Research on Pressure Comfort of Yoga Suit and Optimization Scheme of Pattern Based on CLO 3D Software

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Abstract. Based on the improvement of yoga clothing pressure comfort, this paper used Fuyi CAD garment system to make 2d clothing pattern, then, the 3D virtual fitting experiment of the main part of this paper was carried out. In the experiment, the static and dynamic pressure data of the virtual model were collected by using CLO 3D software, and the experimental data were analyzed by using the comparative experimental method. After analysis, the optimization was carried out in the garment piece, and then the same method was adopted to conduct data acquisition again, and it turned out to be that the overall virtual pressure reduces 247.93 Kpa. Finally, the optimization effect of each garment piece was evaluated. The results showed that the sample can be optimized and the pressure comfort can be improved through the virtual pressure test method of CLO 3D platform.

1. Introduction
With the improvement of people's quality of life, more and more women choose yoga as their daily relaxation and recreation. Yoga is a stretching exercise and has high functional requirements for yoga suit, so more and more people began to study the comfort of yoga suit. For example, Xinzhi Hou¹ used the thin film pressure sensor to measure pressure, which involved the static and dynamic pressure measurement of yoga practitioners in different points on the body, and judged combined with the study of pressure comfort range, and meanwhile, changed to the different yoga postures to increase the reliability of the experimental measurement. As for the improvement of the clothing pressure comfort, virtual clothing pressure measuring is now more popular. For instance, Xinhe Yu² measured pressure of 69 survey points in static state and cycling dynamic state with CLO 3D virtual measuring software, and analyzed the change rule of static and dynamic clothing pressure. Then, a clothing pattern optimization scheme was proposed based on clothing pressure difference between static and dynamic clothing pressure, and optimizing the design of cycling jerseys pattern. Kaixuan Liu³ built a pants fit evaluation system based on CLO 3D platform. Finally, it came to the conclusion that, clothing pressure data from 3D virtual fitting software has predictive accuracy on the assessment of garment fitness, and verified the effectiveness of the evaluation system.

This paper measured the pressure of yoga suit under different wearing states through the virtual clothing pressure tool of CLO 3D platform. Based on the principle of minimum average pressure, the pattern of yoga suit was optimized to improve the pressure comfort of yoga suit.
2. 3D virtual try-on experiment

2.1. Experiment conditions

Experiment platform: Fuyi CAD system, CLO3D software.

Virtual model size: the virtual model with standard body shape of 160/84 was taken as the experimental object, and the size of virtual model is similar to that of real person by adjusting the size of details. Size: 160/84A, bust girth: 84, waist girth: 64, neck girth: 36, hip girth: 85, shoulder width: 38, unit: cm.

2.2. Design of experimental clothing

**Fabric selection**: currently, the fabric of yoga suit is mostly nylon and spandex (the content of spandex is 3%-29%). The content of spandex affects the pressure of clothing. In order to eliminate the interference of fabric pressure on the experiment as much as possible, the spandex content fabric with less pressure should be selected for the experiment. According to the study of literature \(^1\), when the spandex content is 17.2% and the surface density is 65g/m\(^2\), the clothing pressure of the fabric is the minimum. In this paper, the blended fabric of 83% nylon and 17% spandex is selected for the study.

**Style selection**: the style of yoga clothing affects both the physical and psychological comfort of clothing. Combined with the characteristics of yoga, the style of yoga suit should meet the following requirements: Yoga exercise needs to be carried out at the same time with breathing, so the clothing should be guaranteed to have a certain degree of looseness, not too close, so as not to cause compression on the chest and abdominal cavity, affecting breathing. Based on this, fitted style or loose style of yoga clothing top should be chosen. Tank tops should be avoided as much as possible. Under the same pressure, thin straps will increase the pressure and create uncomfortable feeling for yoga practitioners. Choosing long-sleeved or short-sleeved styles, which can not only improve the comfort, but also provide good protection for the shouldlers. The design of raglan sleeves can reduce the pressure and resistance caused by the conventional tough silk sleeve to the skin and muscles, so that the athletes can stretch their arms and shoulders more comfortably during the yoga exercise. Therefore, the style of body fitting and short sleeves is selected in this paper, as shown in Figure 1.

**Size design**: when designing a fitting garment with a small amount of ease allowances, the average amount of ease allowances required by taking into account the breathing factor should be 3cm, when taking into account the deep breathing factor. In addition, considering the skin elasticity factor, the minimum amount of ease allowances of the fitting jacket should be 4cm; Take 2cm for the waist and hips. Size of fitted yoga suit is: 160/84A, Length: 50, bust girth: 88, waist girth: 66, neck girth: 36.5, sleeve length: 27, unit: cm.

**Pattern design**: this paper used Fuyi CAD system for patterns design, as shown in Figure 2. It is designed for 9 pieces, including front-middle piece, front-side pieces, back-middle pieces, back-side pieces, back-sleeve pieces, and front-sleeve pieces.

![Figure 1. Style diagram of fitted yoga suit.](image1)

![Figure 2. Pattern diagram of fitted yoga suit.](image2)

2.3. Analysis of experimental action
In this experiment, the movement design selects a yoga dynamic movement process from back to body bending, which was divided into six stages according to the angles formed by the upper body and the lower body, and simulates the movements of the model in each stage. The specific movement design scheme is shown in Figure 3.

Figure 3. Movements design of virtual model.

2.4. Selection of virtual pressure measuring points
In order to obtain accurate experimental measurement data comprehensively and objectively, we should pay attention to the selection of pressure measurement points: besides the characteristic points, other measurement points are all over the garment. Specific selection scheme is as follows: vertical datum is the vertical line as the pivot point of bust point, bicep point, horizontal lines are bust line and waist line, the rest of the lines set to 6 cm intervals or divides dart and the longitudinal reference line averagely. The points formed by crossing lines should fully reflect the measurement data, especially in the part with curved surface of the body, points distribution can intensive appropriately, such as the chest. Finally, 83 measuring points are formed, and their distribution is shown in Figure 4. In the front middle piece of the yoga suit, 19 measuring points A1-A19 are selected, with the dart between the chest and waist as the main distribution.

3. Experimental process

3.1. Experimental process
Step 1: set up the virtual model. Step 2: arrange the two-dimensional pattern. Step 3: import the fabric required for the experiment, adjust the nylon=83%, spandex =17%, and the surface density=65g/m² to control the fabric parameters. Step 4: virtual stitching. Step 5: try it on. Step 6: initial pressure measurement. According to the pressure point selection scheme, the data of each pressure point in 3d window were measured one by one in different pieces of clothing patterns. The measurement was carried out in three times, and the average value of the three results was recorded. Step 7: dynamic pressure measurement. The pressure values of each measuring point from the first stage to the sixth stage in the yoga process were measured respectively, and the average value was taken as the dynamic pressure values in the whole yoga movement process.

3.2. Initial static and dynamic pressure distribution
The pressure values of each piece of yoga suit were measured respectively. Set front-middle piece as an example, the static and dynamic pressure values were as table 1:

Table 1. Static and dynamic measurement values of each measurement point of front-middle piece of yoga suit.
### 4. Data analysis and patterns optimization scheme

According to literature studies[5], the virtual pressure value in the software is not completely consistent with the real pressure value, but there is a positive correlation, and the correlation coefficient of the two is 0.78. Therefore, the virtual pressure measured by the software can represent the actual pressure. The following takes front-middle piece as an example to illustrate the dynamic and static pressure changes and the optimizes the patterns.

![Figure 5. Static and dynamic pressure line chart of front-middle piece](image)

The static and dynamic pressure line chart of the front-middle piece are shown in Figure 5. It can be seen that the dynamic and static difference curve fluctuates greatly. Except A1, the other points are all positive, and the comfort of the position decreases to different degrees. The value of static and dynamic difference curve in A8-A11, A14-A15 is bigger, and in the A8, A11, A15 peak respectively. Analyze with the details, A8-A11 and A14-A15 respectively in the chest and waist, and A8, A11 is around bust points. Therefore, the front-middle piece is adjusted with front-side piece correspondingly when adjusting patterns. Smooth the curve of breast dart and appropriately increase the bust width. Similarly,
the width of the front waist should be appropriately increased to improve the comfort. After several revision of patterns, the dynamic pressure curve in the chest and abdomen decreased and tended to flatten. After adjustment, the model and comparison were shown in Figure 6.

5. Patterns optimization results and optimization degree evaluation

5.1. Patterns optimization results
According to the above analysis, the front-middle piece is optimized. Collect pressure of the optimized pattern analyze compared with the original data. The curve as shown in Figure 7 was obtained.

![Figure 6. Contrast before and after optimization of front-middle piece.](image1)

![Figure 7. Contrast line chart of dynamic pressure before and after optimization.](image2)

According to the comparison diagram of dynamic pressure before and after optimization, it can be seen that compared with the line chart of dynamic pressure before optimization, the pressure value at the measuring points of the optimized garment piece are more evenly distributed, and there is no extreme pressure in some part.

The same method is used to optimize all the garment pieces, and the patterns optimization results are shown in the Figure 8.

![Figure 8. Contrast diagram before and after optimization.](image3)

5.2. Optimization degree evaluation
In order to further accurate quantitative judge if all pieces are optimized, using the method of Xinhe Yu[2], which proposed a formula to evaluate the degree optimization of all pieces: according to this formula, if the value is positive, shows that the optimized average dynamic pressure value decreases, and the pressure comfort of the pieces was optimized.
Where \( i \) represents the \( i \)-th measuring point; \( D_i \) represents the dynamic pressure value at the \( i \) measurement point before optimization; \( C_i \) represents the dynamic pressure value at the \( i \)-th measurement point after optimization; \( n \) represents the total number of pressure measuring points of the garment piece; \( A \) indicates the optimization degree of each garment piece. According to the formula, the optimization degree of each garment piece is calculated, and the results shown in table 2 are obtained. It can be judged that the higher the value of \( A \), the higher the optimization degree. The smaller the value of \( A \) is, the lower the degree of optimization is.

Table 2. Evaluation degree of all pieces

| Name of pieces | A  | Name of pieces | A  |
|----------------|----|----------------|----|
| Front-middle   | 1.20| Back-side      | 2.15|
| Front-side     | 4.23| Front-sleeve   | 3.56|
| Back-middle    | 3.72| Back-sleeve    | 3.84|

The experiment was carried out in the same way for other garment pieces and the optimization degree of each garment piece was obtained as shown in table 2. According to table 2, it can be judged that each garment piece has been optimized, and the degree of optimization is different. The above experiment measured the static and dynamic pressure values of each piece of clothing at each point and made a comparative analysis, and the overall pressure value decreased by 247.93kpa. The method to optimize patterns was feasible, and the pressure comfort of yoga suit was improved.

6. Conclusion

Based on CLO 3D platform, this paper analyzes the static and dynamic virtual pressure values of yoga suit and draws the following conclusions:

(1) This paper designs the yoga movement, which are the chest forward and back backwards with a focus on the chest torso, the experimental data and results acquired from the experiment reflect pressure on the chest, back and armpit as the larger area, which is consistent with the constriction when we wear yoga suit during the yoga process.

(2) In the experiment, the static and dynamic pressure values and difference values were compared for analysis, and the patterns optimization scheme was summarized, so as to reduce the overall pressure of the optimized yoga suit by 60.39%. This can effectively detect changes in pressure comfort.

(3) The model optimization scheme of tight raglan sleeve yoga suit was designed, and its optimization degree was evaluated. The optimization degree of each piece was from high to low: front-side, back-sleeve, front-middle and front-sleeve, which were in line with the parts of the human body that are prone to tension and restraint during yoga movements.

Acknowledgments

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