

# Design Experiment on Easy-to-Wear Warm Boots for Wheelchair Users

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## Abstract

To solve the problems of wheelchair users' shoes and boots in the aspects of convenience, warmth, and comfort in low-temperature environments and better meet their physiological and psychological needs, this paper proposes a structural design scheme of easy-to-wear and take-off warm boots based on a new type of warm wadding. At the same time, the fuzzy mathematics comprehensive evaluation method was used to select a new kind of flocculant with excellent thermal and wet comfort polyester fiber flocculant as the filling material for the follow-up warm boots. This paper has guiding significance and application value to the development and application of wheelchair users to put on and take off warm boots.

*Keywords:* Wheelchair users; Warm boots; Easy to put on; Heat retention property

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## 1 Introduction

According to the World Health Organization (WHO) and the United Nations, about 131 million people in the global population need wheelchairs. Statistics from the China Disabled Persons' Federation show that as of 2020, more than 5 million people in China use wheelchairs every day, either permanently or temporarily [1]. For wheelchair users with poor lower limb activity, the blood circulation ability of the distal part of the lower limb is poor, the heat production is poor because of prolonged sitting, and the heat transfer is slow. Therefore, such people will have a greater demand for the convenience of wearing and removing lower-limb clothing products and the ability to keep warm from the cold.

Limited by physical function, mobility, dexterity, or endurance [2], wheelchair users have a high demand for the ease of wearing and removing clothing and footwear products. Wu Daiwei et al. [3] surveyed 58 test subjects who used wheelchairs due to lower limb disability. They found that most wheelchair users said it was difficult to put on and take off clothes when going to the toilet, bathing, and other activities. For the structural design of barrier-free shoes, almost all are designed into three-piece openings, and more Velcro is used to tighten [4]. These products

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solve the problem of wearing and removing them to a certain extent. However, the overall design function and beauty still lack innovation, and the winter use of warmth is not good, which cannot meet the basic psychological needs of wheelchair users in pursuit of beauty [5]. Therefore, it needs to be improved in many aspects.

According to the literature, an environment with an average temperature lower than 5 °C is defined as a low-temperature environment [6]. Exposure to low-temperature environments poses a serious challenge to human safety and health. The foot is located at the end of the lower limb, away from the heart, and has a relatively low blood supply, making it particularly vulnerable to cold stimulation. [7] Studies have shown that people feel uncomfortable, mostly because of foot discomfort. When the skin temperature of the foot is 28 ~ 33 °C, the human body feels comfortable; when the skin temperature of the foot is 25 °C, the human body begins to feel a little cold; when the temperature is lower than 22 °C, the local blood circulation will be affected, making people feel uncomfortable [8]; when the temperature is lower than 21 °C, people will feel cold obviously, accompanied by discomfort and even pain [9]. When the foot temperature drops below 7 °C, there is a risk of frostbite [10]. As personal protective equipment used in cold environments, thermal boots can reduce the damage to the feet in cold environments. New floc filling materials such as hollow fiber, microfiber, aerogel, and composite thermal materials have become hot spots in the research and development of thermal clothing products. The new thermal materials will gradually lead the trend of the thermal materials market and develop toward thinner, more comfortable, and healthier while improving warmth.

## 2 Method

### 2.1 Research Method of Structural Design Elements of Easy-to-Wear Thermal Boots

Domestic and foreign studies have shown that the convenience of wearing and removing clothing is the primary consideration in designing clothing for people with mobility difficulties [11]. The research based on the convenience of wearing and taking off shoes is mainly aimed at disabled people who cannot wear or take off clothes independently due to physical injury and their desire for independence. In the design, the details of shoes and boots should be considered, such as the choice of opening direction and fasteners, and the basic type of shoes and boots should be changed so that shoes and boots can be easily worn. Narrow the difference between the dress and appearance of people with mobility disabilities and normal people, and take care of their psychological state.

As shown in Table 1, most of the current studies on barrier-free boots start from the perspective of convenience of wearing and taking off. Most of them increase the boot cavity or open the boot upper to facilitate the access of the user's feet and use the buckle or binding to fix it. However, using the buckle leaves a gap between the two boot uppers and affects the thermal performance. The binding will be inconvenient to wear and take off, time-consuming, and laborious. It is necessary to develop a kind of easy-to-wear and take-off warm boots suitable for wheelchair users to solve the problem of the boots in the existing technology having a single structure, which is inconvenient to wear and take off. At the same time, long-term wearing will lead to fatigue and oppression because the shoe cavity space is too small.