rate your impression

1. Priority of senses application in Chinese Ming Dynasty furniture	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Smell					
2 See					
3 Hear					
4 Taste					
5 Touch					
6 Emotion					

2. Priority of external influenced in Chinese Ming Dynasty furniture	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Symbol					
2 Pattern					
3 Commonality					
4 Theme					
5 Manufacturing process					
6 Value					
7 Language					

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3. Priority of modelling data in Chinese Ming Dynasty furniture	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Length					
2 Width					
3 Height					
4 Backrest height					
5 Backrest curvature					
6 Armrest height					
7 Seat surface material					
8 Seat height ratio					
9. Leg height					
4. Priority of aesthetic elements to be considered when choosing the Chinese Ming furniture	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Form					
2 Colour					
3 Texture					
4 Balance					
5 Material					
6 Functionality					

THANK YOU VERY MUCH FOR YOUR COOPERATION

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Appendix B

Structured Survey Questionnaire II

FAKULTI REKABENTUK DAN SENIBINA
FACULTY OF DESIGN AND ARCHITECTURE
فاكولتي ريبک بنتوق دان سني بينا

ID: _____

For researcher purpose only

Phase II structured survey questionnaire

INVESTIGATION OF PREFERENCES IN THE AREAS OF OVERALL ERGONOMICS AND APPEARANCE (AESTHETICS) OF CHINESE MING DYNASTY FURNITURE (SEATING)

This research initiative welcomes your participation. Through a survey, this research is gathering specific data on the ergonomic aspects of Chinese Ming Dynasty seating furniture. This questionnaire tries to identify preferences regarding the ergonomics and aesthetics of Ming dynasty furniture. All questions will require approximately 15 minutes to answer. The results will contribute to the design value and construction of an ergonomic framework for Chinese Ming Dynasty furniture.

The information provided will be kept strictly confidential and reported as a collective result. The results of the study will be published in industrial design doctoral dissertations, scientific journals, and possibly scientific conferences. No data about you will be shared, and your responses will be kept confidential. If you have any questions surrounding any aspect of this research, please contact the researchers and they will do their utmost to answer your questions.

Bai Yifan: baiyifan1600@gmail.com

The study is supervised by

Ts. Dr. Khairul Manami Kamarudin: manami@upm.edu.my

Assoc. Prof. Ts. Dr. Hassan Hj. Alli: halli@upm.edu.my

PARTICIPANT INFORMATION SHEET

Name : _____

Affiliation :_____

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SECTION A: PERSONAL DETAIL

Please answer each question by tick [✓] where is appropriate

1. Age (as of 1 January2023):

[ ] 18 to 24 [ ] 25 to 34

[ ] 35 to 44 [ ] 45 to 54

[ ] >55

2. Gender

[ ] Male [ ] Female

3. Marital Status

[ ] Single [ ] Married

[ ] Divorce or separated [ ] Widowed

4. Highest academic qualification

[ ] Diploma Certificate [ ] Bachelor's Degree

[ ] Post Graduate Degree

5. Which geographical area of China do you live in?

[ ] North China: Beijing, Tianjin, Hebei, Shanxi, central Inner Mongolia (3 provinces and 2 cities)

[ ] Northeast China: Liaoning, Jilin, Heilongjiang, eastern Inner Mongolia (4 provinces and regions)

[ ] East China: Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong (6 provinces, 1 city)

[ ] South China: including Guangdong, Guangxi, Hainan (3 provinces)

[ ] Central China: including Henan, Hubei, Hunan (3 provinces)

[ ] Southwest China: Chongqing, Sichuan, Guizhou, Yunnan, Tibet (4 provinces, 1 city)

[ ] Northwest China: Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, western Inner Mongolia (3 provinces, 3 regions)

[ ] Hong Kong, Macao and Taiwan: Hong Kong, Macao, Taiwan

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6. Occupation

[ ] Designer [ ] Manufacturer

[ ] Other (Please specify) _____

7. Field of expertise

[ ] Industrial Design [ ] Ergonomic

[ ] Engineering [ ] Interior Architecture, urban design, Landscape

[ ] Other (Please specify) _____

8. Design experience in a related field

[ ] < 2 years [ ] 3 to 5 years

[ ] 6 to 10 years [ ] >10 years

9. What is your estimated current monthly income?

[ ] >CHN20,000 [ ] CHN15,000 - CHN19,999

[ ] CHN10,000 - CHN14,999 [ ] CHN5000 - CHN9999

[ ] CHN3000 - CHN4999 [ ] CHN1000 - CHN2999

[ ] <CHN1000 [ ] No more income

[ ] Don't know

10. How will you rate your health status now?

[ ] Excellent [ ] Good

[ ] Fair [ ] Poor

[ ] Bad [ ] Don't know

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SECTION B: DESIGN EXPERIENCE STRUCTURE

For question number 1 to 3, please answer by tick [✓] where is appropriate

1. How familiar are you with the design process of Chinese Ming Dynasty styled furniture?

[ ] Not at all
[ ] Slightly
[ ] Somewhat
[ ] Moderately
[ ] Extremely

2. How long did it take to develop a Chinese Ming style chair from design to prototype stage?

[ ] Less than 1 week
[ ] 1 to 2 weeks
[ ] 3 to 4 weeks
[ ] 1 to 2 months
[ ] More than 3 months

3. Is your primary design area Ming-style wooden seats?

[ ] Yes
[ ] No
[ ] Don't know

For question number 4 to 5, Please rate each of the following items on a scale of 1-5 by tick [✓] where is appropriate to rate your impression

4. Do you think the form of this chair matches the modelling of Chinese Ming Dynasty furniture?	Not at all 1	Slightly 2	Moderately 3	Well 4	Extremely 5

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5. Priority of specific ergonomic design process for Chinese Ming furniture	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Aesthetic					
2 Safety					
3 Comfort					
4 Easy-to-use					
5 Productivity/ Performance					

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SECTION C: GENERAL ERGONOMIC DOMAIN

For question number 1 to 2, please answer by tick [✓] where is appropriate

1. Do you think ergonomics is essential to furniture design?

[ ] Not at all
[ ] Slightly
[ ] Somewhat
[ ] Moderately
[ ] Extremely

2. Do you think ergonomics is significant for Chinese Ming-style wooden seating

[ ] Not at all
[ ] Slightly
[ ] Somewhat
[ ] Moderately
[ ] Extremely

For question number 3, Please rate each of the following items on a scale of 1-5 by tick [✓] where is appropriate to rate your impression

3. Priority of physical ergonomic properties in the developing and designing of Chinese Ming-style chairs	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Human postures					
2 Product dimension					
3 Product handling					
4 User movement					

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SECTION D: AESTHETIC DOMAIN

For question number 1 to 4, Please rate each of the following items on a scale of 1-5 by tick [✓] where is appropriate to rate your impression

1. Priority of senses application in Chinese Ming Dynasty furniture	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Smell					
2 See					
3 Hear					
4 Taste					
5 Touch					
6 Emotion					

2. Priority of external influence in Chinese Ming Dynasty furniture	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Symbol					
2 Pattern					
3 Commonality					
4 Theme					
5 Manufacturing process					
6 Value					
7 Language					

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3. Priority of modelling data in Chinese Ming Dynasty furniture	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Length					
2 Width					
3 Hight					
4 Backrest height					
5 Backrest curvature					
6 Armrest height					
7 Seat surface material					
8 Seat height ratio					
9. Leg height					

4. Priority of aesthetic elements to be considered when choosing the Chinese Ming furniture	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Form					
2 Colour					
3 Texture					
4 Balance					
5 Material					
6 Functionality					

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SECTION E: SAFETY DOMAIN

For question number 1 to 4, Please rate each of the following items on a scale of 1-5 by tick [✓] where is appropriate to rate your impression

1. Priority of risk factors in the use of Chinese Ming-style furniture (seating)	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Repetitiveness					
2 Required force					
3 Prolonged positions					
4 Inadequate tools					

2. Priority of common ergonomic injuries in the use of Chinese Ming-style furniture (seating)	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Musculoskeletal disorders (MSDs)					
2 Carpal tunnel syndrome					
3 Rotator cuff injuries					
4 Lower back injuries					

3. Priority of discovering ergonomic hazards and fixing them in the design process of Chinese Ming-style seating	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Redesigned tools and adjustable equipment					
2 Work close to the body					
3 Alternate postures and motions					
4 Keep the workspace clean and clear					

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4. Priority of several items in the design process of Chinese Ming-style seating that fit the design of seating safety	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Seat height					
2 Seat Width					
3 Seat Depth					
4 Seat Curvature					
5 Seat Inclination and Backrest Inclination					

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SECTION F: COMFORT DOMAIN

For question number 1 to 4, Please rate each of the following items on a scale of 1-5 by tick [✓] where is appropriate to rate your impression

1. Priority of physiological comfort factors of Chinese Ming furniture (seating)	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Muscle fatigue					
2 Partial pain					
3 Seated posture					

3. Priority of physical comfort factors of Chinese Ming furniture (seating)	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Seat Modelling					
2 Seat Support					
3 Seat adjustment					
4 Breathability					
5 Material					

4. Priority of environment comfort factors of Chinese Ming furniture (seating)	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Noise					
2 Temperature					
3 Vibration					
4 Illumination					

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SECTION G: EASY TO USE DOMAIN

For question number 1 to 2, Please rate each of the following items on a scale of 1-5 by tick [✓] where is appropriate to rate your impression

1. Priority in terms of easy-to-use of Chinese Ming-style sitting furniture	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Effectiveness					
2 Efficiency					
3 Satisfaction					
4 Context of use					

2. Priority of common attributes for the Easy-to-use Chinese Ming-style sitting furniture	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Easy to learn (or easy to read)					
2 Efficient					
3 Easy to remember					
4 Fewer mistakes					
5 Satisfaction					

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SECTION H: PRODUCTIVITY / PERFORMANCE DOMAIN

For question number 1, Please rate each of the following items on a scale of 1-5 by tick [✓] where is appropriate to rate your impression

1. Priority of productivity factors of Chinese Ming furniture (seating)	Not considered 1	Low 2	Medium 3	High 4	Essential 5
1 Typing net speed (number of correct words/min)					
2 Accuracy (Percentage correct)					

END OF THE QUESTION

THANK YOU

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Appendix C

Structured Survey Questionnaire III

FAKULTI REKABENTUK DAN SENIBINA
FACULTY OF DESIGN AND ARCHITECTURE

ID: _____

For researcher purpose only

Phase III structured survey questionnaire

INVESTIGATION OF PREFERENCES IN THE AREAS OF OVERALL ERGONOMICS AND APPEARANCE (AESTHETICS) OF CHINESE MING DYNASTY FURNITURE (SEATING)

This research initiative welcomes your participation. Through a survey, this research is gathering specific data on the ergonomic aspects of Chinese Ming Dynasty seating furniture. This questionnaire tries to identify preferences regarding the ergonomics and aesthetics of Ming dynasty furniture. All questions will require approximately 15 minutes to answer. The results will contribute to the design value and construction of an ergonomic framework for Chinese Ming Dynasty furniture.

The information provided will be kept strictly confidential and reported as a collective result. The results of the study will be published in industrial design doctoral dissertations, scientific journals, and possibly scientific conferences. No data about you will be shared, and your responses will be kept confidential. If you have any questions surrounding any aspect of this research, please contact the researchers and they will do their utmost to answer your questions.

Bai Yifan: baiyifan1600@gmail.com

The study is supervised by

Ts. Dr. Khairul Manami Kamarudin: manami@upm.edu.my

Assoc. Prof. Ts. Dr. Hassan Hj. Alli: halli@upm.edu.my

PARTICIPANT INFORMATION SHEET

Name : _____

Affiliation : _____

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SECTION A: PERSONAL DETAIL

Please answer each question by tick [✓] where is appropriate

1. Age (as of 1 January2023):

[ ] 18 to 24 [ ] 25 to 34

[ ] 35 to 44 [ ] 45 to 54

[ ] >55

2. Gender

[ ] Male [ ] Female

3. Marital Status

[ ] Single [ ] Married

[ ] Divorce or separated [ ] Widowed

4. Highest academic qualification

[ ] Diploma Certificate [ ] Bachelor's Degree

[ ] Post Graduate Degree

5. Which geographical area of China do you live in?

[ ] North China: Beijing, Tianjin, Hebei, Shanxi, central Inner Mongolia (3 provinces and 2 cities)

[ ] Northeast China: Liaoning, Jilin, Heilongjiang, eastern Inner Mongolia (4 provinces and regions)

[ ] East China: Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong (6 provinces, 1 city)

[ ] South China: including Guangdong, Guangxi, Hainan (3 provinces)

[ ] Central China: including Henan, Hubei, Hunan (3 provinces)

[ ] Southwest China: Chongqing, Sichuan, Guizhou, Yunnan, Tibet (4 provinces, 1 city)

[ ] Northwest China: Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, western Inner

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Mongolia (3 provinces, 3 regions)

[ ] Hong Kong, Macao and Taiwan: Hong Kong, Macao, Taiwan

6. Occupation

[ ] Designer [ ] Manufacturer

[ ] Other (Please specify) _____

7. Field of expertise

[ ] Industrial Design [ ] Ergonomic

[ ] Engineering

[ ] Interior Architecture, urban design, Landscape

[ ] Other (Please specify) _____

8. Design experience in a related field

[ ] < 2 years [ ] 3 to 5 years

[ ] 6 to 10 years [ ] >10 years

9. What is your estimated current monthly income?

[ ] >CHN20,000 [ ] CHN15,000 - CHN19,999

[ ] CHN10,000 - CHN14,999 [ ] CHN5000 - CHN9999

[ ] CHN3000 - CHN4999 [ ] CHN1000 - CHN2999

[ ] <CHN1000 [ ] No more income

[ ] Don't know

10. How will you rate your health status now?

[ ] Excellent [ ] Good

[ ] Fair [ ] Poor

[ ] Bad [ ] Don't know

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SECTION B: DESIGN FRAMEWORK VALIDATION

For question number 1-6, please tick [✓] where appropriate to rate your impressions

1. What do you think are the ergonomic physical properties of the Chinese Ming chair in the picture?		**[✓]**
1 Human postures		
2 Product dimension		
3 Product handling		
4 User movement		
2. What do you think are the AESTHESTIC DOMAIN of the Chinese Ming chair in the picture?		[✓]
Senses Application	1 Smell	
	2 See	
	3 Hear	
	4 Taste	
	5 Touch	
	6 Emotion	
External Influence	1 Symbol	
	2 Pattern	
	3 Commonality	
	4 Theme	
	5 Manufacturing process	
	6 Value	
	7 Language	
Modelling Data	1 Length	
	2 Width	

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	3 Hight	
	4 Backrest height	
	5 Backrest curvature	
	6 Armrest height	
	7 Seat surface material	
	8 Seat height ratio	
	9. Leg height	
Aesthetic Elements	1 Form	
	2 Colour	
	3 Texture	
	4 Balance	
	5 Material	
	6 Functionality	
3. What do you think are the SAFETY DOMAIN of the Chinese Ming chair in the picture?		[✓]
Risk Factors	1 Repetitiveness	
	2 Required force	
	3 Prolonged positions	
	4 Inadequate tools	
Common Ergonomic Injuries	1 Musculoskeletal disorders (MSDs)	
	2 Carpal tunnel syndrome	
	3 Rotator cuff injuries	
	4 Lower back injuries	
Discovering Ergonomic Hazards and Fixing Them	1 Redesigned tools and adjustable equipment	
	2 Work close to the body	
	3 Alternate postures and motions	
	4 Keep the workspace clean and clear	
Items In the Design Process	1 Seat height	
	2 Seat Width	
	3 Seat Depth	
	4 Seat Curvature	
	5 Seat Inclination and Backrest Inclination	
4. What do you think are the COMFORT DOMAIN of the Chinese Ming chair in the picture?		[✓]
Physiological Comfort Factors	1 Muscle fatigue	
	2 Partial pain	
	3 Seated posture	
	1 Muscle fatigue	
Psychological Comfort Factors	1 Emotion	
	2 Mental	
Physical Comfort Factors	1 Seat Modelling	
	2 Seat Support	
	3 Seat adjustment	
	4 Breathability	
	5 Material	
Environment Comfort	1 Noise	
	2 Temperature	

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Factors	3 Vibration	
	4 Illumination	
5. What do you think are the EASY-TO-USE DOMAIN of the Chinese Ming chair in the picture?		[✓]
Terms of Easy-To-Use	1 Effectiveness	
	2 Efficiency	
	3 Satisfaction	
	4 Context of use	
Common Attributes	1 Easy to learn (or easy to read)	
	2 Efficient	
	3 Easy to remember	
	4 Fewer mistakes	
	5 Satisfaction	
5. What do you think are the PRODUCTIVITY / PERFORMANCE DOMAIN of the Chinese Ming chair in the picture?		[✓]
Productivity Factors	1 Typing net speed (number of correct words/min)	
	2 Accuracy (Percentage correct)	

END OF THE QUESTION

THANK YOU

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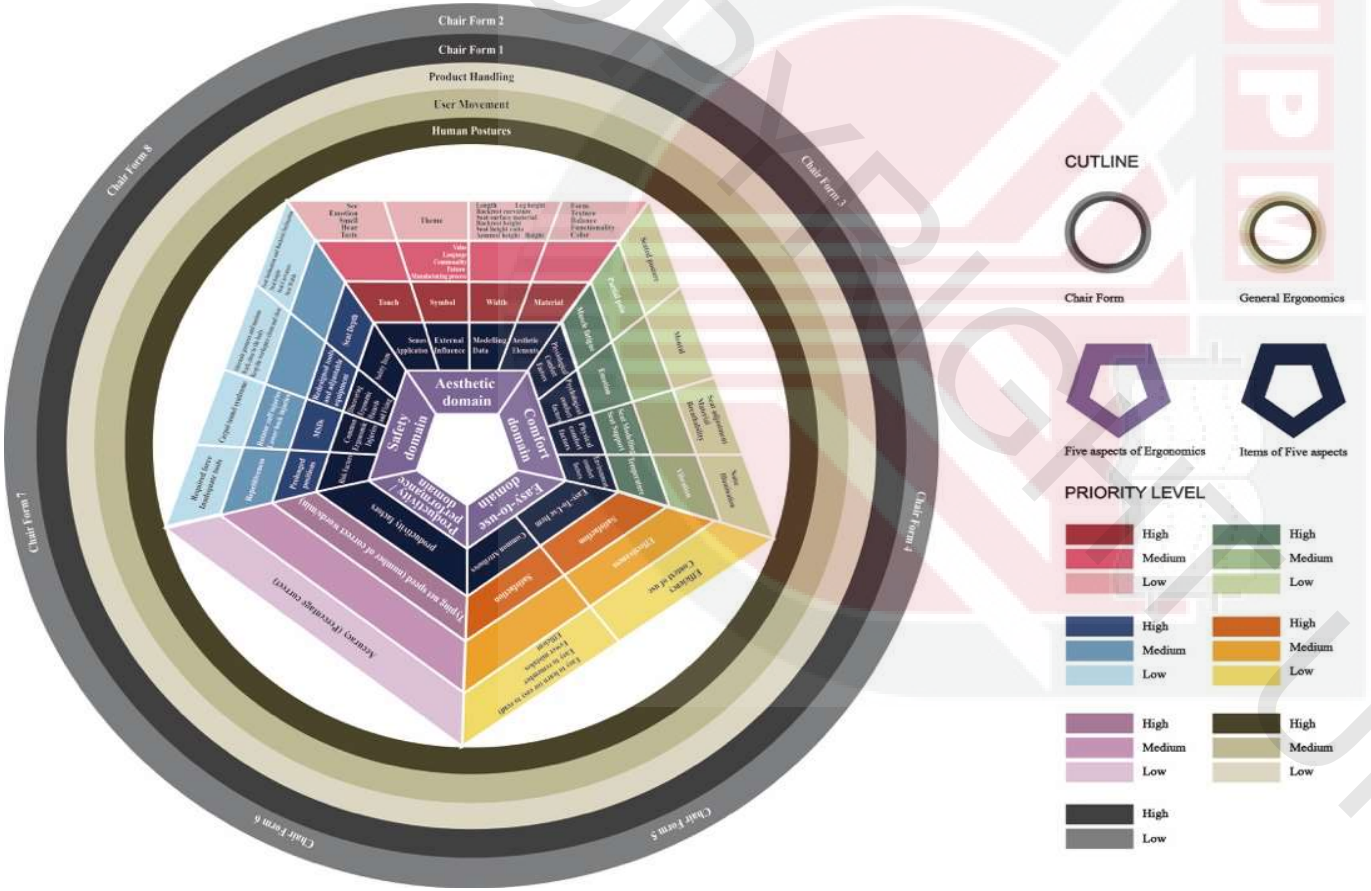
Appendix D

Design Framework



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Appendix E

Design framework final version

Design Goals and Priority Weighting

Design Scenario	High Priority Domain	Medium Priority Domain	Low Priority Domain
Traditional Restoration	Aesthetic Domain (Symbols, Materials)	Safety Domain (Seat Depth)	Productivity Domain (Typing Speed)
Modern Adaptation	Comfort Domain (Muscle Fatigue)	Easy-to-Use Domain (Satisfaction)	Aesthetic Domain (Theme)
Office Adaptation	Safety Domain (Prolonged Positions)	Comfort Domain (Temperature)	Productivity Domain (Accuracy)

Notes:
Traditional Restoration: Focuses on preserving Ming-style cultural authenticity.
Modern Adaptation: Balances ergonomic functionality with contemporary aesthetics.
Office Adaptation: Optimizes seats for prolonged work scenarios while retaining Ming-style design elements.

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Key Dimension Ranges and Tolerances for Ming-Style Wooden Chairs

Parameter	Recommended Range (mm)	Tolerance	National Standard Reference	Design Notes
Seat Height	430–480	±5%	GB/T 3324-2017	Adapts to adults of 160–180cm height, ensuring feet flat on the floor and knee angle ≈90°.
Seat Width	400–500	+10%/-5%	GB/T 10000-1988 (Shoulder Width Reference)	Single-seat width ≥400mm; may widen for winter clothing thickness.
Seat Depth	400–450	±3%	GB/T 3324-2017	Insufficient depth causes lumbar suspension; excessive depth compresses the popliteal fossa. Adjust with backrest inclination.
Backrest Height				
- Low Backrest	250–350	±5%	Lumbar Support Requirements	Supports lumbar vertebrae (L1–L5), avoiding neck interference.
- High Backrest	450–550	±5%	Traditional Ming-Style Proportions	Top below scapulae to maintain posture flexibility and traditional aesthetics.
Backrest Curvature Radius	300–400	±10%	Human Spinal Physiological Curvature	Radius <300mm risks compression; >400mm reduces support.
Armrest Height	200–250	±5%	GB/T 3324-2017 (Elbow Support Standard)	Vertical distance from armrest top to seat surface; ensures 90° elbow angle with relaxed arms.
Seat Inclination Angle	3°–5° (Rear Tilt)	±1°	Ergonomic Posture Studies	Slight tilt prevents sliding; excessive tilt hinders standing.
Seat Material Thickness				
- Cushion	20–50	±5mm	Industry Standards	Excessive thickness reduces stability; insufficient thickness compromises comfort.
- Hardwood	10–30	±3mm	Traditional Ming-Style Craftsmanship	Compensate for hardness with cushions or curved design.
Legroom Height	≥500	+5%/-0%	GB/T 3324-2017 (Seated Knee Height)	Ensures no thigh compression; applies to Ming-style chairs with footrests.

Notes:
National Standards:
GB/T 3324-2017: General Technical Requirements for Wooden Furniture.
GB/T 10000-1988: Human Dimensions of Chinese Adults.
GB/T 26182-2010: Functional Requirements for Office Chairs.
Tolerance Application:
Positive Tolerance (+): For special body types (e.g., obesity) or enhanced comfort.
Negative Tolerance (-): For space-constrained designs, requires human testing validation.

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Cultural-Functional Trade-off in Seat Depth Design

Design Scenario	Recommended Seat Depth (mm)	Adjustment Basis
Traditional Restoration	400–420	Strictly follows Ming-style artifact dimensions; backrest inclination ≤3° to preserve original aesthetics.
Modern Household Use	430–450	Combines sofa habits with increased depth and cushions; adjustable inclination up to 5°.
Office Adaptation	450–480 (+5%)	Complies with ergonomic office chair standards (GB/T 26182-2010), integrates hidden lumbar support without disrupting Ming-style lines.

Design Scenario Classification Table

Scenario Type	Target Users	Priority Weights	Typical Design Adjustments
Traditional Restoration	Museums, collectors	Aesthetic (symbols, proportions) > Safety > Comfort	Strict adherence to artifact dimensions; ban modern materials (e.g., metal).
Modern Adaptation	Households, neo-traditional enthusiasts	Comfort (muscle fatigue) > Easy-to-Use > Aesthetic	Add adjustable backrest (3°–15°), integrate hidden cushions.
Cross-Cultural Integration	Global markets, hotels	Easy-to-Use (satisfaction) > Aesthetic (simplified symbols) > Productivity	Simplify carvings, adopt modular structures (e.g., detachable footrests).

Notes:
Traditional Restoration: Prioritizes historical accuracy and cultural symbolism.
Modern Adaptation: Balances ergonomic needs with contemporary aesthetics.
Cross-Cultural Integration: Focuses on universal usability while retaining Ming-style essence.

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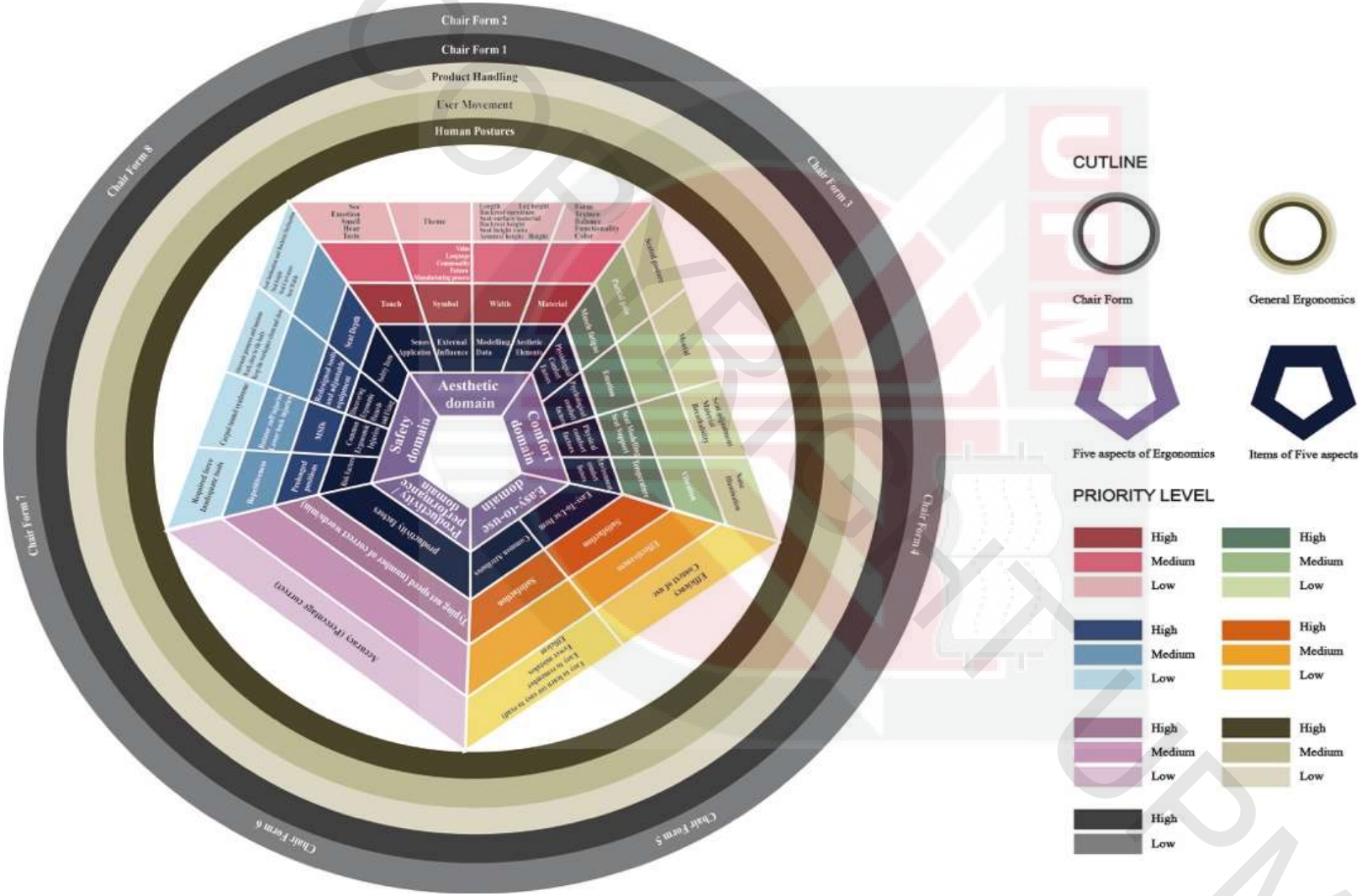

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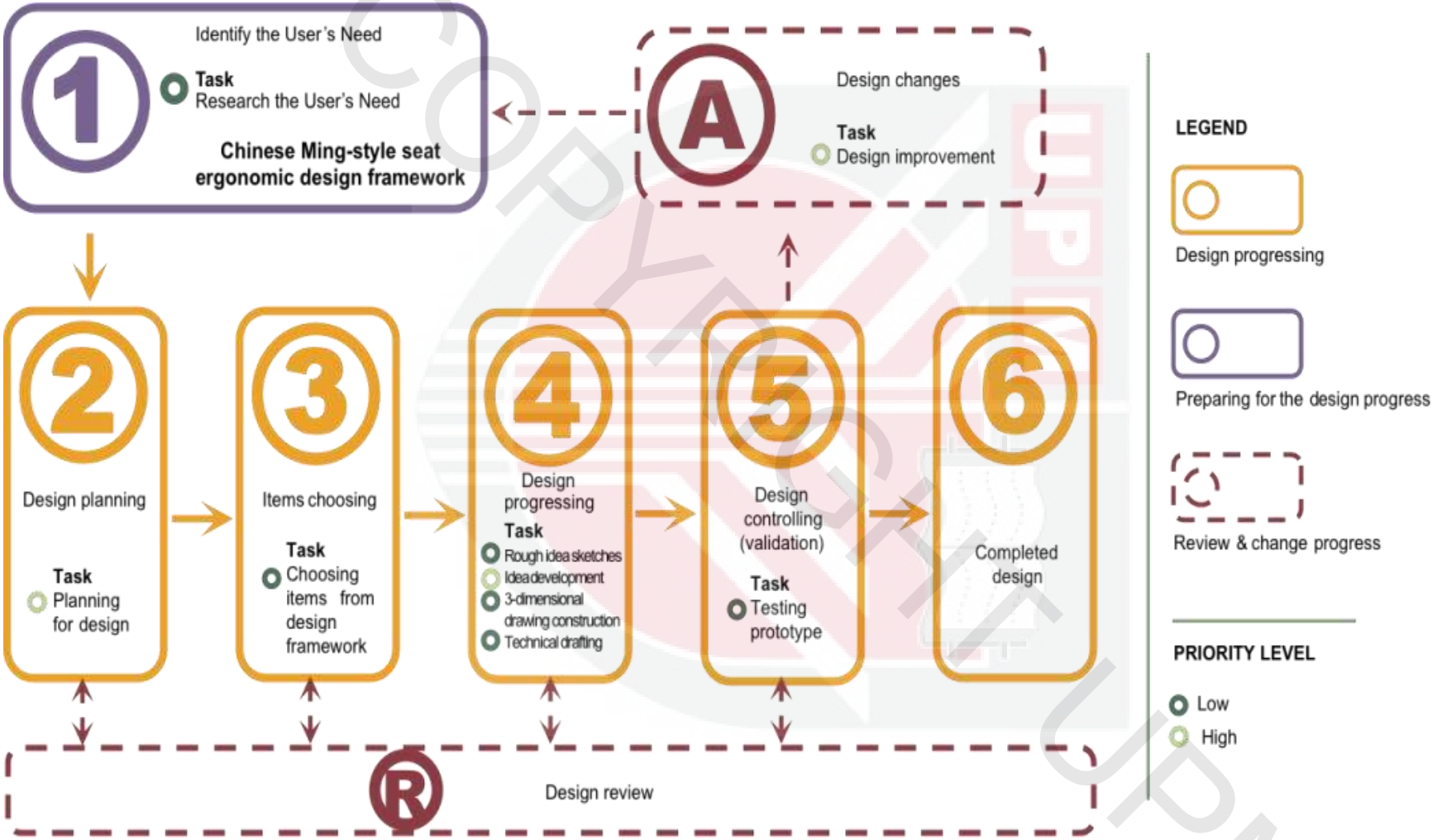

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BIODATA OF STUDENT

Born in Yinchuan, Ningxia Hui Autonomous Region, China, Bai Yifan graduated from Xi'an International Studies University (XISU) in 2014 with a Bachelor's Degree in Art and Design. Next, she studied at Ningxia University (NXU), majoring in Food Processing and Safety, with a research focus on Food Machinery Design, and obtained her Master's degree. Now, she is studying in Universiti Putra Malaysia (UPM) majoring in Industrial Design. She has been working as the Director of Teaching Office in Northern Minzu University (NMU) for more than four years.

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LIST OF PUBLICATIONS

a) Published

Bai, Y., Kamarudin, K. M., & Alli, H. (2024). A systematic review of research on sitting and working furniture ergonomic from 2012 to 2022: Analysis of assessment approaches. Heliyon, 10(7): e28384.

Bai, Y., Kamarudin, K. M., & Alli, H. (2024). A current design approach for Ming chairs. Designs, 8, 42.

Bai, Y., Kamarudin, K. M., & Alli, H. (2024). Furniture Design of Smart Art Classroom Based on Interactive Analysis of Intelligent Sensing and ITIAS. International Journal of Human-Computer Interaction, 15.

Bai, Y., Kamarudin, K. M., & Alli, H. (2024). Furniture Form Innovation and Human Machine Comfort Evaluation Model Based on Genetic Algorithm. International Journal of High Speed Electronics and Systems, 18, 2540114.

b) Submitted

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