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Research on intelligent clothing for disabled people based on questionnaire

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Abstract: *With the rapid development of science and technology and the increasing attention of society to disabled people, the design and research and development of disabled people's clothing has become a high-profile field. However, there is very little research on intelligent clothing for disabled people. This paper aims to discuss the design concept, technology application and future development trend of smart clothing for disabled people, in order to provide more convenient, comfortable and safe dressing experience for disabled people.*

Keywords: *People with disabilities; Intelligent clothing; Questionnaire survey* [1]

1. Introduction

With the continuous progress of wearable technology, the integration of technology and fashion is creating a new fashion interface, and smart clothing, as a cutting-edge product in this field, heralds a revolutionary change in the way of wearing in the future. Smart clothing is not only a fashion statement, but also a perfect combination of functionality and practicality. From health monitoring to environmental adaptation, interactive entertainment to data communication, smart clothing is increasingly being used in a wide range of applications. In recent years, many research institutions at home and abroad have begun to devote themselves to the research and development of intelligent clothing, from the existing and under development of intelligent clothing point of view, the intelligence of clothing is generally through the following two different technical routes: One method is to interweave smart fabrics with sensory and reactive functions with ordinary fibers, and make smart clothing using fabrics containing smart fibers. 2014 Chongqing University and the United States. Georgia Institute of Technology jointly developed an automatic power supply fabric, that is, on the surface of polyester fiber gold plating layer and semiconductor coating, the smart fiber and ordinary fiber mixed weaving, collecting light energy while generating electricity and storing energy through friction， can be used to make a variety of styles of clothing. In 2017, Wang Feixiang's team woven fiber as a sensor into the woven fabric structure, and the developed fiber sensor was mainly used for the detection of breathing signals. In October 2024, the Beijing Institute of Fashion Technology and Qinghua University jointly designed a "temperature adaptive smart fabric (SF)" in interdisciplinary cooperation. The research results were published in Science Advances, demonstrating an innovative thermal management solution that does not require additional energy consumption and realizes the adaptive temperature regulation function of artificial fabrics. Another way is to combine ordinary clothing with additional components to make smart clothing. These additional components include various sensors (such as GPS, body temperature, humidity, heart rate and other sensors), controllers and communication modules. Through data processing, processing algorithms, communication and other systems, the information obtained by the sensor and the information needed by people is classified, processed and transmitted. At present, the first way to make smart clothing is mostly in the laboratory stage, and the smart clothing made by the second way is more commonly used on the market. The introduction of smart clothing will bring more convenience and innovative solutions to people’s lives. In recent years, some well-known clothing companies, computer industry giants, such as IBM, Nike, etc., have begun to put forward and research and development of computers, chips and other control of “smart clothing”. This kind of clothing has both fashionable design and super functionality. For example, when the user exercises too much and the body value changes significantly, the smart clothing will detect possible safety hazards, remind the user to rest properly through vibration or voice prompts, or tell the user to adjust the intensity of exercise. The new design and technology make us believe that this is an indispensable part of the smart life in the future. With the rapid development of science and technology, smart clothing will become more and more diversified and intelligent in the

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future, which will also promote the development of the fashion industry. Despite the rapid development of smart clothing, there is little research on smart clothing for disabled people, one of the important research directions of smart clothing. China has the largest population in the world. According to the National Bureau of Statistics, the number of disabled people in China has reached 859.14 million by the end of 2023, accounting for 6.34 percent of the country's total population, making it the country with the largest number of disabled people in the world. People with disabilities have great special needs in terms of clothing, food, housing and transportation, especially in the garment industry. In foreign countries, the clothing industry for the disabled has emerged very early, so that there has been a special term -- Adaptive clothing, which is specially designed and made for people with disabilities or mobility difficulties. With the continuous promotion, emphasis and solidification of the idea of "equality for all" in foreign countries, the adaptive clothing industry specially designed for the disabled is becoming more and more mature. Among them, the well-known brands are IZ, Silverts, JAM and so on. These foreign brands have attracted the attention of the fashion and magazine industries at home and abroad by hiring models with disabilities. Due to the physical defects of disabled groups, they lack the ability to take care of themselves and have certain difficulties in daily life. Adaptable clothing has been reformed in the structure and design to facilitate the independence of special groups. For example, in order to make clothing more convenient at the same time, look more in line with fashion norms, the device is more invisible, these companies usually use (including but not limited to) clip, Velcro, magnets and other devices to make simple changes on the basis of ordinary clothing, so that disabled people can change clothes independently on certain occasions. With the progress of science and technology and the improvement of people's requirements for quality of life, smart clothing has gradually entered people's field of vision. For people with disabilities, smart clothing can not only improve their quality of life, but also assist their daily life to a certain extent. At present, there are few researches on the use of smart clothing by disabled people. Different from the needs of normal people to wear clothes, the disabled may face various problems, which makes them more eager for technology to help the physically or mentally disabled to solve their clothing problems. Therefore, this study aims to deeply understand the needs and preferences of the disabled for smart clothing by means of questionnaires, and provide useful references for the design and production of smart clothing for the disabled.

2. The research background

For centuries, people with disabilities have often been portrayed in Chinese and foreign literature as weak and pitiful, and readers have instilled in them an emotional color of "sympathy". Disability, on the other hand, has always been a victim of serving the main theme. Under the illusion of "pity" and "sympathy", people's incomprehension, even disdain and discrimination towards "disability" are hidden. In the past investigation and research, the goal of adaptive clothing is to pursue the functionality and convenience of wearing, and the requirements for the beauty of clothing are less considered, and the average level of aesthetic clothing is far from the society. With the development of science and technology and the improvement of aesthetic level, clothing design for people with disabilities is no longer limited to functionality and practicality, but more aesthetic and artistic considerations have begun to be incorporated. In particular, the prosthetic limb design for disabled people is no longer just a deliberate imitation of the healthy human body, but increases its sense of design and decoration, and even considers the functionality of different materials and structures, providing consumers with a variety of possibilities for free choice, so that wearers have a more comfortable and natural experience in the process of wearing, and improve their psychological acceptance. In recent years, artificial intelligence in industry, medical care, finance, transportation and other fields of development has shown a comprehensive and in-depth trend, smart rings, smart glasses and other smart wear has become a new outlet of consumer electronics. The year 2024 is regarded as the first year of the outbreak of "AI hardware" in the industry. The forms of AI hardware are becoming more and more diversified, and wearable devices are gradually becoming a new application scenario of AI large models. Intelligent clothing is bound to usher in accelerated development. At present, there are few explorations about the application of artificial intelligence to adaptive clothing. On the one hand, it may be because the research on clothing for disabled people in China started late, temporarily lagging behind foreign countries; On the other hand, it may be because the application of artificial intelligence in clothing is still in the exploratory stage and the production cost is high. The purpose of this study is to deeply understand the needs and preferences of disabled people for smart clothing by means of questionnaires, and provide useful references for the design and production of smart clothing.

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3. Research methods and data sources

3.1 Research methods

This paper adopts the literature research method, field investigation method and questionnaire survey method for analysis and research. First of all, read the relevant literature and materials about adaptable clothing at home and abroad, and summarize and sort out, which can comprehensively and systematically understand the topic that needs to be studied, and clarify the direction and method of research. Secondly, walking into rehabilitation centers, hospitals and other places where disabled people gather, communicating with disabled people, and observing their lives can also facilitate the understanding of the psychology of disabled people. Finally, according to the above research, a questionnaire on the study of intelligent adaptive clothing is designed, and questionnaires are distributed to disabled people through a combination of online and offline methods. Excel was used to sort out and enter the survey data. SPSS 22.0 statistical software was used to analyze the data. Counting data were represented by n (%).

3.2 Source of data

This study was carried out by "Questionnaire Star", aiming at people with disabilities in all regions of China, and a total of 200 valid questionnaires were received. The research data came from the "Questionnaire on the Research of Intelligent Clothing for Disabled People". The questionnaire covers the regional distribution of people with disabilities, understanding of smart clothing, expectations and needs for smart clothing, etc.

3.3 Survey results and analysis

3.3.1 Regional distribution of investigated groups (single choice)

Table 1: Regional distribution of investigated groups

	Number	Percentage
Eastern China	115	57.50%
Southern China	22	11.00%
Northern China	11	5.50%
Central China	4	2.00%
Southwast of China	40	20.00%
Northwest of China	3	1.50%
Northeast of China	5	2.50%
total	200	

A total of 200 valid questionnaires were collected in this survey. As shown in Table 1, the respondents are distributed in East China, South China, North China, Central China, Southwest, Northwest, Northeast and other regions, with East China accounting for 57.92%, which is relatively high.

3.3.2 Experience of smart products (multiple choices)

Table 2: The number and proportion of respondents experiencing smart products

	Number	Percentage
Smart glasses	18	9.00%
Smart watch	139	69.50%
Smart wristband	100	50.00%
Smart wearable clothing	3	1.50%
Smart jewelry	1	0.50%
Smart belt	1	0.50%
Smart headband/helmet	4	2.00%
Other	36	18.00%
total	200	

In this survey, as shown in Table 2, most people with disabilities have experienced smart products, and the groups that have experienced smart watches and smart bracelets account for a relatively high proportion, accounting for 69.50% and 50.00% of the total number of surveyed groups respectively. It can be seen that, at the right price and market conditions, consumers have a high acceptance of smart products.

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3.3.3 Type preference of smart clothing (multiple choices)

Table 3: The respondents' preferences for the types of smart clothing

Item	Number	Percentage
Smart vest	62	31.00%
Smart T-shirt	37	18.50%
Smart shirt	24	12.00%
Smart jacket	22	11.00%
Smart suit	18	9.00%
Smart down jacket	54	27.00%
Smart pants	21	10.50%
Smart outdoor jacket	96	48.00%
Other	30	15.00%
total	200	

In this survey, as shown in Table 3, 48.00% of people with disabilities want to buy smart outdoor jackets, 31.00% want to buy smart vests, and 27.00% want to buy smart down jackets. In this survey group, people are more inclined to choose outerwear such as jackets with both warmth and insulation functions. This is consistent with the results of the subsequent survey of purchase intention of smart clothing. It may be that some respondents still have concerns about the safety of smart clothing and other factors.

3.3.4 Monitoring indicators of smart clothing (multiple choices)

Table 4: Which monitoring indicators are being monitored

Item		Number	Percentage
Monitor heart rate		151	75.50%
Monitor blood presssure		137	68.50%
Monitor blood sugar		103	51.50%
Monitor respiratory rate		90	45.00%
Monitor pressure conditions		81	40.50%
Monitor blood oxygen saturation		100	50.00%
Monitor blood sugar levels		79	39.50%
Other		33	16.50%
total		200	

In this questionnaire survey, as shown in Table 4， the majority of people with disabilities expressed greater concern about monitoring heart rate, blood pressure, blood sugar, respiratory rate, stress status, and blood oxygen saturation. Among them, the proportion of people who pay attention to clothing monitoring for heart rate, blood pressure, and blood glucose function is 74.75%, 67.82%, and 50.99%, respectively, all exceeding half. This shows that in today's advanced science and technology, people with disabilities pay more attention to the basic indicators of the body.

3.3.5 Main factors to consider in fashion design (multiple choices)

Table 5: Main factors to consider in fashion design

Item	Number	Percentage
Comfort	168	84.00%
Invisibility	58	29.00%
Individuation	42	21.00%
High accuracy	121	60.50%
Easy to operate	83	41.50%
Aesthetic	50	25.00%
total	200	

In this survey, as shown in Table 5, most people with disabilities hope that designers can give more consideration to the comfort of intelligent clothing, the accuracy of intelligent monitoring and the convenience of intelligent clothing operation, which account for 84.00%, 60.50% and 41.50% respectively. Among them, the comfort of smart clothing is the most concerned factor for disabled people.

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3.3.6 Functional requirements of smart clothing (multiple choices)

Table 6: Functional requirements of smart clothing

Item	Number	Percentage
Fall prevention for elderly	140	70.00%
Febrile therapy	67	33.50%
Solar charging	55	27.50%
Memory function	58	29.00%
Physiological data monitoring	134	67.00%
GPS positioning	100	50.00%
LED light warning	32	16.00%
Play music	27	13.50%
Muscle tremor monitoring	25	12.50%
total	200	

In this questionnaire survey, as shown in Table 6, the products with anti-fall function for the elderly and physiological data monitoring function are the most demanded by the disabled, accounting for 70.00% and 67.00% of the surveyed people respectively. Secondly, GPS positioning function is in high demand, accounting for 50.00% of the respondents. Falls are the second leading cause of injury and accidental death worldwide. With the acceleration of the global aging process, the probability of falls among older people has increased. If the rescue is not timely, it is likely to cause serious harm to the body. Kang Ting et al. designed the intelligent clothing with anti-fall detection and warning function by verifying the effectiveness of machine learning algorithm to solve the problem that the disabled and the elderly are prone to fall and cause damage [2], analyzing and studying the wearing characteristics and anti-fall detection methods of elderly people, and proposing different fall detection algorithms based on the magnitude of movement amplitude, human posture, motion acceleration, etc. This function is not only convenient and easy for the elderly and guardians, but is especially important for the disabled. Some disabled people who are unable to take care of themselves are easy to be injured twice in the process of guardians' negligence or deliberately trying to complete actions independently. This not only causes harm to the body again, affecting the possibility of recovery, but also carries a huge blow to the psychology of the disabled. Therefore, the use of intelligence to avoid secondary trauma is expected. At the same time, smart GPS positioning clothing can track the position of the wearer in real time through the built-in positioning chip, which is usually connected with smart phones or external devices, to ensure the safety of the disabled to a certain extent. At present, there are many researches on the physiological data monitoring function of clothing products. The physiological data monitoring of the disabled can timely understand the physical and psychological health status, such as through the ECG system detection, the heart condition of patients with heart disease can be forewarned. Emotional recognition through physiological information will be of great help to people with mental disabilities. The research and development of a series of functional smart clothing will help disabled people live a more convenient life.

3.3.7 Color preferences for smart clothing (multiple choices)

Table 7: Color preferences for smart clothing

Item	Number	Percentage
Dark colors (black, dark blue, gray, etc.)	114	57.00%
Bright colors (bright red, bright yellow, bright orange, etc.)	42	21.00%
Morandi colors (garnet red, haze blue, ink green, etc.)	61	30.50%
Macaron colors (light blue, light pink, light yellow, etc.)	51	25.50%
Other	9	4.50%
total	200	

In this questionnaire survey, as shown in Table 7, people with disabilities are more inclined to choose dark clothing series (black, dark blue, gray, etc.), and the proportion of people who choose dark clothing series is 57.00%, more than half of the total number of people surveyed. This is consistent with other research reports that disabled people tend to choose darker clothing. People with disabilities tend to prefer dark and unprominent colors in their choice of colors, which may be related to their inferiority and not wanting to be noticed. However, with the development of The Times, more and more disabled people hope to show a positive side through clothing, and give themselves encouragement through the color of

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clothing. In this questionnaire survey, the number of people who choose Morandi color (garnet red, haze blue, ink green, etc.) accounted for 30.50%, and the number of people who choose Macaron color (light blue, light pink, light yellow, etc.) accounted for 25.50%. More and more disabled people begin to choose bright and cheerful colors, combined with the current fashion trend, to show their unique personality.

3.3.8 Psychological Price (multiple options)

Table 8: The psychological price of smart clothing

Item	Number	Percentage
100-200 RMB	28	14.00%
200-300 RMB	47	23.50%
300-500 RMB	73	36.50%
500-1000 RMB	76	38.00%
1000-2000 RMB	46	23.00%
Over 2000 RMB	18	9.00%
total	200	

In this survey, as shown in Table 8, the price of smart clothing acceptable to most people with disabilities ranges from 300 yuan to 1,000 yuan. Considering that the proportion of disabled people in this survey is relatively high in East China, and the economy in East China is relatively developed, the actual price accepted by disabled people for smart clothing should be slightly lower than this price. After communication with Shenzhen People International Technology Clothing Co., LTD and other smart clothing OEM enterprises, the current price of smart clothing is mostly more than 500 yuan, or even more than 10,000 yuan. However, with the expansion of the output of smart clothing and the emergence of new technologies and new materials, the cost of smart clothing will decline rapidly. Predictions show that in the near future, smart clothing will become the mainstream trend of clothing and enter thousands of households.

3.3.9 Purchase intention (single option)

Table 9: Purchase intention of smart clothing

Item	Number	Percentage
Will buy	137	68.50%
Will not buy	2	1.00%
Be on the fence (worried about safety, etc.)	61	30.50%
total	200	

In this survey, as shown in Table 9, the vast majority of disabled people are willing to try to buy smart clothing, accounting for 68.50% of the group, the number of people who have no intention to buy no more than 1%, and some groups are hesitant because of concerns about safety and other issues. It can be seen that the disabled have a high degree of acceptance of intelligent clothing. It is believed that after the price is idealized and exposed to the smart products safely used in the actual production, the disabled people with a wait-and-see attitude will also join the people who readily accept it, and truly realize the intelligent step forward of the nursing industry.

4. Conclusion

In this era of rapid advancement of science and technology, smart clothing is quietly reshaping our daily life as an innovator, becoming a bright star of cross-border integration between the fashion industry and the field of technology.[3] It is not only the carrier of the vision of the future life of the disabled, but also the treasure to be discovered in the Blue Ocean market. International brands such as Nike, Adidas, Under Armour and Hexoskin are also actively involved in the research and development of smart clothing. The continuous emergence of various wearable products has made smart clothing more acceptable to people with disabilities. The formulation of unified industry standards and norms will help improve the quality and safety of intelligent clothing and protect the rights and interests of consumers. The research and development of intelligent clothing in China is still in its infancy, and there is still a big gap compared with developed countries abroad. Environmental protection, ecological, intelligent textile and clothing is the future trend of clothing development. If China wants to complete the transformation from a clothing country to a clothing power, it must occupy a place in the research and development of intelligent clothing. Smart clothing combines the latest science and technology with the traditional textile and clothing design and technology, and integrates the latest industrial technology achievements such as materials, electronics, machinery, automation, computer, information and communication, with the mutual

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penetration of multi-disciplinary technology, the connotation continues to extend. Compared with the general functional clothing, the price of intelligent clothing is higher, but this does not affect its market potential. With the improvement of people's living standards, people's demand for personalized and intelligent clothing increases, and the development prospect of intelligent clothing is immeasurable.

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