A summary of the research status and development trends of protective clothing for the elderly

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Abstract: In order to understand the current status of the development of elderly fall-preventive clothing, focusing on the current application of energy-absorbing cushioning materials, protective equipment and wearable clothing in the field of fall-protective clothing, this paper summarizes the main domestic and foreign research on elderly fall-protective clothing. The results, specifically analyzed the advantages and disadvantages of energy-absorbing cushioning materials, protective equipment and wearable clothing in its application. It points out the precautions for the development of anti-fall clothing for the elderly, and draws the research and development trend of anti-fall clothing, and provides functional clothing for the elderly in daily life that is healthy, comfortable and self-help convenient. It is in line with the current "elderly-oriented" design conception provides guiding suggestions for the development of anti-fall clothing for the elderly.

1 Introduction

With the improvement of human living conditions and the intensification of aging problems, the phenomenon of falls and injuries among the elderly is more prominent. In recent years, smart old-age clothing has become more and more popular. As older people grow older, their physical fitness is getting worse and worse, and various diseases follow. Most of the old people live alone, their children are not around, and they are prone to various accidents. Such as accidents caused by falling or getting lost[1]. According to incomplete statistics, more than 8 million fractures occur annually in people over the age of 60 worldwide[2]. In China, at least 20 million elderly people fall and fall[3] each year. Then broken bones pierce the internal organs, threatening life. The cause of death from falls and injuries ranks 4th among the causes of death among the elderly in my country[4].

With the development of smart clothing, many products have appeared in the field of smart clothing for the elderly, such as monitoring clothing for the elderly living alone, smart clothing for monitoring the heart rate, blood pressure, mood of the elderly, solar infrared physiotherapy clothing for the elderly, solar pressure measurement clothing, etc. Therefore, The elderly have a great demand in the field of smart clothing[4]. But in general, there are few studies on the protection of the elderly against falls and injuries. Therefore, concerns about the safety protection, health, and daily health care of the elderly group[5], and at the same time, the elderly clothing market has gradually become a hot spot. At present, wearable devices are used to monitor the daily activities of the elderly, that is, the elderly start to fall after the fall alarm device and related protective equipment to reduce the impact pressure of the fall, in order to shorten the rescue time; mostly take the clothing itself as the starting point, the focus is on the selection of suitable suction Can cushion materials to improve the impact resistance of clothing[6]. This article mainly sorts out and analyzes the research status of several
common and emerging energy-absorbing cushioning materials, and provides a reference for the development of anti-fall clothing for the elderly in my country.

2 Application of energy-absorbing buffer materials in the field of protection

Energy absorption refers to the absorption capacity of impact force. Cushioning refers to the use of cushioning materials or absorbing impact energy, and then transforming it into heat energy, or gently releasing it to prolong the time of speed change, so as to minimize the impact force. Energy absorbing buffer refers to materials that have the ability to resist external impact loads. The material is widely used in sports and medical, aerospace, automotive military, mechanical shock absorption and other fields. Common energy-absorbing buffer materials include sponge materials, airbags, and new energy-absorbing buffer gel materials such as STG gel materials and D30 gel materials.

2.1 Sponge material

Sponges are currently a wide range of protective energy-absorbing cushioning materials. Because of their low price, light weight, reusability, easy clothing combination, and outstanding recovery performance, they are often used as protective devices for hips, thighs, and joints. Earlier, some scholars obtained the cushioning coefficients and performance curves of various materials through the impact vibration test of 8 kinds of cushioning materials such as foam plastic, corrugated cardboard and sponge, and made a comparative analysis of these curves and reached a conclusion. In addition to the better absorption of shock and vibration energy, other properties of sponge materials, such as resilience, compression creep, and moisture absorption, are particularly prominent[7]. Because the maximum impact force of its own bones is far less than the momentary impact force when the human body falls, causing the elderly to fall and fall, so whether the use of sponge materials as energy-absorbing buffer materials can achieve the ideal protective effect, Zhang Tong et al.[8]Simulated the stress situation of the elderly during natural fall, and carried out an experimental study on the cushioning performance of the sponge material. The results show that the cushioning performance of the sponge material is related to the two main factors of the hardness and thickness of the sponge material, and needs to be within a certain range To achieve human protection. Yin Yupeng et al.[9]made polyurethane sponge materials with high shock resistance and high comfort based on microporous elastomer and slow rebound formula, which solved the shock resistance and sports comfort of sponge materials, which is similar to ordinary sponges. Compared, greatly improve the protective effect.

Although sponge materials have many advantages, generally speaking, sponge materials have low aesthetics and poor permeability, which is not conducive to human health. Long-term wear cushioning performance will be reduced and need to be replaced. Therefore, it is not recommended to use sponge materials as energy-absorbing cushioning materials Clothing materials.

2.2 Airbag

The airbag can receive the fall signal sent by the sensor when it falls, and automatically activate the air pump or the gas generating device to inflate quickly, so as to achieve the buffer protection effect[10], its storage and transportation space before inflation is small, easy to use, protect Strong performance, does not affect the appearance and comfortable wearing under normal conditions, and the technology is relatively mature. The airbag needs to be combined with various electronic sensing technologies during use to sense the speed change of the human body when it falls, and is equipped with a gas generating device or a portable air pump. Of course, when airbags are used in protective clothing, the most important point is that the inflation time of the airbag should be shorter than the time when the human body falls down.

Helite's company designed a Hip'Air airbag apparel[11]. This device can detect that the wearer is falling within 0.2 seconds, and inflates the airbag within 80 milliseconds, absorbing 90% of the impact of the fall. Its absorption capacity It is 9 times better than traditional protection devices to achieve the effect of protecting the safety of the elderly. At present, the best airbag fabric on the market is nylon.
Airbags must withstand high expansion forces when inflated, so on the one hand, the airbag fabric must have high strength, on the other hand, it must have good elongation performance, high elasticity and energy absorption recovery, to ensure the airbag It is elastic and does not break\cite{12}. For example, Japan Prop Co., Ltd. designed a wearable airbag garment that can inflate two airbags placed on the human hips and head in 0.1 seconds, and can operate independently without external hardware.

But generally speaking, this type of airbag needs manual activation, which delays time, and the airbag only provides protection for falling backwards, but there is no protection for falling in other directions. The airbag needs to be replaced after each fall, which is expensive.

2.3 New shear thickening gel material

The shear thickening gel material is soft and elastic under the condition of no force. Once subjected to severe impact, the molecules will quickly lock each other, quickly tighten and harden to form a protective layer, when the external force disappears, The material quickly returned to its original soft state \cite{13}; and the preparation process of shear thickened gel material is relatively simple, the cost is low, and large-scale production can be carried out. At present, there are few studies on the application of shear thickening gel materials in protection at home and abroad, which is of great value and significance for the development of protective clothing for the elderly who fall and fall. Representative materials such as STG gel material and D30 gel material have already been applied to the field of sports protection.

2.3.1 STG gel material

Under normal conditions, STG gel materials have soft plastic properties, which can be kneaded into various shapes like plasticine, and STG has creep properties. Under high-speed impact, objects will directly sink into the STG gel, so in application Foreign objects must be used to maintain a certain shape of the STG gel and make it resilient. Polyurethane foam (PU) is a common cushioning material. Combining the two, on the one hand, the polyurethane foam skeleton can be used as a carrier for STG, on the other hand, the shear thickening of STG can improve the impact absorption of polyurethane foam (PU) effect. At present, experiments have proved that when the impact speed is large, the composite material of STG and PU will improve the ability of STG to absorb energy. This is because the speed makes STG hard instantly, greatly improving the protection performance of PU. Xia Yanli\cite{14-15} et al. conducted experiments on STG-PU. Figures 1 and 2 show the residual impact load and peak duration of polyurethane foam before and after impregnation at different impact speeds.
Figure 2. Peak duration of polyurethane foam before and after impregnation at different impact speeds.

At present, the method of compounding shear thickening gel (STG) and high-performance fabrics has been widely used at home and abroad to prepare flexible protective materials, but it is more used in bulletproof and stab-proof aspects, but it is rarely used in the field of elderly protection. Report\(^{[16]}\). The protective material based on shear thickening gel (STG) not only absorbs and disperses impact energy, but also has cushioning and shock absorption capabilities. At the same time, the composite material formed by shear thickening gel (STG) and other cushioning materials has both resistance to impact protection performance and clothing comfort, using it to develop elderly protection products has broad application prospects.

2.3.2 D30 gel material

D30 gel material is developed by D30 laboratory, a British high-tech company. Compared with other commonly used protective materials, D30 is much lighter and has a better degree of fit with the protective parts\(^{[17]}\). At the same time, it has a stronger ability to absorb energy and can play a better protective role; the use and processing of materials are very convenient, has good comfort and breathability, and can be used in occasions requiring high flexibility and moderate impact protection\(^{[18]}\).

D30 gel material can combine free movement and protection of collision and strike parts, and is an ideal material. This material is also called "soft armor". At present, it has been used in ski wear, motorcycle wear, bicycle riding wear, water sports wear, etc. Abroad, some skiers in the United States and Canada have used D30-containing materials at the Winter Olympics; the United States is using D30 gel materials R&D police use gloves to protect\(^{[10]}\); the British military uses D3O gel materials to develop new bulletproof clothing. In November 2009, Baizu's BAIZUS cooperated with the British D30 Lab to take the lead in applying D30 materials to the field of outdoor sportswear in China. This is a revolutionary improvement of traditional outdoor sportswear and has important significance. Figure 3-4 shows breathing and protective gloves made with D30 material.
Figure 3-4. Protection products prepared with D30 material.

Compared with the shear thickening gel (STG), the specific molecular structure of the D30 gel material is still in a confidential state, and the cost is relatively high, because the duration of material hardening and the duration of impact are extremely short \[18\], so it is difficult to accurately measure its impact resistance, so it is not widely used in elderly protective clothing.

3 Development trend of fall protection clothing
At present, the development of elderly protective clothing is mainly from the clothing itself, research or improvement of cushioning materials, and although the monitoring part of falls and falls is involved, but the research in the field of protection is not enough, the former focuses on after falling How to effectively protect, and the latter is to predict, judge the fall behavior and then proceed to the next protection. The design of old-age clothing should include two aspects: fall monitoring system and fall protection, involving the fields of clothing design, ergonomics, and electronic information technology. To sum up the development process of old-age clothing, the development of old-age fall protection clothing should be considered from the following two aspects:

① From the perspective of electronic information technology, to improve the monitoring efficiency of the fall and fall monitoring system, on the one hand, it is necessary to efficiently and quickly monitor the fall data of the elderly's fall behavior. It is necessary to have high sensitivity, precision and stability, without affecting the comfort and appearance of the clothing, and without hindering the normal activities of the elderly.

② From the perspective of clothing design and ergonomics, due to the deterioration of the physical functions of the elderly and their own needs, the clothing must be both beautiful and convenient in both static and dynamic aspects, and it must also consider the moisture permeability and breathability of the clothing material. Form the organic unity of people, clothing and environment \[19\].

For the application of wearable sensors in clothing, both high accuracy, miniaturization, low power consumption, and low cost of the sensor must be considered, which can fit the clothing well, enhance the aesthetics of the clothing, and must be washable and easy to play. It has the characteristics of good management, good flexibility, excellent stretchability and large strain sensing range. In addition, it is necessary to improve the efficiency of multi-module monitoring, with multi-directional fall behavior monitoring; prepare small wireless sensor elements, and the terminal is designed as a bracelet; etc.; even predict the occurrence of a fall or issue an alarm and control Active intervention to help the human body walk normally. In addition, the relationship between the clothing version structure and the thickness, softness and hardness of the cushioning material should be analyzed, and reasonable treatments that have the characteristics of softness, flexibility, lightness, elasticity, and wrinkle resistance and anti-slip properties should be considered to meet the needs of the elderly in life. Kinds of needs. Based on the above, electronic sensing equipment should have the characteristics of flexibility, miniaturization, and practicality, and the materials should have the characteristics of environmental protection, safety, and impact resistance. In addition, how can electronic sensing equipment and materials be used in a better way Clothing will be the future development direction of protective clothing.

4 Conclusion
This article mainly introduces the application of various energy-absorbing cushioning materials in the field of protective clothing for the elderly, and looks forward to the future development of the protective clothing for the elderly. As the aging society continues to deepen, the research and development of elderly fall protection clothing will become a social problem. In the future, fall protection clothing should combine smart wearable device technology and cushioning materials to ensure that the elderly are oriented and strengthen the elderly. Diversified quality of life, reduce the risk of falls and injuries, and protect the physical and mental safety of the elderly. Therefore, it is of great research value to intelligently monitor the activities of the elderly and use the protective devices
to reduce the injuries of the elderly and the fall after falling, which opens up broad prospects for the development of protective clothing for the elderly.

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