An innovative design of mechanical auxiliary device for assisting flexor and wears

Jiankang Zhang1, *, Zhen Yan2 and Yijing Chen2

1School of Mechanical and Electronic Engineering, Wuhan University of Technology, Wuhan, China
2School of Mechanical and Electronic Engineering, Wuhan University of Technology, Wuhan, China

*Corresponding author: 283450@whut.edu.cn

Abstract. Today, the aging of the population is becoming more and more prominent, and the aging of the population brought about by the social, health and other problems on the family and society for the elderly function also has a higher and higher requirement. Through research and literature review, most of the elderly have the symptoms of leg and foot inconvenience or nape and lower back pain, which brings great obstacles for them to wear pants and socks with bending body. However, it is difficult for the accessory products of flexor wearers sold on the market to truly complete the function of non-flexor movement. For this reason, this project designed a device that can help the elderly to complete the movement of wearing pants and socks without bending down. Moreover, through multi-stiffness adjustment, linkage drive structure is designed to realize the integrated wearable process. According to ergonomics, relevant design is made for the device size, and the combination of multiple adaptive modules can realize the adaptive matching for the elderly with different heights and body shapes.

1. Introduction

With the aging trend of the global population, the issue of caring for the elderly has become increasingly urgent. "Caring for the elderly” has gradually become a hot issue in the society and caring for the lives of the elderly has also become a social need. At present, automation and intelligence technologies have become more and more mature, and smart endowment has become a new direction for the development of aging cause and industry as a modern endowment mode organically combined with modern science and technology and endowment service. Therefore, the use of science and technology to help the elderly, the design of machinery to assist the elderly living is very necessary. However, there are few kinds of auxiliary dressing equipment for the elderly in the market, limited for the situation, low degree of automation, relying on manpower and other problems. Based on this, we conducted a study on the daily wearing of the elderly under the premise of indomitable body, which can only be completed by bending the body.
2. Research background analysis

2.1. Political Background
The aging of population is becoming more and more serious due to the increasing average life expectancy of the population. China Population Outlook (2018) points out that the size and degree of population aging is increasing year by year in China at the present stage. In 2017, the statistical result is 160 million, accounting for 11.4% of the total population, and it is expected to increase by more than 300 million by 2033, accounting for 21.0%. It can be seen that China is rapidly entering an aging society, and the social and health problems caused by the aging population pose a higher challenge to the function of family and society in providing for the aged.

The Chinese government has issued many policies to support the development of the elderly care service industry and encourage the construction of auxiliary equipment for the elderly. The General Office of the State Council has issued opinions on promoting the development of the elderly care service, and proposed that the elderly people should carry out the renovation project to adapt to aging at home. The State Council issued the 13th Five-Year Plan for the development of national undertakings for the elderly and the construction of the old-age care system, and carried out the construction, allocation and renovation of family auxiliary equipment to meet the living characteristics and safety needs of the elderly.

\[ c_2 = a_2 + b_2 \] (1)

2.2. Social Background
Through the elderly people's body and health status investigation, with the growth of age, the elderly in all parts of the body degenerative diseases, the ability to bear various external forces weakened, prone to shoulder peri arthritis, rheumatoid arthritis and other diseases. This has brought great troubles and inconveniences to the old People's Daily life, as well as difficulties and obstacles for the necessities of life.

Through the investigation of the elderly community found that 74% of the elderly have leg and foot inconvenience or low back pain, and due to the process of wearing pants and socks need a lot of bending, bending leg movements, this part of the elderly is difficult to wear pants and socks situation.

![Figure 1. Ratio of nape and back pain to leg and foot inconvenience in the elderly Technical Background](image)

2.3. Technical Background
There are mainly the following kinds of equipment to assist the elderly to wear pants and socks on the market: 1) The auxiliary lever for dressing and wearing socks; 2) Easy to wear and take off pants; 3) Wear socks. According to the investigation, the existing assistance for the elderly is mainly manpower, the use of AIDS is not popular enough, and there are only a few kinds of AIDS, limited for the situation, manpower, low degree of automation. Therefore, the equipment for assisting the elderly to wear socks and trousers on the existing market is still in the initial stage, with a greater development space.
3. Overall design and job description

3.1. Overall introduction to the design

The overall device is shown in Figure 3.1. This project designs an integrated device to assist the elderly to bend and wear. The device is composed of a trouser lift module, a trouser leg support module, an auxiliary sock wearing module and a transmission module, etc. The trouser lift module is mainly able to fix the waist and lift the trousers. The trouser leg support module is mainly used to ensure that the lower part of the trouser leg can generate enough space to ensure that the elderly can easily extend their feet; The auxiliary hosiery wearing module mainly ensures that the elderly can complete the hosiery wearing action independently under the circumstance of indomitable body and can actively control its process at the same time.

3.2. Workflow design

For different elderly people, first select the appropriate telescopic rod spacing, and then adjust the pants lifting module, pant leg support module, and auxiliary socks module to the device about 1.0m-1.2m from the ground. For use, first fold the trouser legs and cover them above the soft sleeve, then extend the waistband to the supporting cushion side, and then cover the socks to the sleeve side after completion. Then the old man to set foot on device platform, press the down button, each module comes with wheel movement down, dropped to about 60 mm above the platform, the old man to his feet into the hole in the legs, the press of a button, after the completion of pants ascend upward movement module, the module, to the old man right waist position, the old man can manually to get off his trousers, adjust do wear pants at the same time.

Finally, the old man put his foot into the sock hole, and at the same time, he took the initiative to manually control his own situation of wearing socks, until he was satisfied with the release of grip,
complete the movement of wearing socks. After finishing putting on the socks, I also stepped down from the platform.

Figure 4. Flow chart of device operation

4. Calculation and Analysis

The overturning moment of the frame part is calculated according to the stiffness distribution:

$$M_e = \sum_{i=1}^{N} \sum_{j=1}^{M} V_{ij} h_i$$  \hspace{1cm} (2)

Where: $M_e$ is the overturning moment assigned to the frame part under the prescribed lateral force of frame shear wall structure; $N$ is the number of structural layers; $M$ is the number of column roots in the $i$ layer of the frame; $V_{ij}$ is the calculated shear force of the $J$th frame column in the $I$ story; $h_i$ is the $i$th layer height.

Regardless of whether the frame shear wall is a hinged system or a rigidly coupled system, the total overturning moment at the bottom of the structure can be calculated by the following formula:

$$M = F_1 h_1 + F_2 (h_1 + h_2) + \cdots + F_n (h_1 + h_2 + \cdots + h_n) = \sum_{i=1}^{N} V_i h_i$$  \hspace{1cm} (3)

In the equation, $F_i$, $V_i$ and $h_i$ are respectively the horizontal force, shear force and height of the floor on the $I$ floor.

In this scheme, the rigid connection system is carried out by angular connection group. Due to the existence of the connection beam, the overturning moment borne by the frame is different, as shown in FIG. 4. In the figure, $N_i$ is the beam coupling axial force of the $i$ layer, and $Q_i$ is the shear force of the beam connecting the $i$th layer, both of which are positive in the direction shown in the figure.

Figure 5. Frame part calculation diagram
According to the mechanical method to calculate the overturning moment borne by the frame, it is necessary to calculate the resultant vertical force at the bottom of the structure according to the following formula:

$$x_0 = \frac{\sum |R_i| x_i}{\sum |R_i|}$$  \hspace{1cm} (4)

Where: $x_0$ is the coordinate of the resultant vertical force at the bottom of the structure; $R_i$ is the axial force of each frame column under the action of specified horizontal force; $x_i$ is the coordinate of the center of each frame column.

The overturning moment borne by the frame can be divided into two parts, one of which is generated by the specified horizontal force $F_i$ and beam connecting axial force $N_i$, which is expressed by $M_{e1}$:

$$M_{e1} = (F_1 - N_1) h_1 + \cdots (F_n - N_n) (h_1 + h_2 + \cdots h_n) = \sum_{i=1}^{n} \sum_{j=1}^{m} V_{ij} h_i$$  \hspace{1cm} (5)

The other part is generated by the coupling shear $Q_i$ and is represented by $M_{e2}$:

$$M_{e2} = Q_1 x_{L1} + Q_2 x_{L2} + \cdots + Q_i x_{Li} + \cdots + Q_n x_{Ln} = \sum_{i=1}^{n} Q_i X_{Li}$$  \hspace{1cm} (6)

Therefore, the overturning moment ratio borne by the frame is:

$$M_e = M_{e1} + M_{e2} = \sum_{i=1}^{n} \sum_{j=1}^{m} V_{ij} h_i + \sum_{i=1}^{n} Q_i X_{Li}$$  \hspace{1cm} (7)

The model was built by SATWE software, and the overturning moment borne by the frame was calculated by mechanical method. The results are shown in Table 1. The overturning moment ratio of frame bearing calculated by mechanical method is 41.39%.

**Table 1. Overturning moment table of frame bearing**

| Computational Method | mechanical analysis | mechanical analysis |
|----------------------|---------------------|---------------------|
|                      | X-scale             | Y-scale             |
| Bottom frame overturning moment | 248.34 | 248.34 |
| Total overturning moment at the bottom | 600 | 600 |

In the case of the elderly support frame, meet the requirements.

5. **Conclusions**

To sum up, the integrated device for assisting the elderly to wear and wear described in this article has effectively improved the intelligence and adaptability of the assistance products for the elderly in China's current market and filled the gap in the field of assisting the elderly to wear. This device can develop many additional functions in the future, and its main functions can also be upgraded and improved to more integrated, multi-adaptive, safer and other aspects. It has very prominent advantages and has a very broad application prospect.

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