The utility model relates to a shoe-wearing device for the aged

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Abstract. This paper introduces a new way of wearing shoes for the elderly who live at home. Through repeated dimensional design and mechanical design of multi-degree of freedom shoe opening, it can adapt to the leg shape of most old people. The operation process of the combined device is simple. The old man only needs to apply a force to clamp the shoes, and the shoe mouth is stuck, which greatly facilitates the old man to put on shoes and slippers, so that the old man can complete the operation of putting on shoes and taking off shoes without bending over on the chair. This device in compliance with the national standard premise, superior performance, complete functions, low cost, high use value, has a broad market prospect.

1. Introduction

In the process of the daily life of the elderly, wearing shoes to take off shoes is always one of the essential activities of every day, because the elderly waist muscle atrophy, spine instability, the elderly's daily bending to wear shoes has become a very difficult activity. And at present, there is no more effective tool to wear shoes on the market, so the elderly in the process of putting on shoes and taking off shoes inevitably carry out bending activities, there is a greater risk to the health of the elderly life.

Based on the above background. A kind of auxiliary shoe-wearing and shoe-taking device for the elderly was designed. To assist the elderly to complete the activities of putting on and taking off shoes. The device is composed of stroke adjustment module, shoe expanding module and shoe clamping module.

2. Project background

2.1. Analysis of survey results:

At the beginning of the design, we conducted surveys and interviews through the following methods:

1) consult relevant materials to preliminarily understand the existing types of elderly auxiliary machinery in China's current market, but the existing devices are insufficient, and the market demand for elderly auxiliary shoes.

2) designed an online questionnaire, conducted a survey on the families with the elderly at home, to understand the demand degree of the elderly for auxiliary machinery and the pain points of existing devices.
3) field research: visited fujiapo disabled persons' federation of wuchang district and nursing home of luonan street community of wuhan city for field research, conducted field tests on relevant equipment, and further understood the living status of the elderly.

2.2. Determine the plan of taking off shoes and wearing shoes:
After investigation and the above discussion and analysis, it can be concluded that the shoe-pulling device for the elderly in this project should be improved in the following directions:

1) moderate volume, light weight, convenient for the elderly to take off shoes at any time;
2) it is labor-saving and easy to operate. It needs a simple and brisk operation flow for the elderly as the main object of use;
3) minimize the hand movements of the elderly and design the way of sitting, standing and wearing shoes, so as to avoid the risk of falls caused by the reduction of foot lifting and supporting points during the process of wearing shoes.
Therefore, after comprehensive consideration and weighing the pros and cons, we can preliminarily determine the technical scheme of taking off and wearing shoes by hand control sitting and standing.

3. Systematic research content and research objectives:

3.1. Research objectives:
This work is suitable for a certain independence ability, waist is relatively fragile elderly, assist the elderly to take off, the action of shoes machinery, through a variety of scheme comparison, eventually USES the device of movement through variable leverage system schedule change, The multi-degree-of-freedom double-shoe-pulling structure in the shoe reaming module can fit well with the physiological structure of the joint of crus and ankle of the elderly, and the shoe-pulling on the heel and instep can make the feet of the elderly take off and put on shoes freely. To sum up, the design of the choice of the scheme for human driven, reciprocating motion.

3.2. Research content:
Through a movement to achieve the shoes and clamp the sole two functions

3.2.1. Handle lever mechanism

The main function of the handle lever mechanism of this device is to make the process of pulling and pressing the handle become a labor saving process by pressing and pulling the handle and adjusting the size of the moment arm. The original resistance of clamping the sole and expanding the shoes by applying the handle becomes 26.7%, which further saves labor.
3.2.2. Multi-link slide mechanism

In order to simplify the old people to use the device and make the device structure to simplify, so that the device can achieve a driver to complete multiple functions. The working stroke of the shoe clip module and the shoe expanding fixing device connected with the multi-link mechanism is adjusted by combining the multi-link mechanism with the lever mechanism. Thus, the force of the handle pressure is decomposed into the shoe expanding device and shoe clamping device, and the working stroke ratio of the shoe clamping device and shoe expanding device is 1:1.8, so as to complete the shoe expanding work and shoe clamping work simultaneously, achieving the effect of multiple forces.

The multi-link sliding track mechanism is mainly composed of two sliding tracks and three bar mechanism. It is through the handle lever mechanism of the straight bar downward pressure, and under the action of the connecting rod for the shoe expanding mechanism to provide power. The combination of multi-link mechanism and lever mechanism forms a combined lever variable mechanism to achieve the effect of adjusting stroke and multi-use of one force.

3.2.3. Multi-degree-of-freedom rocker mechanism

According to the research conclusion, most of the shoes worn by the elderly are one-foot-type cloth shoes or cotton shoes. Therefore, during the process of putting on and taking off the shoes, it is easy to step on the heel cloth and bend the cloth along the top of the shoes, leading to difficulties in the process of putting on the shoes.

According to the elderly when taking off the shoes, the shoe pull should fit the instep and clamp the ankle, so two degrees of freedom are needed to meet the needs of a good fit of double shoe pull and clamp the ankle in the shoe expanding mechanism.

Therefore, the device USES the torsion spring to rebound the shoe to complete the task. In addition, there are two degrees of freedom in the X-axis and Y-axis in the space, which are linked by torsion spring to make the shoe puller fit perfectly.
3.2.4. Push rod slider mechanism

![Figure 4. Push rod slider mechanism](image)

Through investigation, in the process of the old man taking off the shoes, the sole is mainly fixed by the clamping mechanism, and the sole of the old man's shoes is generally hard, which can withstand certain pressure. When the device is used to assist the elderly to remove and wear shoes, the shoes need to be fixed in order to avoid the unstable condition of the shoes. On the premise of not affecting the elderly's experience of using the device, the rigid sole is selected as the fixed stress surface.

In order to simplify the device structure and improve the use efficiency of the device, the clamping booster structure is a push rod slider mechanism. By increasing the push rod pressure Angle as far as possible within the range of travel permission, the push rod slider mechanism becomes a force booster structure in the process of clamping shoes, further reducing the force required by the elderly to pull and press the handle.

4. Research basis and feasibility analysis of the project

4.1. Spring check:

The push rod that squeezes the sole in the shoe clip module needs to be pressed by the spring. Class B carbon spring steel wire with oil quenching and tempering is selected for the tensile spring. It is preliminarily assumed that the diameter of the steel wire is 0.5mm-1mm. Look-up table to \[ \sigma_b = 1860 \text{MPa} \]. Check the table to obtain the allowable shear stress \[ \tau_s = (0.32 - 0.38) \sigma_b = (0.32 - 0.38) \times 1860 \text{MPa} = 595.2 - 706.8 \text{MPa} \].

The maximum shear stress of the test \[ \tau_s = 0.44 \sigma_b = 0.44 \times 1860 = 818.4 \text{ MPa} \].

The shear modulus is obtained by looking up the table \[ G = 7.9 \times 10^3 \text{ MPa} \].

To ensure spring characteristics, the working load: \[ F_1 \text{ and } F_2 \] are required to be between 20% and 80% of the test load: \[ F_s \]. If \[ F_1 = 0.8 F_s \], \[ F_2 = 375 \text{N} \].

Choose the diameter of the stretching spring to be 1mm, and the external diameter of the spring to be 8mm, \[ F_s = 9.33 \text{N}; f_a = 3.73 \text{mm}; k_d = 2.5 \text{N/mm} \].

Calculate the maximum load of spring test:

\[ F_2 = \pi d^2 f_a = 2571.1 \text{N} \]

This value is greater than the test load \[ F_2 = 9.33 \text{N} \], so the spring is appropriate.

The internal and external diameters of the spring are:

\[ D_1 = D - d = 7.4 \text{mm} \]
\[ D_2 = D + d = 6.6 \text{mm} \]

Calculate the spring stiffness:

\[ k = \frac{F}{f} = \frac{10}{120} = 0.83 \text{N/mm} \]

Calculate the effective winding number:

\[ n = \frac{k}{K} = \frac{2.5}{0.83} = 30.1 \]

Take the effective winding number as \[ n=30 \], and the actual stiffness of the spring is:
When $C = \frac{D}{d} = 13$, look-up table to take the early tension $\tau_0 = 32 - 80$ MPa. Take $\tau_0 = 50$ MPa, calculate initial tension: $F_0 = \frac{\pi d^4 \tau_0}{8 n} = 157N$.

The calculated installation deformation and working deformation of the spring are:

- $f_1 = \frac{P}{k} = 5mm$
- $f_2 = \frac{P}{k} = 120mm$

Work schedule: $h = f_2 - f_1 = 115mm$

Verify the fatigue strength of the spring:

With $C = \frac{D}{d} = 13$, the curvature coefficient $K=1.12$.

Calculation of working shear stress:

- $\tau_{min} = \frac{8KDF}{\pi d^3} = 235$ MPa
- $\tau_{min} = \frac{8KDF}{\pi d^3} = 500$ MPa

To calculate the $\frac{\tau_{max}}{\sigma_b} = 0.35$

Therefore, the diameter of the selected stretch spring is 1mm, the outside diameter of the spring is 10mm, and the original length is 15mm, which meets our requirements.

5. Project innovations

1) functional innovation: this device is mainly used for putting on and taking off shoes, integrating the function of clamping shoes and expanding shoes;

2) mechanism innovation: by combining the guide rail with multi-link mechanism, two functions of shoe clamping and shoe expanding can be realized by one action;

3) combination innovation: the combination of lever mechanism and multi-link mechanism can achieve the adjustment and combination of the working stroke of expanding shoes and clamping shoes

6. The application prospect of

1) adapt to the process of wearing, taking off and changing shoes in the daily life of the elderly, reduce the bending in the process of taking off/putting on shoes, and meet the needs of the elderly to take off/putting on shoes independently;

2) Simple operation, the elderly can achieve the two functions of expanding shoes and clamping shoes through one action, so that the process of taking off/putting on shoes is labor-saving and efficient;

3) The device is portable, occupies a small area, and is convenient for home placement. It can be widely used in families and nursing homes, and has a good application prospect.

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