An Ergonomic Study of Child Seat Comfort Based on Pressure Distribution

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Abstract: As the living standard improves, users also put forward higher requirements for the comfort of child seats. This paper studied the comfort of child seats from the perspective of human pressure distribution characteristics, and the effect of different child seat angles on the human pressure distribution. The X-sensor pressure distribution test system was used to test the human pressure distribution and the subjective evaluation of human comfort under different child seat angles. The effect of child seat angle on the pressure of the ischial tuberosity position of the hip contact surface, mid-thigh position, front-thigh position and the backrest was analyzed, and then the area values of these three different levels of pressure areas and their respective percentages of the total contact area were extracted separately, and the effect of the child seat angle change on them was analyzed. Finally, the most relevant index parameters for human subjective comfort were selected and the most comfortable child seat angle was solved.

1 INTRODUCTION

1.1 Mics Overview

Ergonomics is a comprehensive applied discipline that studies the relationship between people, machines and the environment, and it covers many fields such as anthropometry, psychology, behavior, and medicine. Ergonomics has been involved in all aspects of people's lives, especially in household products. In this paper, ergonomics-based child seat comfort evaluation research can effectively improve the comfort of child seat products. (Li, Zhang, 2021)

1.2 Child Seat Design

The child seat is an indispensable learning facility in the current home learning and education place, in order to further improve the learning efficiency of children and meet the requirements of the learning and growth stage to provide healthy development, the seat set for children's learning is being continuously optimized and designed, and the child seat has now changed from a traditional seat to a seat set with both intelligent and entertainment functions. Relevant designers should pay attention to the following design principles when carrying out child seat design: First, safe and comfortable. Provide children with safe materials and comfortable products. Second, easy to use. In the case of diverse functions can also be convenient to operate. Third, the appearance of the design. The appearance of the child seat design cannot be boring, and needs to meet the aesthetics of children.

2 RESEARCH SIGNIFICANCE ON THE COMFORT OF CHILD SEATS BASED ON PRESSURE DISTRIBUTION

The correct sitting posture must be the pressure on the body is evenly distributed on the intervertebral discs, and the static load should be evenly distributed on the muscle tissue. (Liao, 2021) Nowadays, some important parts of the well-designed child seats can be adjusted independently (such as the reclining angle of the backrest, the reclining angle of the seat surface, etc.), but there are no specific recommendations for the appropriate child seat backrest angle and seat surface angle, resulting in people still adjusting various parts of the child seat according to their own preferences in the process of

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using the child seat. (He, Ma, Zhang, Ma, Wang, Xu, Yang, 2017) Some researchers found that 97.5% of the participants used the seat angle adjustment function every day; 70% of them use these features when resting and relaxing to increase comfort and pain relief. Researchers studied the use of child seat features, and the results showed that the participants used the child seat 11.8 ± 3.4 hours per day; the average number of times users left the child seat was 5.0±5.3 times/day; the average time for posture change was 53.6±47.0 minutes; the longest hold position was 214.68±7.4 minutes; functional use shows that the use of recline, backrest recline, seat surface elevation were 11.9±9.4 times/day, 10.9±9.4 times/day, O±7.9 times/day and 4.3±4.5 times/day, respectively. However, this adjustment may make the child seat comfortable to use for a period of time but may not be scientific for a long time. Long-term use of improperly designed child seats will increase the pressure on the skeletal muscles, resulting in fatigue and discomfort, and sometimes numbness in the lower limbs. In the long term, this can lead to neck and shoulder pain, lumbago and other spinal diseases, as shown in Figure 1. In particular, the unreasonable distribution of sitting body pressure caused by improper design can lead to decubitus ulcers in patients with spinal injuries. (Zhao 2020)

Some studies have shown that child seats with tiltable seats and backrests can be adjusted at an angle to reduce user fatigue, and placing them at an angle can help reduce contact pressure and prevent skin ulcers. However, few studies have studied the comfort of child seats through the angle of the child seat. Most people who use child seats are those who cannot take care of themselves and cannot move independently, which makes the comfort of child seats especially important in their view. Furthermore, the reasonableness of human pressure distribution is an important factor in determining the comfort of child seats.

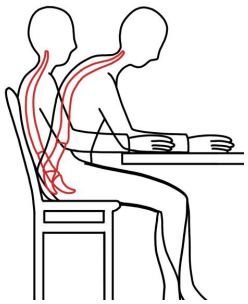

Figure 1. Spinal deformation caused by poor sitting posture

3 RESEARCH METHODS ON THE COMFORT OF CHILD SEATS BASED ON HUMAN PRESSURE DISTRIBUTION

3.1 Sample Selection

20 healthy and normal children aged 4-8 years with body weight less than 25 kg were selected as subjects, including 10 males and 10 females. The subjects were required to have no history of musculoskeletal disorders, no sports injuries and no physical discomfort in the past 6 months. The test was completed under the guidance of the experimenter. At the same time, the tested children were able to think logically, had their own subjective sense of things, and were able to distinguish between good and bad and give advice. Some of the data were collected with the informed consent of the tested children and their parents. For the accuracy of the experimental data and in consideration of the low temperature in winter, the subjects were asked to wear no more than two layers of clothes, and some test data are shown in Table 1.

Table 1. Data of some tested children

Subject data	S1	S2	S3	S4	S5	S6	S7	S8	Mean ±standard deviation	Min	Max
Sex	Male	Female	Male	Female	Male	Male	Female	Female	-	-	-
Age/year	6	5	8	6	7	6	4	8	6.25±1.39	4	8
Height/cm	113	96	115	116	100	109	103	126	109±10	96	126
Weight/kg	20.95	12.61	21.00	20.05	16.00	17.05	11.00	21.65	17.53±4.43	11.00	21.65
Shoulder width/cm	31	24	36	31	25	26	21	28	28±5	21	36

Waist width/cm	20	18	25	21	18	19	16	20	20±2	16	25
Hip width/cm	22	20	24	24	23	21	18	21	22±2	18	24
Thigh length/cm	19	15	17	18	16	16	12	20	16±3	12	20

3.2 Otal Pressure Distribution Test

This test is conducted under normal driving or riding conditions using a pressure test mat laid on the seat of the vehicle to be measured. The subject rides on the seat in a normal sitting position, and the pressure distribution on the seat should be uniform, with no pressure peaks. The pressure distribution cloud map should not show red areas except for the ischial tuberosity position, and the backrest should not show red areas. Pressure distribution can not appear clamp change phenomenon.

4 STUDY ON PRESSURE DISTRIBUTION CHARACTERISTICS OF HIP CONTACT SURFACE OF CHILD SEAT

This chapter mainly studies the pressure distribution characteristics of the contact surface of child seat and human hip, that is, the contact surface between the human hip and the child seat, because the pressure distribution on the contact surface of the human hip in a sitting position has an important influence on the human comfort. According to the anatomical characteristics of the human body, the locations where the human body is under pressure in a sitting position are selected, i.e., the contact surface of the ischial tuberosity, the mid-thigh and the front-thigh positions. Pressure contact area which is how the pressure distribution also has an important role in comfort. The whole hip contact area was divided into low pressure area, medium pressure area and high-pressure area according to the pressure range, and the area values of these three different levels of pressure areas and their respective percentages of the total contact area were extracted and analyzed.

The pressure distribution cloud diagram of the pressure test mat was divided into three equal positions: the position of the ischial tuberosity, the middle of the thigh and the front of the thigh, as shown in Figure 2.

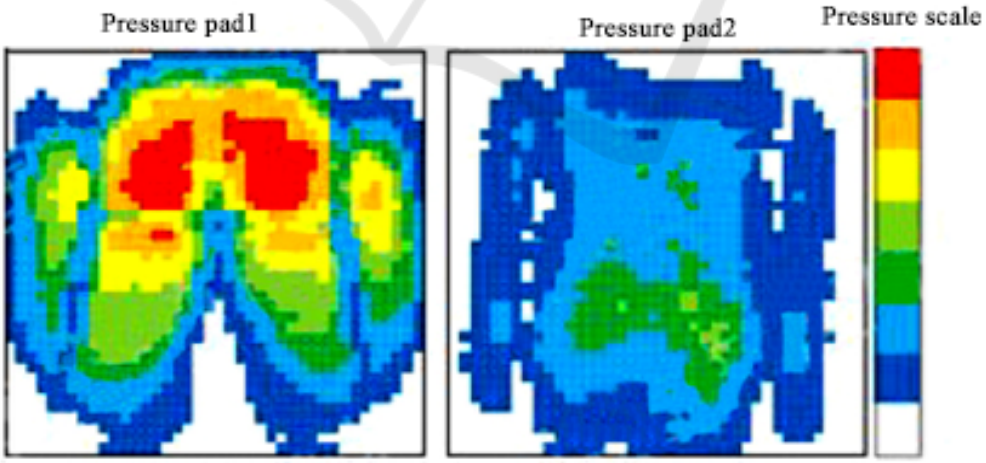

Figure 2. Pressure distribution cloud output example

The pressure distribution cloud map of the backrest is divided into three equal parts: the pressure curves of the corresponding areas in the upper backrest position, the middle backrest position and the lower backrest position. The maximum pressure (N), the average pressure (N) and the contact area (cm) are analyzed. See Figure 3.

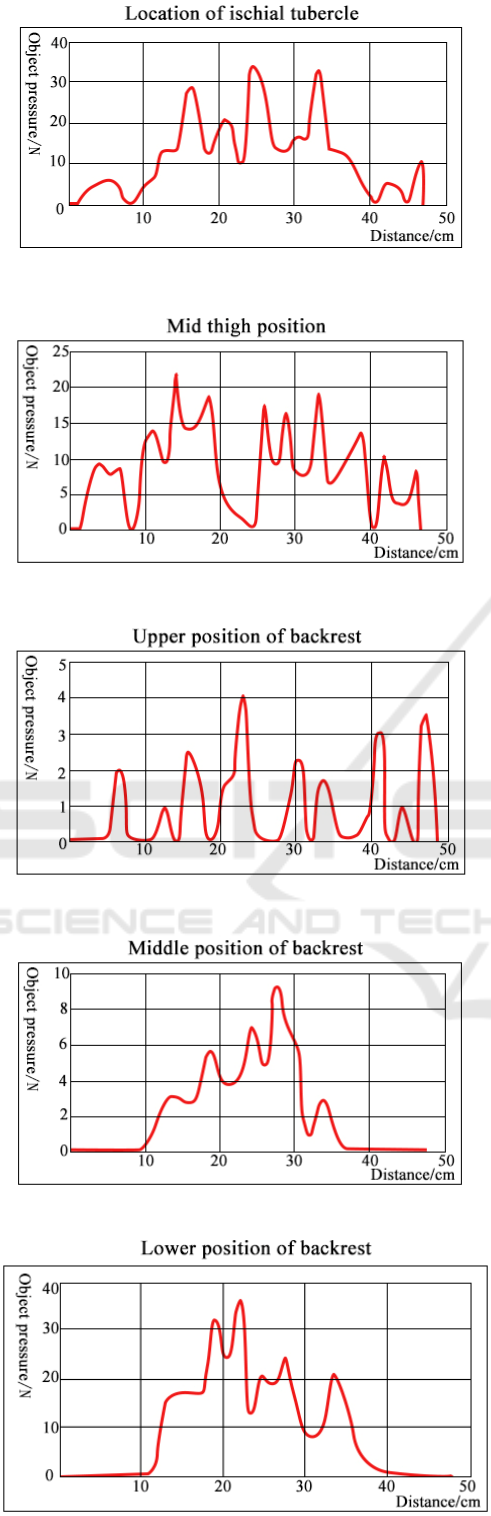

Figure 3. Pressure distribution diagram

5 CONCLUSION

(1) From the experimental data processing, it can be seen that with the increase of the child seat angle, the overall trend of the average pressure on the back, the maximum pressure on the back and the back contact area are increasing. In the meantime, the overall trend of the average pressure on the hip, the maximum pressure on the hip and the hip contact area are decreasing. The reason is that the child seat angle increases, the subject as a whole tilts backward, and the force on the back of the human body increases and takes up part of the force on the human body's hip. Therefore, an appropriate increase in the seat angle can effectively reduce the force on the human body's hip.

(2) The average back pressure, maximum back pressure, back contact area, average hip pressure, maximum hip pressure and hip contact area were obtained by measuring the human pressure distribution under different child seat angles. The regression analysis of the index parameters and the child seat angle was conducted to obtain the variation law of the index with the seat angle and its polynomial regression equation.

Based on the results of the study, the following laws were obtained: the contact area is larger to fit the human-computer morphology, and the comfort is higher, which verifies the point made by previous researchers - one factor affecting comfort or discomfort is the pressure distribution of the body or the body-object contact part; comparing the pressure trend after the contact surface, the riding experience of children before 30CM is more comfortable. By extracting time points and plotting the trend, it proves that children's ride comfort has a certain pattern with time, which is effective and feasible; children's comfort of the seat depends on the size of the contact area. This provides a new innovation point for future child safety seat design, which can help companies further improve the comfort and enhance the experience of their products. (Yuan, Yu, Zhong, 2017)

Examples taken from published papers:

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