Ergonomic performance research and evaluation method of cycling clothes

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Abstract: In recent years, with the rapid development of cycling, the cycling clothes have also become more and more popular, however, its poor breathability, sultry wearing, not light skin and some other comfort issues have become the shackles of the rapid growth of this product. From the perspective of clothing ergonomics, the article analyzed the materials of the cycling clothes including fabric attributes, color matching and style structure design, and combined with the current popular intelligent designs technology to expound the current status of the development of cycling clothes. On this basis, the evaluation method of ergonomic performance of cycling clothing was discussed from two aspects: subjective evaluation and objective evaluation, and the development trend of cycling clothes was summarized, which provided related ideas for the design of cycling clothes.

1. Introduction
Cycling can effectively relieve people's work pressure, not only strengthen the body, but also enrich spare time. Cycling clothes play a protective role in the human body during the cycling exercise, can effectively relieve the problems of lactic acid backlog and muscle soreness, and well repair chronic injury and physiological fatigue of the human body [1]. In the course of riding, you will encounter a relatively harsh environment and maintain the same riding movement for a longer period of time, which will result in reduced body comfort. Riding for a long time will also cause a certain degree of friction and damage to human skin and muscles. Wearing inappropriate clothing will cause physical discomfort to the human body and affect people's sports effects [2]. Therefore, there are very high requirements for the protective performance, sweat permeation and safety performance of the riding clothes. Improve the details of style design, optimize for the needs of cyclists, organically combine different functionalities, multi-function, simple and easy to use will become the mainstream trend of outdoor product design. In addition, the evaluation method of ergonomic performance of cycling clothing cannot be ignored.

2. Cycling clothes materials

2.1. Fabric
The mainstream direction of the development and design of high-performance cycling suits is to use "skin-like" fabrics to protect the skin from external object stimulation while ensuring comfort

Liu X et al. [3] pointed out that in uninterrupted cycling, the human body consumes a lot of energy, emits more heat, and discharges more sweat, which causes the body to form a state of high temperature and high humidity. The performance of the fabric is the key factor for whether the clothing can effectively adjust the microclimate area to achieve the best state. Li C et al. [4] pointed
out that when the friction of the fabric is large and the elasticity is poor, the movement of the human body will cause the skin to stretch, and the poor sliding performance of the fabric will lead to excessive pressure on the clothing and uncomfortable compression.

Qiu C Y [5] used Cool Max Lycra fabric for the upper body in the research. The surface of this fabric is smooth, with good moth resistance, corrosion resistance, light resistance, wear resistance, excellent elasticity and elastic recovery, improve The elasticity and extensibility of the fabric are worn, the body is breathable, almost unconstrained, and has a high degree of sports comfort; the use of Cool Dry high-permeability mesh fabric on the side and underarms can quickly dissipate heat and reduce heat consumption, leaving the rider in a relatively dry, Cool and comfortable environment.

Luo N N [6] used 96% polyester-coated fabric and 4% polyester fabric breathable mesh fabric in the study of smart cycling clothing, which has good windproof, waterproof, stain-resistant, wear-resistant and tear-resistant The performance such as splitting, as well as good comfort and breathability, can not only meet the solid placement of smart devices on smart cycling wear and intelligent data collection, but also meet the requirements of clothing comfort.

Shen Y P et al. [1] pointed out that by changing the fabric structure and fabric modification, fabrics with good moisture permeability and breathability, and faster heat and moisture conductivity can be developed, such as multi-groove fibers can quickly conduct sweat on the skin surface, make the body dry, and the fabric Long life span; Cool Dry fabric is light and has better wearing comfort; cycling pants often use the moisture-absorbent and quick-drying Cool Max®, whose four-pipe structure can quickly absorb moisture and perspiration; Lycra® fiber has good stretch and recovery It is blended with other materials during use, which can effectively improve the performance of the fabric. The new air-deformed nylon Cordura® fiber has about twice the wear resistance of traditional air-deformed nylon. The wear resistance is conventional polyamide, polyester and cotton products 2-7 times [3, 7].

Figure 1. Cool Max fiber structure diagram.

Li X et al. [8] through multivariate analysis of variance, qualitatively obtained the effect of far infrared yarn content of the cycling pants, the organizational structure of the cycling pants and the acting muscles on muscle fatigue during cycling; Pants can really relieve fatigue caused by exercise. With the increase of the far-infrared yarn content, the time during which the muscles are in the recovery phase increases significantly, and the time during the fatigue state decreases significantly.

2.2. Color
Color is also one of the important factors that influence the effect of clothing. Under the premise of ensuring the functional conditions of clothing, appearance has become the main design factor. While promoting the function, it creates aesthetic value of appearance and increases market purchases [2, 9].

Zhou H [2] proposed that in the color selection of clothing design, it is mainly used in the matching of similar colors, similar colors, complementary colors, contrasting colors, and medium-difference colors. The purpose of outdoor clothing color matching is to beautify the appearance and enhance the visual effect, To a certain extent, improve the safety warning function.

Shen L [10] and others used simple solid colors and then used fluorescent fabrics to fight colors, which concentrated the visual effects and at the same time appeared more harmonious. Adding posture control LED light group and fluorescent fabric on the back has a good safety warning effect.

Chen Z H [11] and others used eye trackers to obtain the data of consumers' gaze time and initial time in different regions of different riding clothes samples. The analysis found that in the two colors
of riding clothes, consumers pay more attention to the choice of background color; in the three colors of cycling suits, consumers have different embellishment colors for different background colors.

In summary, when selecting materials for cycling clothes, you must choose elastic fabrics with high moisture permeability, windproof, waterproof, and wear resistance; in color, it is best to choose simple and elegant monochrome, similar colors, and similar colors, etc. Splicing fluorescent fabrics or LED lights can achieve safety warning. It is urgent to develop new functional fabrics.

3. Style structure design

3.1. Human body size measurement

The size of the human body is the fundamental basis for clothing design. Measuring the physiological indexes of the human body is one of the methods for detecting the sports comfort of the clothing. Measuring according to the sports characteristics can make the design of the clothing structure more scientific and professional [3].

In order to reduce the center of gravity and reduce the resistance during riding, the rider generally bends his body forward, his head stretches slightly forward, his upper body is basically level with the ground, his arms are naturally bent, the arms are 90° from the body, the hips sit firmly on the seat or Keep standing and repeat the pedaling motion of the lower limbs [3,12]. According to the above characteristics, the nodes with obvious skin deformation trend are selected, the body surface length and circumference data of each node's posture are measured, and the horizontal and vertical change data are used to guide the structural design.

Cheng N B [13] used the Opti Track motion capture system to collect the position changes and movement trajectories of human body markers during riding, qualitatively analyzed the dynamic changes of the human body, and used the body surface drawing method to further improve the law of human skin deformation during riding Research to analyze the changes in the size of the human body before and after wearing the cycling suit, so as to determine the clothing pressure and the impact on the human fatigue caused by the cycling pants.

Huang L [14] analyzed the laws and key postures of the human lower limb movement during riding through 3D dynamic capture, and then used 3D scanning and human lower limb movement morphology modeling to obtain lower extremity skin surface data during riding and measure the degree of skin deformation To lay the foundation for the later use of the three-dimensional cutting principle of clothing and the improvement plan for designing cycling pants.

Measuring the physiological indexes of the human body in the riding state can be used to evaluate the applicability of apparel fabrics and the rationality of apparel structure. This is also an important content of apparel science and performance optimization.

3.2. Style and structure design

Clothing style is one of the key elements of the appearance of clothing, which directly affects consumers' purchase and wearing mood. When designing, not only the rationality of the structure but also the overall shape curve of the clothing should be considered. The clothing structure is determined according to the static body shape and dynamic changes of the human body. The change in body
surface size during exercise has a great influence on the amount of relaxation of the clothing and the structural design.

Niu H Y and others [15] pointed out that the riding clothes are relatively tight, and the dividing lines are more and streamlined. They skillfully combine the provincial roads with the dividing lines that reflect the structural characteristics of the human body to achieve a shape-fitting effect, blending decoration and function. As a whole, make cycling clothing more rhythmic and sporty.

Zhao J [16] analyzed the movement characteristics during riding, the length of the front piece should be shorter than the length of the back piece, to reduce the accumulation of clothing; zipper should be installed on the placket for putting on and taking off; Easy to carry small items. In order to prevent the cuffs and trousers from moving up, install non-slip tapes at the corresponding parts; mesh fabrics under the armpits and the rear cuffs to ensure moisture absorption and ventilation [3].

Yang J et al. [17] proposed that the front crotch length of the riding pants becomes smaller due to the forward leaning during riding, which results in the accumulation of fabric, so it can be designed for saving. In order to reduce the influence of excessive provincial roads on the comfort of standing, the provincial roads can be transferred appropriately, and the size of the rear crotch should be increased accordingly, and the amount of crotch bend and back waist lifting should be appropriately increased. The movement of the knee joint changes the body length, so the structure should be lengthened on the front knee and the rear knee to be saved to meet the sports needs of the rider.

In general, when designing the structure of cycling clothing, we must consider the parts of the body that require greater comfort during exercise and whether the clothing design meets the needs of sports. This part of domestic research is temporarily lacking.

4. Intelligent

Smart clothing is a type of clothing that can sense changes in the human body and the environment, and respond to and adjust to the changes through a feedback mechanism. It integrates a variety of technologies such as electronic information technology, biochemical technology, human-computer interaction technology, and bionic technology, and gradually develops into the product of multi-disciplinary and multi-disciplinary research [18].

At present, the main research of smart clothing is high-tech clothing materials, clothing and electronic components fusion, clothing and external sensor response, clothing power supply and circuit control system improvements. This includes: controlling functions by directly connecting micro-electronic components to clothing; giving special functions to ordinary clothing through innovative materials or chemical modification; and weaving smart fibers into clothing through woven or knitting technology [19,20]. Nowadays, smart clothing has been applied in the fields of sports health, medical health, safety protection, military equipment, life entertainment, etc., and is developing in the direction of comprehensive functions, diversified technologies, comfortable wearing, and intelligent materials [18,21].

Tengfei Technology introduced the latest Sens Elast technology from Germany. The main functional advantages are: non-marking comfort, high resilience, washing resistance, good decoration and strong designability. This technology has great potential for development in the fields of clothing, sports and medical plastic surgery, and can accelerate the transformation and upgrading of products to intelligent and high-end. If Sens Elast technology is applied to cycling clothing, the functionality and comfort of cycling clothing will be greatly improved [22].

The University of Washington has researched and developed a smart fabric that can store data and information without additional electronic products or sensors. Levi's and Google have jointly launched a smart jacket made of this smart fabric. The jacket can be used for data storage, just like a mobile hard disk. If this kind of smart fabric is used in cycling clothes to become a fashion and function apparel, it can store athlete-related information and competition data, and can lead the trend [23].

Although there are many technical problems in smart clothing, as the current hottest research direction in the clothing industry, its future market prospects and economic benefits are huge.
5. Ergonomic performance evaluation method of cycling clothes

5.1. Subjective evaluation
The subjective evaluation of the ergonomic performance of the cycling suit can be done in an artificial climate room, using the physiological indicators such as temperature changes, metabolic heat production, and sweating of the subject as the evaluation basis; at the same time, the subject can record the wear Subjective evaluation of the comfort of heat and moisture during sportswear [3].

Huang L [14] selected 20 riding enthusiasts who meet the requirements, wore optimized cycling pants for cycling, and filled out the questionnaire 30 minutes later. "Moisture repellency", "pain" and "tensile comfort" are subjective evaluation of the optimized riding pants wearing experience, in order to obtain the performance evaluation of riding pants.

Zhou H [2] evaluated subjectively from three aspects: "comfort feeling", "sports function assistance", and "appearance fashion" worn by women's road cycling clothes. A 5-level description of subjective try-on evaluation was made from static wear (the first feeling of wearing the upper body of the clothing) and dynamic riding of the human body (Outdoor riding for more than one hour).

5.2. Objective evaluation
The objective evaluation of the ergonomic performance of cycling clothing, that is, the use of professional testing equipment for testing, and the use of analytical software or processing methods to analyze the data. This method eliminates the influence of subjective factors and is more scientific. It can study and evaluate various factors that characterize the performance of cycling clothing. For example: use a pneumatic pressure test device to test the pressure value of the riding suit on the human body, and find out the best structural design plan based on the pressure data [3,25].

Cheng N B [13] obtained clothing pressure value and surface EMG signal of each test part in riding through clothing pressure test system and wireless surface EMG test system, and recorded the heart rate value and subjective fatigue RPE value of the subject at each moment, RPE value and objective indicators RMS, MF for correlation analysis, clothing pressure and EMG indicators for variance analysis. Finally, on the basis of investigation and analysis and experimental results, optimized design and verification of cycling pants.

Yu X H et al. [26] adopted the virtual try-on method and used the CLO 3D virtual try-on software to measure the virtual pressure values of 69 measurement points under static state and riding dynamics. In order to accurately analyze the pressure data of each piece of cycling clothing, first analyze the pressure difference curve as a whole to obtain the overall change trend of pressure comfort; then analyze the measurement points with significant changes by region to further understand the change of pressure comfort in each region. Finally, a clothing model optimization method based on the difference between static and dynamic clothing pressure is proposed to optimize the design of cycling clothing models.

![Figure 4. Distribution of pressure measuring point at avatar](image)

Yao R X [27] simulated the riding test on the GIANT-XTC790 mountain bike, and used the Motion Lab MA300-II model EMG measurement system to collect and record the sEMG signal. According to the physical characteristics of the surface EMG, the low-speed and high-speed movements were respectively The course is divided into 18 segments, and then the MATLAB R2014a software is used to calculate the indicators of each segment of EMG data, and the percentile
standardization is processed. Finally, the Levene’s method, Least-significant difference method, Tamhane’s T2 method, curve estimation, and variance homogeneity test are used. Single factor analysis of variance, multiple comparison test and regression analysis, etc. to investigate the difference between the EMG values of each group in the same time period, and the trend of change, and then explore the effects of different riding pants and different riding pads on myoelectric activity impact.

In conclusion, when objectively evaluating the ergonomic performance of cycling clothing, it is necessary to select the appropriate experimental equipment to start the experiment according to the needs. Generally, clothing pressure testing system and wireless surface EMG testing system are used more, and then combined with some mathematical methods, such as: linear regression analysis, significance analysis, homogeneity test, etc.

6. Conclusion and Outlook

With the gradual development of technology and the gradual improvement of people's pursuit of life, the future development of the apparel industry must constantly break through new technologies and optimize apparel performance. Through the article, the development trends of ergonomic performance and evaluation research of cycling clothes are mainly:

(1) On the fabric, knitted elastic fabric with high moisture permeability, breathability, smooth and light skin can be selected; you can also try to develop and use more advanced new functional materials, such as far infrared fabric, etc., to make the clothing more comfortable and beautiful

(2) In terms of color, pay attention to beautifying the appearance and enhance the visual effect, to a certain extent, improve the safety warning function of clothing

(3) In terms of structure, we should deeply analyze the changes in body size during the movement of the human body, establish a mathematical model, and analyze the relationship between human body size and clothing structure design

(4) In terms of intelligence, more research should be made on the combination of electronic components and cycling clothes to realize the highly integrated miniaturization, flexibility, especially to ensure human health and comfort. Future cycling clothes can perform long-term wearable monitoring, perform detailed assessments of human movement status, and self-reports can be re-analyzed by data stored on smartphones to provide users with detailed and objective physical status reports, allowing riders to effectively perform self physical health management.

(5) A comprehensive evaluation system for ergonomic performance of cycling clothing should be established. In terms of subjective evaluation, because there are many factors that affect the performance of clothing, in addition to the clothing itself, it should also be combined with the human body to evaluate, divide the human body into multiple areas, evaluate based on the partition map and the degree of activity felt by the body, and establish a subjective evaluation scale. In terms of objective evaluation, it is necessary to study each factor that characterizes the ergonomic performance of cycling clothing, and on the basis of making separate comments on each factor, a comprehensive evaluation of all factors can be considered. The fuzzy analysis method is a comprehensive method based on fuzzy mathematics. Fuzzy mathematics can be used to make an overall evaluation of the ergonomic performance of cycling clothing affected by various factors.

Functional cycling clothing is gradually occupying the market. Only by understanding the development trend of the sports industry, the development of fabrics and the market needs can we design a cycling clothing that meets the needs and meets the trend.

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