

Design of female white-collar office chair based on ergonomics

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Abstract. In the daily work of office workers, the comfort of the office chair has a great impact on the staff's work efficiency and human health. Sitting on the office chair for a long time may cause diseases such as cervical, shoulder, and lumbar spine. This article uses online literature research, brand analysis, and offline field research to understand the current status and deficiencies of office chairs, find design points and design directions, and based on ergonomics and sitting analysis research, design general office chairs for female white-collar workers to achieve a comfortable and healthy office purpose.

1 Introduction

With the continuous advancement of the information age, the number of office workers is increasing day by day, and the modern office environment and working methods are gradually improved. More and more work needs to be done by sitting down, and the office chair has become an indispensable supply for office workers. Occupational diseases caused by work (such as scapulohumeral periarthritis, cervical and lumbar spondylosis) are becoming more and more serious, for female employees, even can cause diseases such as gynecological inflammation, one of the reasons is sitting uncomfortable office chairs for a long time, which not only affects the physical and mental health of office workers, but also affects the work efficiency of office workers. Therefore, it is necessary to design an office chair that conforms to the relationship between human and machine according to the design shortcomings of most ordinary female white-collar office chairs. It is hoped that this product will not only meet the basic seating functions, but also ensure that the office chair has a comfortable use experience, and at the same time have no negative impact on the physiology and psychology of ordinary female white-collar workers.

2 Investigation and analysis of existing office chairs

The preliminary research is divided into literature research and offline research. The offline survey is mainly to go to the local furniture city of Changzhou to conduct an office chair test sitting experience and analyze it. Through the analysis of the previous survey results, we look for design points and design directions, accurately locate and analyze, find problems, and solve problems.

2.1 Literature research

According to literature research, at present, the innovative design of most office chairs lies in the design of adjustable functions and the functional design of massage and upright sitting, which is also a reflection of the current multifunctional design trend of office chairs. In addition, the analysis of the four main sitting postures of office workers at work (see figure 1 [1]) shows that office workers often feel discomfort in the neck, shoulders and waist in the office, so the design of the office chair in the headrest and backrest is particularly important for the human-computer relationship.

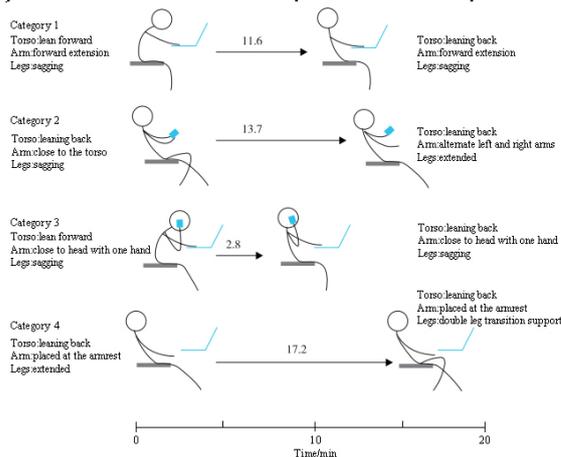


Figure 1 Four main sitting postures

2.2 Analysis of the shortcomings of existing office chairs

2.2.1 Chair back. Most of the existing office chairs do not fully consider the size of the human body in terms of the height design of the seat back, most office chairs can

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only be used by a small number of people, and they are not friendly to the comfort experience of other people. Taking the office chair shown in figure 2 (1) as an example, its main problem is that the back of the entire chair is designed to be high, and it is fixed, and it cannot adapt to most human body sizes. In addition, there are two other problems with the back of office chairs in the market: the curve of the back does not conform to the curve of the human body and the force is unreasonable; the material of the seat back is not flexible enough, and the soft and hard grips are improper.

2.2.2 Headrest. The existing office chair with a headrest generally sets the headrest too high and the angle adjustment is very limited, so that most people cannot use it to support the cervical spine and even cause discomfort. Figure 2 (2) This office chair, after a trial sitting experience, we found that the obvious disadvantage of this product is that its headrest is set too high and the angle adjustment is very limited. When a person sits on his back, the cervical spine is lower than the headrest. For slightly taller people, because the adjustment range of the headrest angle is quite small, it may also cause a discomfort in the neck curve. In addition, there are two other problems with headrests of office chairs in the market: the side curve of the headrest does not conform to the neck curve of the human body, and the force is unreasonable; the material of the headrest is not flexible enough, and the soft and hard grips are improper.



Figure 2 Schematic diagram of insufficiency of chair back, headrest, seat, armrest

2.2.5 Adjustment controls. Most of the existing office chair seat height adjustment is generally through the air lever, users often need to bend to control, inconvenient and uncomfortable; In addition, some office chairs with more adjustment performance, they have too many adjustment controls, which is very inconvenient.

2.2.6 overall chair frame. There are two other problems with the chair frame of the office chair on the market: The chair frame is the skeleton of the entire chair, the chair frame of most existing office chairs is too bulky, and at the same time, the chair frame cannot be guaranteed to be firm and elastic; the chair frame connects various parts of the chair, and the connecting part has low flexibility and reliability.

2.2.7 Overall form. There are two other problems with the overall appearance of office chairs in the market: The

2.2.3 Seat. The main disadvantages of most existing products in terms of chair seats are uneven body pressure distribution, failure to consider repression of the reproductive system, and adaptive adjustment of body size. The obvious disadvantage of this office chair in figure 2 (3) is that its seat surface is very smooth, long-term use can easily cause uneven body pressure distribution and squeeze the reproductive system. In addition, most of the office chair seats on the market are made of materials that are not breathable, thin enough, and sweat-absorbent, which can easily cause female diseases.

2.2.4 Armrest. The armrests of most of the existing office chairs are free-standing, they are basically similar in shape, lack multi-dimensional adjustments, and some are even narrower. Taking the office chair shown in figure 2 (4) as an example, the main problem with this office chair is that the length of the armrest cannot satisfactorily support the forearm in the sitting position. On the one hand, the width is too narrow, on the other hand, the front and back of the armrest cannot meet the demand because it cannot be translated. In addition, the material used for the armrests of most office chairs on the market is not breathable, thin enough, and sweat-absorbent, and long-term work breaks can easily cause arm discomfort.

overall shape of the chair is not in line with the aesthetics of contemporary white-collar women, and the lines and frames are too rigid. The color scheme of the chair is black, white, and gray, which looks old-fashioned and lacks vitality.

3 The analysis of the redesigned office chair

3.1 Office chair overall effect

Figure 3 is the overall effect diagram of the office chair improvement scheme. The service group for this design is young white-collar women, so the overall shape of the office chair is mainly curved. On the premise of satisfying the function, try to use the curve as a frame to reflect the beauty and softness of female lines from all angles, avoiding rigid and cold visual and psychological feelings.



Figure 3 overall effect diagram

3.2 Design principles for office chairs

3.2.1 Meet the physiological characteristics of the target group. In order to keep the user in a natural posture while sitting, the design of the seat should match the natural physiological structure of the human body, and should conform to the relevant principles of human biomechanics. The redesigned seats should meet the relevant requirements of shape characteristics and body pressure distribution in terms of structure[2], and

minimize the fatigue and wear of the human body. The following will explain the various parts of the office chair.

1) Determination of the overall size: Before designing the office chair, we must first grasp and understand the average human body size of the staff in the sitting position, and then understand the body size range of modern white-collar women, and develop a suitable range of office chair size design[3]. Sitting body size (female) is shown in table 1.

Table 1 Sitting body size (female)

Measurement Item	Mean	Standard Deviation	mm						
			P1	P5	P10	P50	P90	P95	P99
Height	1631.2	47.9	1520.0	1550.0	1570.0	1630.0	1695.0	1709.2	1735.0
Sitting height	866.7	52.9	753.8	793.2	813.6	870.0	924.0	950.0	992.4
Sitting cervical point height	646.5	57.6	519.4	554.8	580.0	650.0	710.0	730.0	780.0
Seated eye height	757.1	57.8	521.3	667.0	700.6	760.0	818.0	850.0	892.4
Sitting shoulder height	578.1	63.7	410.0	469.6	515.2	590.0	631.0	668.4	730.0
Sitting elbow height	274.9	49.5	165.2	201.6	220.0	270.0	340.0	360.0	420.0
Sitting thigh thick	129.7	22.3	97.6	100.0	102.6	130.0	155.0	169.2	206.9
Sitting knees height	516.0	40.7	420.0	450.0	465.0	510.0	574.4	580.6	600.0
Calf height	434.9	38.4	323.2	369.4	388.4	440.0	481.0	500.0	516.2
Sitting deep	444.9	39.6	350.0	380.0	390.0	450.0	498.0	508.0	530.0
Sitting lower limb length	923.5	62.2	757.6	820.0	850.0	922.0	1000.0	1029.2	1100.0

Considering the requirements of ergonomics, and taking the human body size in the sitting position as the reference, the office chair size is determined as follows(table 2) based on the factors such as seat height,

seat depth, seat width, seat surface inclination, backrest height and width, backrest and seat surface angle, seat surface hardness, armrest height and other factors.

Table 2 Dimension description of each part of the improved design scheme

Parameter	Size/ range	Parameter	Size/ range
Backrest fixed height	480mm	Headrest width	200mm
Backrest width	420mm	Headrest height	100mm
Backrest height adjustable range	120mm	Adjustable range of headrest angle	95°-240°
Backrest tilt angle adjustable range	95°-115°	Headrest thickness	30mm
Backrest Waist Back Thickness	30mm	Armrest fixed length	280mm
Adjustable range of armrest height	200-230mm	Adjustable range of sitting height	380-450mm

Adjustable range of armrest tilt angle	-12°-12°	Adjustable range of seat depth	360-430mm
Armrest horizontal twist angle	-15°-15°	Sitting wide	500mm
Front and rear armrest range	70mm	Adjustable range of seat angle	-5°-10°
Armrest width	85mm	Chair frame average width	70mm
Chair frame thickness	6mm	Foot stand footprint	650mm
The height of the lower edge of the backrest from the seat surface	70mm	Height of lower edge of headrest from upper edge of backrest	80mm

2) Backrest: According to relevant physiological knowledge, when the human body stands naturally, the spine of the upper body maintains the most natural posture, at this time, the pressure on the intervertebral disc and the static load of each section of the spine are evenly distributed[4], the human body is not easy to fatigue, and the lumbar spine is not easy to wear, when the human body is in a sitting position, the spine changes from forward to convex, turning from "S" to arch, and the degree of kyphosis of the spine changes with the change of sitting posture. Under normal circumstances, the cervical spine is anteriorly concave, and the curve with a large range of motion is the largest part of the spine's range of motion, and the curvature of the cervical spine is also related to the curvature of the thoracic and lumbar spines, thereby maintaining spinal balance [5]. Figure 4 shows the shape of the human spine under normal conditions. Therefore, from the top to the bottom of the office seat backrest, a headrest, a shoulderrest and a waistrest should be provided.

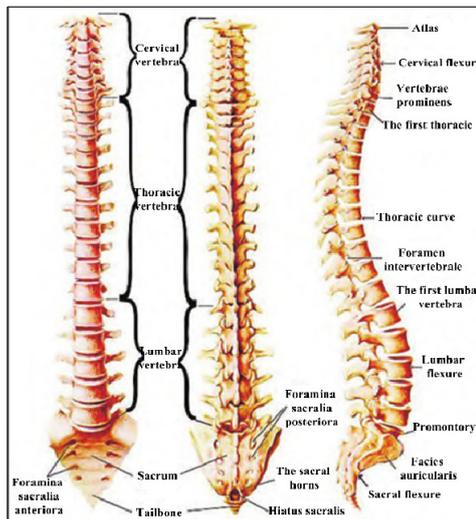


Figure 4 Human spine morphology

As a result, the redesigned office seat back is shown in figure 5 (left): the front mimics the shape of the female back; the sides show a soft S-shape, the thickness increases from top to bottom, and the shoulder and waist backs are set by curvature. It adopts adaptive adjustment, tilting angle can be adjusted and locked, and it can be adjusted with the curve of the back. In addition, the height of the backrest can be adjusted up and down through the manual control button.

The redesigned office chair headrest is shown in figure 5 (right): The front has a gentle U-shape, and the curve is soft and beautiful; the side supports the cervical vertebra by curved arcs; the headrest angle is adaptively adjusted, and at the same time, it is controlled by the manual button one-touch flip cover for use.



Figure 5 Backrest shape (left) and headrest shape (right)

3) Armrest: According to the study of the sitting position of the human body during work, it can be known that even the same person, during the work process, will continue to change and adjust the sitting position as the task changes, and the overall change of sitting posture of different human bodies is consistent. Through the study of the four main sitting postures in figure 1, the following conclusions are drawn: When the user is in a

state of relaxation, talking, etc, the torso leans back, and the arm will naturally be placed on the armrest, and modern urban white-collar women do not have to perform high-intensity work all the time, there are fragmented breaks. So office chairs should be equipped with armrests to facilitate rest and improve office efficiency.

Figure 6 is the armrest of the redesigned office chair. The armrest has a curved shape, and the front part is slightly higher than the rear part, which conforms to the shape of the arm when leaning back. The width of the armrest is slightly wider than the forearm, so there is no chance of pinching. The back of the armrest is slightly raised, which does not cause pressure on the elbow. At the same time, the armrest can be adjusted in 4D. The seat, back, and armrest adjustment controllers are set on the armrest, the design is differentiated by size, shape, brightness, position and pattern, striving for visual and tactile differences.

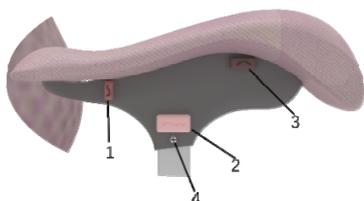


Figure 6 Armrest shape

4) Seat surface: When the human body is in a sitting position, the pressure distribution of body weight on the seat surface and the backrest is called the seated body pressure distribution. According to the body pressure distribution curve in figure 7, it can be seen that the hip-sciatic junction is the body's most tolerable pressure and should bear more than half of the human body's weight, so the outward pressure gradually decreases until the



Figure 8 Front and side shape of seat

3.2.2 Tunability Principle. According to the analysis of the sitting posture of the human body, the sitting posture of the human is not fixed. In order to meet the user's regular sitting habits and subconscious adjustments, the office chair should be structurally and functionally compatible with the sitting posture and provide sufficient compatibility.

In order to meet the size requirements of most female white-collar workers, there are many parts that need to be adjusted in the design of the seat, such as the seat, back and armrest. The electric adjustment buttons of the car seat provide a reference for our design. The design of the control button is based on the principle of the car seat adjustment buttons, as shown in figure 9.



Figure 9 Car seat adjustment buttons

front edge of the chair contacts the thigh, where the aorta is distributed, and the pressure will cause poor blood circulation in the lower limbs, so it is the most unsuitable for bearing weight.

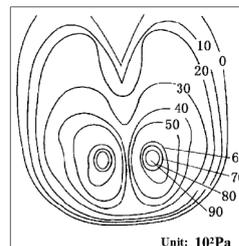


Figure 7 Body pressure distribution curve

In this regard, the office chair redesigned in this article uses a different hardness design: the seat part in contact with the ischium joint is made of harder hard steel as the internal material, and a thin layer of foam material is provided outward. Thick foam is used in contact with the thighs. In addition, the shape of the seat adopts a curve based on human biomechanical research. The seat surface is slightly forward, and the rear seat surface is convex, which can make the ischium joint bear most of the body's weight. The middle of the front of the seat is slightly concave to protect the reproductive organs from compression; the edges are inclined downward and the curve is gentle, reducing the thigh stress. See figure 8.

The car seat buttons are used, as shown in figure 6: the adjustment button 1 is used to adjust the height of the seat back, and the telescopic mechanism on the backrest is controlled by it, as shown in figure 10 (left). The button is near the back of the chair, which is long and has the smallest volume, and it is designed with a curved curve pattern on the back side of the seat, and the brightness is centered. The adjustment button 2 is used to adjust the seat height, seat depth and seat surface inclination, it is used to control the telescopic mechanism under the seat, as shown in figure 10 (middle). The button is close to the seat surface and has a square shape with the largest volume, the design has a pattern with a curved arc on the side of the seat surface, with the brightest brightness. The adjustment button 3 is used to adjust the armrest to move back and forth, up and down, and turn up and down, it controls the telescopic mechanism of the armrest, as shown in figure 10 (right). The button is close to the skin-friendly surface of the armrest and is square in shape, it is centered in size and has an arched pattern on it, with the darkest brightness. In addition, the armrest can be rotated in the horizontal direction by the balls 4.



Figure 10 (from left to right) telescopic mechanism for seat back, seat, armrest

3.2.3 Material comfort and feasibility. Taking into account the different hardness design of the seat, the breathability and comfort of the skin-friendly surface of the seat, the use of existing materials, etc, the back and headrest are mixed with five layers of materials: the middle layer is an elastic and innovative support frame, and the two outward layers bubble-permeable cotton, the top two layers of breathable woven mesh. The skin-friendly surface of the armrest is mixed with breathable cotton + double-layered woven mesh, and the armrest support is mixed with elastic plastic + hard plastic. The seat part is designed with different hardness, and the anastomosis of the ischial junction is mixed with five layers of material: elastic plastic with a large hardness in the middle, two thin layers of air-permeable cotton outside, and two layers of breathable woven mesh on the outermost surface. Three layers of materials are mixed in the other parts of the seat: the middle is breathable foam + surface breathable woven mesh.

4 Conclusion

4.1 Completion

For an office chair that is indispensable for office workers, its design must be based on human-computer relations, in terms of size, structure and function, as well as in color, material, and shape. Only full use of ergonomic principles when designing, the concept of "people" as the core will be reflected. The health problems faced by office staff due to the irrational design of office chairs, reduced work efficiency, physical discomfort and psychological unhappiness will only be improved. The ergonomic office chair redesigned in this article strives to optimize and innovate in the aspects of aesthetic expression on colour and shape, materials, and human-computer relations, it mainly solves the problems of insufficient human-machine relationship considerations such as insufficient adjustable functions, poor body size adaptability, and insufficient aesthetic expression in most existing office chairs, it also embodies the people-oriented design concept and respect and care for users.

4.2 Suggestions for similar research in the future

In the future, we hope to have more designs of various products based on ergonomics. In the design of office

chairs, designers must also fully consider the human-computer relationship, so that office workers can work comfortably and healthily, and improve their work efficiency. In this regard, we make the following suggestions for future research:

- Ergonomics is a broad subject, designers should conduct research and practice from various fields, such as the selection of materials and the feasibility of institutional settings. Therefore, a design team should be composed of members of various professions.
- Before designing, the service crowd of the product should be specified, designing for a specific population, blindly trying to meet the needs of all populations may be counterproductive.
- The function cannot be combined and superimposed blindly for the purpose of function diversification, which may actually hinder the main function of the product.
- Humans are still evolving, the appropriate size in the past may no longer fit the current human scale. The use of relevant data should keep pace with the times.
- In the design of ergonomics, not only should it be considered physiologically reasonable, but also the psychological factors of the person should be comprehensively considered to attract users with emotional design.

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