Journal of Mechanical and Construction Engineering, 2025,
Vol. 05, Iss. 01, S. No. 081, pp. 1-10
ISSN (Online): 2583-0619

Design and Fabrication of Convertible Rods for Chair

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How to cite this paper: S. Tiwari and P. K. Singh, "Design and Fabrication of Convertible Rods for Chair," *Journal of Mechanical and Construction Engineering (JMCE), Vol. 05, Iss. 01, S. No. 081,* pp. 1–10, 2025.

https://doi.org/10.54060/a2zjournals.jmce.81

Received: 05/01/2025
Accepted: 09/03/2025
Online First: 25/04/2025
Published: 25/04/2025

Abstract

Ergonomics is the study of how humans interrelate with their environment in which they do their physical work. Ergonomics is a very less discussed topic. Chairs is one of the major parts of the field of ergonomics. In this article, numerous papers were reviewed and tried to explain the evolution of chairs. It has been found that new and innovative inventions in the field of chairs for providing maximum comfort to humans and detecting their wrong postures using various types of sensors and different types of fabrics were effective. It also proposed an idea of making chairs convertible, more efficient and taking less space.

Keywords

Design, Prototype, Base rod

1. Introduction

Chairs—objects we often take for granted—have been silent yet vital companions in our daily lives. Despite their omnipresence, chairs have seldom been celebrated or acknowledged for their influence on human civilization. Historically, chairs were not always accessible to the masses, and even today, their role in our health, productivity, and lifestyle is oft en overlooked. Yet, when examined closely, chairs are far more than just furniture—they are artifacts of design, culture, and human ergo-

nomics. The origin of chairs is shrouded in mystery. Unlike other inventions whose birth can be traced through ancient manuscripts or archaeological evidence, the chair evolved quietly and subtly.

In ancient civilizations like Egypt, Mesopotamia, and Greece, early forms of seating were reserved for the elite. Pharaohs sat on thrones crafted with gold and ivory, while the common people sat on mats, stools, or the ground. The presence of a chair signified authority, respect, and privilege. For centuries, this status symbol remained largely unchanged. In medieval Europe, chairs were primarily reserved for royalty, religious leaders, and high-ranking officials. The "chair" was not merely an object but often represented a position of power—hence terms like “chairman” or “chairperson.” In academia, a "chair" still refers to the head of a department. Over time, as societies grew more democratic and industrialization made furniture more affordable, the chair began to transition from a luxury to a necessity.

The 19th and 20th centuries saw massive changes in lifestyle, work environments, and domestic settings, which led to the development of various chair designs aimed at enhancing comfort and functionality. Among these, the ergonomic chair has emerged as one of the most significant innovations in recent decades.

Ergonomics, derived from the Greek words ergon (work) and nomos (laws), is the science of designing objects to fit the human body, its movements, and limitations. Ergonomic chairs are engineered to provide optimal support for the spine, promote proper posture, and reduce physical strain. They typically include adjustable features such as lumbar support, armrests, seat height, and tilt mechanisms to accommodate a wide range of body types and preferences.

The rise of the information age and the proliferation of desk jobs have amplified the importance of ergonomic furniture. Employees now spend long hours in front of computers, often sitting for prolonged periods without breaks. This sedentary lifestyle has been linked to a host of health issues, including lower back pain, neck stiffness, frozen shoulders, poor postu re, and even reduced cardiovascular health. Ergonomic chairs aim to mitigate these risks by promoting a more natural seating position that aligns with the body’s biomechanics.

While ergonomic chairs have revolutionized workplace comfort, they come with their own set of challenges—most notably, their size, weight, and lack of portability. Traditional ergonomic chairs are often bulky, equipped with multiple mechanical adjustments, and designed for stationary use in office environments. As remote work and digital nomadism become increasingly common, there is a growing demand for portable, space-saving, and lightweight alternatives that do not compromise on ergonomics. This is especially relevant in urban areas, where living and working spaces are shrinking. People now work from home, cafes, co-working spaces, airports, and even parks. The need for a chair that can be easily transported, quickly assembled, and adapted to any environment has never been greater.

Despite this shift in work culture, innovations in portable seating solutions have lagged. The concept proposed in this paper envisions a groundbreaking evolution of the ergonomic chair: a portable, minimalist seating device designed to offer the same level of support as a full-sized chair, while being compact, foldable, and easy to carry. The idea is to reduce the chair to its most essential components—essentially a pair of support rods—that provide core spinal support while allowing the user to maintain a healthy sitting posture. These rods could be strategically designed to anchor themselves to the floor and to th e user’s body, acting as a backrest that maintains lumbar support without the need for a complete seat structure. They could be adjustable in height and curvature to cater to individual spinal needs.

When not in use, the rods could collapse or fold into a small case, making them ideal for travelers, freelancers, and remote workers who value mobility and health equally. To achieve portability without sacrificing strength, carbon fiber emerges as the ideal material. Known for its high strength-to-weight ratio, carbon fiber is already widely used in aerospace, automotive, and sports equipment industries. Its durability, flexibility, and lightweight nature make it an excellent choice for ergonomi c applications.

Using carbon fiber would ensure that the chair support system remains light enough to carry in a backpack while being strong enough to support the user’s body weight over long periods. Additionally, its modern aesthetic aligns with contempo-

rary design trends, offering both functionality and visual appeal. Designing such a portable ergonomic support system would require extensive research in biomechanics, material science, and user interface. The challenge lies in mimicking the benefits of a full chair—especially lumbar support, hip alignment, and shoulder relaxation—within a minimalistic framework.

This future-forward ergonomic tool could also pair with mobile apps to guide users through posture optimization routines or track long-term sitting habits. The possibilities for customization and smart technology integration are vast. Such innovation has the potential not only to redefine comfort but also to elevate awareness about the significance of proper posture and the role of design in everyday well-being.

2. Literature Survey

History of chairs has been a significant yet unnoticed since years. Inventing of chairs is dated back from 9000 years old and evidences show that it was brought into existence during Egyptian and Mesopotamia civilization. Chairs cannot be taken as primary inventions since no evidence or traces were found during the Paleolithic age. It was also found that early chairs were named as Thorne and the klismos, made for a specific reason. Klismos chair came from the times of ancient Greece, exact time being unknown. Klismos were familiar from depictions of ancient furniture. Kings used to have different sitting object and the nobles and other members of king's court. This thing remained prevalent in roman era. But roman era also saw the introduction of beds which was a basically an advancement in the field of ergonomics [1].

Stools were also a category of chairs which were used only by lower levels of people during monarchy, still considered in many countries where hierarchy is the form of government. There was no specific material for chairs, a person could make a sitting object with metal pipe and leather. For example, plastic chairs of that time were painful for human as there was no space for gluteus maximus and made person difficult to stand or get up from it.

Though now it can have foldable chairs, chairs according to the need of person, but since then also, there has been a consistent theme in design of chairs, there is still experiments and advancements going on to provide maximum comfort to humans [2]. Paneling, often carved with linenfold and sometimes with other Gothic motifs, was used on the back, arms, and base. Many of these chairs had exaggeratedly high backs terminating in elaborately carved canopies; some were freestanding, while others had their backs fixed to the wall in the manner of a church stall.

As the revolutions happened, forms of government changed, slowly the creativity and ease of humans were coming into consideration and new forms of chairs started developing. Now, instead of design and structure, focus on materials was the focus, like rattan and wood.

In the twentieth century, chairs were of various designs, but never focused on the comfort or the human need, as technology was also somewhere the reason for these disadvantages. IF talking at a global level, China did not know about chairs, but after opening of the silk road made them introduce about the chairs, and in 3 rd century AD, folding stool were introduced in the Chinese imperial court. In the late twentieth century, ergonomic design of chairs are gaining importance as office cul- ture has taken a steep growth in last 100 years, so matter of comfort of employees is also being taken seriously.

It has become mandatory nowadays for offices to keep the ergonomic design feature for office chairs, to smoothen the work flow. Since then, ergonomic design is always considered while designing any type of chair. These major advances are seen nowhere in regular chairs and discomfort is more, regardless of the age factor [3].

3. Objective

The project's objective is to automate the existing chairs, converting them into a portable chair and reducing the size to ju st a size of a pair of rods. Chairs takes up a lot of space and for travelling purposes, or for camping, taking own chairs becomes a hinderance in traveling. Also, many older people, when they go for a walk, sometimes need a place to sit, and they cannot

find it. Convertible rod is a one stop solution for these, because a pair of rods can be hold by just one hand and can be tak en anywhere. If a person wants to sit, these rods can be converted into a full chair with arms in just three steps.

For making it convert into rods, just three steps and it converts into a pair of rods. The chair provides a backrest and arm rest so that person gets the feel of sitting an actual chair. Chair material is to have aluminum to make the rod light-weight and can withstand high load also. The base rod, all other parts are made of carbon fiber so that rods are extremely light-weight and have good strength. As materials play an important role in affecting the quality of a product, carbon fiber can be a good alternative in making chairs, as it is lightweight, has more strength compared to other materials used. Following properties makes carbon fiber on top of choice than other materials.

1. Strength-to weight ratio- it is lighter than steel
2. It has high resistance i.e. it can withstand high load and does not get deforms easily.
3. Low density
4. Corrosion resistance- it has high corrosion resistance and does not get corroded unlike other metals.
5. Withstand high temperature- It can high withstand high temperature.

For converting back the chair into pair of rods, the baton attached in the base rod and arm must be rotated so that cloth gets wrapped back around it and the rods get attached back. For the arms, legs and base, they just have to be rotated back and compressed into the rod.

3.1. Target customer

Our target audience are the ones who travel on a frequent basis and the ones who are elderly citizens. In detail, how can our chair be useful, they are as follows-

1. Travelers travel to places where there are no facilities.
2. Senior citizens, especially the one who have weak legs and cannot stand for long.
3. For event management companies and the ones who give chairs on rent, so that more and more chairs can be transported easily, without any having an issue of piling up or taking large space.
4. In areas where people must wait for long hours and does not have facility, like bus stands and in metro stations.

3.2. Feasibility

The prototype is completely feasible as the technology is very basic and just an automation and improvement over the current existing chairs, making it and portable and of better quality. The material used is aluminum which has high strength and is lightweight, and there is no electronic or electric component included in the whole structure, so making cost will als o be very less.

The chair is economically feasible for customers also as the price variation between a normal chair and convertible rods will be very less, and customers can choose convertible rods over normal chair as it is more efficient than a normal chair.
Statistically proving, following are the breakup costing of each part of Prototype- Costing for each part during manufacturing-
Aluminum- 200/- per plate Required sheets (approx.)- 04 Total costing- 800/-
CV joint costing (made of wood)- 20/- Labor cost- 200/- approx.

Total cost for manufacturing whole prototype- 1000/- approx. A normal chair having all necessary supports never costs less than 1000/-, and we can see that the costing of making convertible rods is around same as of normal chair, so we can say that the chair is economically feasible and reliable for the people using it. The chair also has high strength because the material used for making the chair is aluminum which is light in weight but has high strength.

4. Methodology

Our method was secondary data analysis/ archival study. This approach allowed us to investigate existing literature, analyze documented findings, and drawing comprehensive insights from a wide range of sources. For the review paper, it examined and scrutinized ten scholar papers that detailed historical, functional, and ergonomic evolution of chair and seating furnitu re, and then interpreted the chronology of evolution of chairs and furniture used for sitting.

By reviewing these selected papers, we were able to map out a chronological progression of how chairs have transformed over time, both in terms of design and functionality. This historical analysis underlined how various social, cultural, and technological developments influenced chair design through different eras. It took around 6 -7 articles to study how the comfort can be increased through chairs for people who are sitting for a longer duration, as employees having desk job have a working period of 9 to 5.

For the inspiration of prototype, we studied various predesigns of chair and also studied the ergonomics field, wherein we understood the concept of comfort and the need of chairs. We also looked upon the current world scenario of what advantages and disadvantages are there in the chair, what improvements can be done and how it affects the person's overall posture.

In our study, special emphasis was placed on understanding the growing importance of comfort in chair design, particularly for individuals who spend extended hours seated, such as employees with 9 -to-5 desk jobs. Out of ten reviewed papers, approximately six to seven were specifically dedicated to studying factors that influence comfort and support for long-term sitting.

It also explained how ergonomics came into existence and how ergonomic chair gained importance. It also introduced a concept of convertible rods which can be fully converted into chairs. The idea is purely practical and efficient for the place where large number of chairs are required and are easily portable.

These papers provided valuable insights into pressure distribution, lumbar support, armrest design, and material usage, all crucial elements in ensuring ergonomic well-being. Such featured are especially critical in modern work environments where sedentary behavior is linked to physical strain and health issues.

To develop ideas for prototype, we explored various pre-existing chair designs and thoroughly reviewed the field of ergonomics. This included examining how the discipline of ergonomics has evolved over time, from its early applications in industrial settings to its widespread usage in modern office furniture. Through this exploration, we gained a deeper understanding of what constitutes a "comfortable" chair and why that comfort is essential not only for physical health but also for productivity and mental well-being. Additionally, our review delved into the importance of proper posture, which is directly influenced by the quality of seating. Poor chair design can result in long-term musculoskeletal problems, while a well-designed chair can promote correct spinal alignment and reduce fatigue.

We also assessed the current global landscape of chair usage, highlighting both the advantages and shortcomings of existing models. This helped us identify potential areas for innovation, such as enhanced adjustability, improved portability, and multifunctional features.

One particularly innovative concept that emerged from our review was the idea of using convertible rods that can be fully transformed into chairs. This concept offers a practical and space-saving solution for environments that require many chairs, such as conference halls, events, and temporary workspaces. These roads would be easy to transport and store, making them ideal for flexible usage scenarios. Ultimately, the study not only illuminated the historical and functional progression of seating but also provided a foundation for designing a new type of chair that is both ergonomic and adaptable to various user needs. Our findings reinforce the significance of research-based design in creating furniture that aligns with the physical and psychological needs of modern users.

5. Mechanism

- Major parts include a pivoted headrest, a lumbar supportive backrest, and casters for making chair movable.
- Overall design should be as waterfall edge, depth being adjustable. These major parts assemble to make a chair, and most of the parts must be adjustable so that when chair gets converted into rod, these parts get folded and thus result in overall reduction in the size of chair.
- Material used for arm, base and leg of chair will be aluminum as it is lighter and has a good strength.
- Joints used between the arm and the leg will be constant velocity joint, a cv joint which makes the leg rotate fully while opening, as the leg and base will be forming a simple turning pair, so when the arm will come out from the rod, the leg and base attached will also come out, firstly making an S-shape structure.
- Since, there is a CV (constant velocity) joint between leg and arm, so leg and base will rotate 180 degrees, and base shaft will attach at the bottom of the base rod.
- The two rods will be having the same attachment (leg, base, and arm), and both the rods will be joined by a cloth at the pelvis resting area and at the top of rods for the lumbar support.
- A button will be at the top of the right rod which, on pushing, will release the lever which is holding the spring attached to the baton preset inside the rod, and the cloth will release, thus, as a result, the other base rod will separate from the right rod and both the base rods will become stiles of chair.
- While making the chair compact and converting into rods again, just de-attach the base shafts from the base rods and rotate about 180 degrees and all three shafts will contract and move inside the base rod.
- The arm, which is currently at 90 degrees from the original position, will again move 90 degrees and get inside the base rods
- There are 2 batons present in the right base rod, the cloth providing lumbar support will wrap around one of the batons, and the cloth providing the pelvis support will wrap around the other baton. Both batons will be rotating around the hollow cylindrical area present inside the arm and base rod.

Dimensions and components of chair is as follows-

1. Base rod
2. Arms shaft
3. Leg shaft
4. Base shaft
5. Spring (present inside the base rod)
6. Spring (present inside the arm shaft)
7. Cloth (for lumbar support)
8. Cloth (for pelvis support)
9. Push button

Table 1. Dimensions of components present inside base rod

Name (all shafts of cuboid shape)	Length	Breadth
Arm shaft	10 inches	4 inches
Leg shaft	15 inches	4 inches
Base shaft	10 inches	4 inches
Baton (inside base rod)	3 inches	1 inch diameter
Baton (inside arm shaft)		

Table 2. Details of material used in chairs

Name	Material used
Base rod	Aluminium
Arm shaft	Aluminium
Base shaft	Aluminium
Leg shaft	Aluminium
CV joint	Wood
Baton (inside base rod)	Plastic
Baton (inside arm shaft)	Plastic

For calculating the degrees of freedom between the shafts, formula used was- 3(n-1) – 2j – h, where, n= no. of links j= no. of joints h= higher pairs

5.1. Types of joints between shafts

a) Between arm shaft and base rod- hinged joint.
b) Between leg shaft and arm shaft- CV joint(constant velocity) having rotation motion.
c) Between leg shaft and base shaft- hinged joint.

5.2. Design Specifications

The figure shown below is a 2-d design (drawn on AutoCAD), an isometric view showcasing a fully opened chair form, having all the necessary dimensions shown. All the drawings, designs are constructed in AutoCAD, using essential tools. The imaginative design was implemented and constructed considering all the laws and forces, resulting in the final design of the imaginative design of the convertible rods for chair

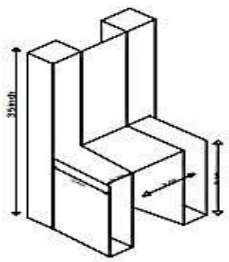

Figure 1. Isometric view of chair

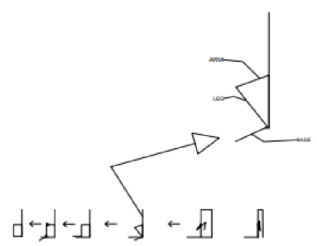

Figure 2. Side view of mechanism

Above figure is basically the sequence in which the rods will get converted into chair. The sequence is basically in the following steps-

1. The arm shaft, leg shaft and base shaft, all will get contracted in the base rod, in a parallel direction, overlapping each other and coming inside the base rod.
2. On opening the base rod for chair, the arm shaft is connected to the base rod, with a pivot joint. The arm shaft is connected to the leg shaft through a cv joint, and the leg shaft is connected to the base shaft through a hinge joint.
3. As arm shaft will move direction 90 degree towards the top, the leg shaft and base shaft will automatically get out of the base rod and leg shaft will turn 90 degrees towards outer side and similarly the base shaft will turn 90 degrees.
4. Thus, all three shafts will form an S-shape.
5. Since, there is a CV joint between arm shaft and leg shaft, so the whole leg shaft will rotate 180 degrees towards the base rod and as there is no such type of joint between leg shaft and base shaft, so there is no rotation motion happening between leg shaft and base shaft.
6. In result, the base shaft will also rotate 180 degrees and ultimately join the bae rod.
7. Regarding the support for pelvis and lumbar region, there is a baton present in the arm shaft and the base rod around which a cloth is wrapped around.
8. As soon as the button is present, the rods will get distanced and the cloth will open fully, acting as the support for lumbar region.
9. Similarly, both the arm shafts of each rod will turn 90 degrees and the cloth present between them will come out and will act as a support for pelvis region.

The drawing below showcases the CV joint present between the arm and leg shaft which can rotate 360 degrees, and will be responsible for joining the base shaft with base rod, as there is no rotating joint between leg and base shaft, so to join the base rod with base shaft, the user just needs to rotate the arm shaft 180 degrees and the chair support will be formed.

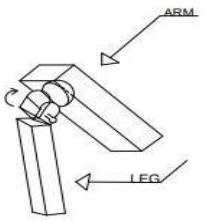

Figure 3. Joint movement between Arm and Leg

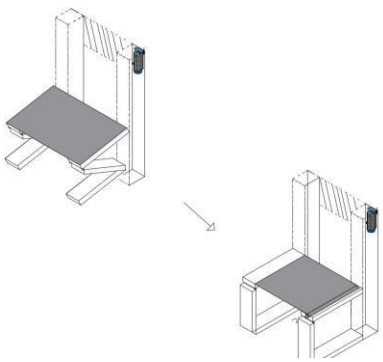

Figure 4. Isometric view of Project C.R.

The above design is the inside view of base rod having the mechanism of cloth being stretched between chairs for lumbar support and a cloth for the pelvis rest. Inside the base rod, there is a spring attached with both the batons, which will give the force to ither base rod to get distanced and form the back support and pelvis support. There is drawing is showing the cross-section view of the base rod, wherein it can be seen that the baton is present in the base rod around which the cloth is wrapped which is used for supporting lumbar region. There is also a baton present inside the arm shaft and around which there is cloth wrapped which will act as a pelvis support when the person will be sitting on that chair. The rods will get separated by the means of force of springs, as when the button will get pressed, the springs will get released, resulting in pushing the other rod to open and form the lumbar and pelvis support.

6. Comparative Study

A comparative study was conducted, in which the design and functioning of existing chair was compared to the prototype convertible rods. Talking about a normal chair, for making it portable, there is no possible way that chairs size can be reduced or it can get converted. This problem is solved and the design prototype is portable as when the prototype is in the chair form, for making it portable, a person can make its legs and arms shift inside the base rod, and just rotating the baton, the cloth will get rolled inside the arm shaft and leg shaft, so the person can take whole chair in one hand. If several chairs are required somewhere, for example, 50 chairs can be taken somewhere, convertible rods make that number to 150, as on reaching the place, on just pressing the two buttons, lever will push the cloth, separating the two rods and creating support for lumbar and pelvis region, and so the shafts will come out automatically, making the arm, leg and base support. In comparison to the traditional chair, there is no choice rather than carrying the whole chair from one place to another.

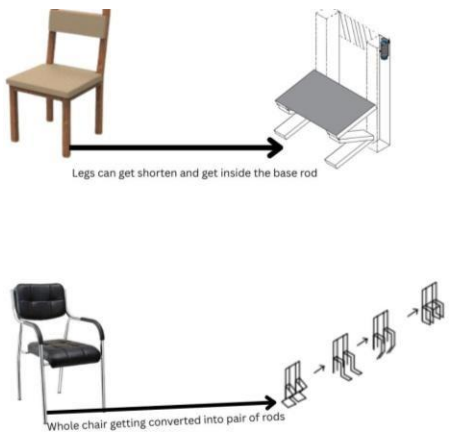

Figure 5. Pictoral view of changes in chair design

7. Findings and conclusion

7.1. Findings

Based on testing done of the functionalities of prototype, findings suggest that the prototype convertible rods are completely plausible and conceivable. All the movements in the prototype are completely practical using a combination of all the methods of mechanical field and, and it is ready to use for the people using it. All the mechanisms involved in the proto- type are not completely copied from any of the existing designs, but inspiration or an idea is taken from them. The proto- type material is completely reusable, making it ecofriendly and nontoxic to environment.

7.2. Conclusion

The prototype presented in the report is not only entirely plausible but also demonstrates a significant improvement over conventional chair design. The evaluation conducted throughout the development and assessment phases reveals that the prototype offers an effective automation of existing chair functionality. Rather than being a mere replication of traditional models, the new design incorporates innovative features aimed at enhancing user comfort, accessibility, and overall utility. The upgraded design is built with the intention of addressing several common limitations associated with standard chairs, such as adjustability, ergonomics, and material efficiency, while simultaneously introducing automation to simplify usage. One of the most noteworthy aspects of this prototype is its user-centered design approach.

It places a strong emphasis on convenience and adaptability, ensuring that users of all ages and physical capabilities can benefit from its features. The chair incorporates automated mechanisms that allow for seamless adjustment in terms of height, reclining angle, and lumbar support—all of which can be customized with minimal effort. This level of automation is particularly beneficial in environments where users may need to frequently shift positions or require assistance with posture control, such as in workplaces, healthcare settings, or for elderly users at home.

Moreover, the technical components and mechanisms integrated into the prototype are designed to be cost-efficient. The engineering team has focused on utilizing readily available materials and simple mechanical systems that do not compromise durability or performance.

This careful consideration of affordability without sacrificing quality ensures that the final product remains accessible to a broad market base. Customers are likely to appreciate this blend of modern features and economic feasibility, making the chair not only desirable but also practical for mass production and distribution.

In terms of testing and validation, the prototype has undergone thorough evaluation in line with the established norms and safety standards applicable to seating furniture. These tests included load-bearing assessments, stability evaluations, endurance trials, and ergonomic testing to verify that the chair performs well under various conditions. Special attention was paid to ensuring compliance with national and international safety regulations, which adds a layer of credibility and readiness for commercial release.

The results of the testing phase have been overwhelmingly positive. The prototype has been declared fit for use by individuals across different demographics, with no significant flaws or safety issues detected in its design or operation. The chair successfully met or exceeded all key performance indicators set forth during the development phase. Feedback from trial users highlighted the chair's ease of use, comfort, and the added value of its automated features. In conclusion, the report affirms that this prototype represents a meaningful advancement in chair design. By integrating user convenience, innovative automation, cost efficiency, and strict adherence to safety standards, the prototype is well-positioned to set a new benchmark in the furniture industry. It not only modernizes an everyday object but does so in a way that enhances its functionality and broadens its appeal.

References

[1]. M. G. Helander, "Forget about ergonomics in chair design? Focus on aesthetics and comfort!," *Ergonomics*, vol. 46, no. 13–14, pp. 1306–1319, Oct. 2003.

[2]. L. Zhang, M. G. Helander, and C. G. Drury, "Identifying Factors of Comfort and Discomfort in Sitting," *Human Factors: The Journal of the Human Factors and Ergonomics Society*, vol. 38, no. 3, pp. 377–389, Sep. 1996.

[3]. D. P. Michel and M. G. Helander, "Effects of two types of chairs on stature change and comfort for individuals with healthy and herniated discs," *Ergonomics*, vol. 37, no. 7, pp. 1231–1244, Jul. 1994.